Integrative taxonomy, systematics and biogeography of geometrid moths in a Middle Eastern biodiversity hotspot

Dissertation to obtain the doctoral degree
of Natural Sciences (Dr. rer. nat.)

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University of Hohenheim
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2023

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Submitted on:	04.07.2023
Oral examination on:	12.12.2023

The present work was accepted by the faculty of Natural Science as “Dissertation for obtaining the Doctoral Degree of Natural Science (Dr. rer. nat.)” on 02.11.2023.

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2. I only used the sources and aids listed and did not make use of any impermissible assistance from third parties. In particular, I marked all content taken word-for-word or paraphrased from other works.

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Abstract

Iran is an important biodiversity hotspot in the world. Recent studies have shown that two of the 36 global biodiversity hotspots are located in Iran: The Irano-Anatolian and the Caucasian hotspots. These two hotspots include parts of the two mountain ranges in Iran, the Alborz Mountains and the Zagros Mountains, which are crucial for the biodiversity, hosting a large number of endemic species. However, climate change and anthropogenic activities threaten its diversity. This study uses geometrid moths as a model group to better understand general patterns of biodiversity and zoogeography in Iran. Geometridae are suitable for such studies and scientifically interesting for several reasons: The family is species-rich with nearly 24,000 known species worldwide (539 known species in Iran), the species have short life-cycles and thus react quickly to environmental changes, and they occupy specialized ecological niches.

Knowledge of Palearctic geometrid moths is rather advanced compared to other regions. The Western Palearctic, in particular, has been the target of considerable research. However, this is not the case for regions in the Middle East and Central Asia, where much is still unknown and further research is crucial.

To fill this gap for geometrid moths in this region, data on their species richness and distribution patterns were collected to reveal regions with special faunal elements. Therefore, this dissertation consists of three parts, each of which contributes an essential element to achieve these goals.

The first part deals with the taxonomic problems of partially species-rich and morphologically very difficult genera within the three subfamilies Sterrhinae (*Problepsis*, *Scopula*, *Cinglis*, *Pseudocinglis*, *Scopuloides*, *Glossotrophia*, *Zygophyxia*); Geometrinae (*Xenochlorodes*); and Ennominae (*Nychiodes*, *Synopsia*, *Synopsidia*, *Eumera*). Type specimens and original descriptions were used for critical revisions to understand the diagnostic characters of the species. Additionally, large series of specimens from many different museums and private collections were examined to highlight morphological variations. Using an integrative taxonomic approach that includes morphological and molecular data, a total of one new genus and four new species were described and 37 taxonomic changes (e.g., new synonyms, new combinations) were made.

The second part addresses genera with uncertain tribal affiliation or questionable taxonomic status, which were also partially targets of the taxonomic revisions. A multi-gene phylogenetic analysis was performed using one mitochondrial gene and up to nine nuclear genes, sequences generated as part of this work and sequences from published phylogenetic studies were taken to run the analyses.

As a result, the genus *Eumera* was determined to belong to the tribe Prosopolophini, the genera *Cinglis* and *Scopuloides* were removed from synonymy with *Scopula*, two genera were synonymized (*Glossotrophia*, *Pseudocinglis*), and two species were transferred to a different genus (*Problepsis wiltshirei*, *Aphilopota tyttha*).

In the third part, distribution data of Iranian Geometridae was used to identify biodiversity hotspots and regions of high endemism. In addition, a network-based method was used to divide the country into unique bioregions and highlight areas with specific faunal elements. As a result, an exceptional species richness was found along the two main mountain ranges, Zagros in the west and south and Alborz in the north. Considering only the endemic species, the southern mountain areas were identified as the most species-rich regions. The bioregionalization analysis also identified six main bioregions. Most of these bioregions reflect specific faunal structures and are in accordance with previous studies. This highlights the complex species composition in Iran and demonstrates the exceptional biodiversity of the country. In addition, our results indicated two transition zones between zoogeographical realms. Of the six zoogeographical realms defined by Wallace, three occur in Iran meeting in the south of the country: The Palearctic and Saharo-Arabian along the foothills of the Zagros Mountains and the Palearctic and Oriental in southeastern Iran. At these transition zones, Iran has very specific faunal elements of the Geometridae, which makes these zones important for conservation.

Overall, this work contributes to a better understanding of the biodiversity of geometrids in Iran and neighboring countries. It serves as a resource for the identification of species, their distribution and habitats, which are of great interest for conservation efforts in Iran and neighboring countries.

Zusammenfassung

Der Iran ist ein wichtiger Hotspot für die biologische Vielfalt der Welt. Studien haben gezeigt, dass sich zwei der 36 globalen Biodiversitäts-Hotspots in den Iran erstrecken, der Iran-Anatolien und der Kaukasus Hotspot. Diese Hotspots fallen in die zwei großen Gebirgszüge im Iran, dem Alborz- und dem Zagros-Gebirge, die für die biologische Vielfalt von entscheidender Bedeutung sind und eine große Zahl endemischer Arten beherbergen. Diese Vielfalt ist durch den Klimawandel und anthropogene Aktivitäten bedroht.

In dieser Studie werden Geometriden (Lepidoptera) als Modellgruppe verwendet, um allgemeine Muster der Biodiversität und Zoogeografie im Iran besser zu verstehen. Geometriden sind für solche Studien prädestiniert und aus mehreren Gründen von wissenschaftlicher Bedeutung: Die Familie ist mit weltweit fast 24.000 bekannten Arten (539 bekannte Arten im Iran) sehr artenreich, Arten haben kurze Lebenszyklen und reagieren daher schnell auf Umweltveränderungen, zudem besetzen sie verschiedene ökologische Nischen.

Paläarktische Geoemtriden sind im Vergleich zu anderen Regionen relativ gut bekannt und insbesondere die westliche Paläarktis war Gegenstand zahlreicher Forschungsarbeiten. Dies gilt jedoch nicht für die Regionen des Nahen Ostens und Zentralasiens, wo vieles noch unbekannt und weitere Forschung unerlässlich ist. Zum schließen dieser Lücke, wurden Daten über Artenreichtum und Verbreitungsmuster gesammelt und um Regionen mit besonderen Faunenelementen zu ermitteln. Diese Arbeit besteht daher aus drei Teilen, von denen jeder ein wesentliches Element zur Erreichung dieser Ziele beiträgt.

Der erste Teil befasst sich mit den taxonomischen Problemen teilweise artenreicher und morphologisch sehr schwieriger Gattungen innerhalb der drei Unterfamilien Sterrhinae (*Problepsis*, *Scopula*, *Cinglis*, *Pseudocinglis*, *Scopuloides*, *Glossotrophia*, *Zygophyxia*); Geometrinae (*Xenochlorodes*); und Ennominae (*Nychiodes*, *Synopsia*, *Synopsidia*, *Eumera*).

Für diese Revisionen wurden Typusexemplare und Originalbeschreibungen untersucht, um die diagnostischen Merkmale der Arten zu verstehen. Morphologische Variationen wurden mithilfe großer Serien von Exemplaren aus vielen verschiedenen Museen und Privatsammlungen untersucht und aufgezeigt. Unter Verwendung eines integrativ taxonomischen Ansatzes, der morphologische und molekulare Daten umfasst, wurden eine neue Gattung und vier neue Arten beschrieben und 37 taxonomische Änderungen (z. B. neue Synonyme, neue Kombinationen) vorgenommen.

Der zweite Teil befasst sich mit Gattungen unsicherer Zugehörigkeit oder fragwürdigem taxonomischen Status, die zum Teil auch Ziel der taxonomischen Revisionen waren. Es wurde eine phylogenetische Analyse mit mehreren Genen durchgeführt, bei der ein mitochondriales

Gen und bis zu neun nukleäre Gene verwendet wurden. Die im Rahmen dieser Arbeit erzeugten Sequenzen sowie Sequenzen aus veröffentlichten phylogenetischen Studien wurden für die Analysen verwendet. Dadurch konnte die Gattung *Eumera* dem Tribus Prosopolophini zugeordnet werden, die Gattungen *Cinglis* und *Scopuloides* von der Synonymie mit *Scopula* herausgehoben, zwei Gattungen synonymisiert (*Glossotrophia*, *Pseudocinglis*) und zwei Arten in eine andere Gattung überführt (*Problepsis wiltshirei*, *Aphilopota tyttha*) werden.

Im dritten Teil wurden Verbreitungsdaten iranischer Geometriden genutzt, um Biodiversitäts-Hotspots und Regionen mit hohem Endemismus zu ermitteln. Eine netzwerkbasierte Methode wurde verwendet, um das Land in Bioregionen zu unterteilen und Gebiete mit spezifischen Faunenelementen hervorzuheben. Als Ergebnis konnte ein außergewöhnlicher Artenreichtum entlang der beiden Hauptgebirgszüge, Zagros im Westen und Süden und Alborz im Norden, festgestellt werden. Betrachtet man nur die endemischen Arten, so wurden die südlichen Berggebiete als die artenreichsten Regionen identifiziert. Die Bioregionalisierung ermittelte sechs Hauptbioregionen, wovon die meisten dieser Bioregionen spezifische Faunenstrukturen widerspiegeln und im Einklang mit anderen Studien stehen. Dies verdeutlicht die komplexe Artenzusammensetzung im Iran und zeigt die außergewöhnliche Biodiversität des Landes. Zudem deuten unsere Ergebnisse auf zwei Übergangszonen zwischen zoogeografischen Regionen hin. Von den sechs von Wallace definierten zoogeografischen Regionen erstrecken sich drei in den Iran, welche sich im Süden des Landes treffen: Die paläarktische und die Saharo-arabische Region entlang der Ausläufer des Zagros-Gebirges und die paläarktische und die orientalische Zone im Südosten des Iran. In diesen Übergangszonen weist der Iran sehr spezifische Faunenelemente an Geometriden auf, was diese Zonen für die Erhaltung der Biodiversität wichtig macht.

Insgesamt trägt diese Arbeit zu einem besseren Verständnis der Artenvielfalt der Geometriden im Iran und der angrenzenden Länder bei. Sie dient als Ressource für die Identifizierung der Arten, ihrer Verbreitung und Lebensräume, die für den Naturschutz im Iran und in den Nachbarländern von großem Interesse sind.

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I Introduction

An overview on the geography, topography and climate of the study area Iran

Iran, with a surface of 1,648,195 km^2, is located between 25° and 40° north latitude and 44° and 64° east longitude in the south-western part of Asia (Ghorbani 2013). The country borders with seven countries on land: Azerbaijan, Armenia and Turkmenistan to the north, Afghanistan and Pakistan to the east, and Turkey and Iraq to the west (Bazrafshana & Khalili 2013; Ghorbani 2013). It is surrounded by three major seas, the Caspian Sea to the north, and the Sea of Oman and Persian Gulf to the south (Ghorbani 2013).

The majority of Iran is part of the Iranian Plateau, an area of approximately 2,600,000 km^2 covering Iran, Afghanistan, Pakistan, Turkmenistan, Azerbaijan and Iraqi Kurdistan (Ghorbani 2013). Iran is a mountainous country with a mean elevation of 1,000 m, which can be separated into four main mountainous areas (Noroozi et al. 2008; Ghorbani 2013): first, the northern mountain ranges (Alborz Mts., Kopet Dagh); second, the Zagros Mts.; third, the central mountains (Khorud, Yazd–Kerman massifs); and fourth, the eastern mountains (Makran Mts.) (Ghorbani 2013; Doostmohammadi et al. 2020; Noroozi et al. 2020a) (Fig. 1).

Figure 1. Iranian map with the most important mountain ranges in Iran.

Of these four areas, the Zagros Mts. and Alborz Mts. are the largest mountain ranges in Iran (Ghorbani 2013; Yusefi et al. 2019). The Zagros Mts., ranging from north-eastern of Iraq to southern Iran, represent the major mountain range in Iran (Noroozi et al. 2020b). With a length of about 1,300 km and a width of 250 km, it covers about a quarter of Iran's surface (Noroozi et al. 2020b). Dena Mt. peak (4409 m) in southern Iran represents the highest elevation of the Zagros Mts. (Noroozi et al. 2020b).

The Alborz Mts. extend from west to east in the north of Iran, with a length of 950 km, and are divided into three parts: western, central and eastern. (Ghorbani 2013; Noroozi et al. 2020a). The central part contains high mountain peaks, with Mount Damavand (5,771 m) marking the highest point in Iran (Noroozi et al. 2020a).

Regarding Iran's climate, this altitudinal heterogeneity leads to a great diversity of climatic conditions, and the two main mountain ranges mentioned above (Zagros and Alborz), combined with two major desert areas (the Dasht-e Kavir and Lut deserts), play an important role in the country's uneven precipitation (Sodoudi et al. 2010; Malakoutikhah et al. 2018). For instance, in the province of Isfahan there are strong fluctuations in temperature and precipitation (Malakoutikhah et al. 2018). The main climate of the country is arid or semiarid, with the exception of the coasts in the north and the western parts of the country (Sodoudi et al. 2010; Mansouri Daneshvar et al. 2019). Continental climates with hot and dry summers and very cold winters are present inland (Sodoudi et al. 2010). Besides its diverse climate, the country is also known for its extreme climatic conditions, as minimum temperatures of -40 °C can occur in the northwest of the country, and the Lut Desert in the southeasternmost part of Iran is the hottest place on Earth, with 80.83 °C based on land surface temperature (LST) (Ghorbani 2013; Azarderakhsh et al. 2020). Rainfall also varies widely across the country, ranging from possibly no annual rainfall at all in the Lut Desert and 100 mm in the central basin to about 2,400 mm at the coast of the Caspian Sea in the north (Ghorbani 2013).

Importance of Iranian mountain ranges for biodiversity

Due to their high diversity in habitat and abiotic factors, the mountains of Iran have been shown to harbor high species richness as well as high rates of endemism (Noroozi et al. 2019, 2021; Noori et al. 2021; Rajaei et al. 2023a). Moreover, parts of the territory of Iran are included within two of the 36 global biodiversity hotspots, the Caucasus and the Irano-Anatolian hotspots, which cover parts of the main two main mountain ranges, Alborz and Zagros (Myers et al. 2000; Mittermeier et al. 2011; Hrdina & Romportl 2017).

The Caucasus biodiversity hotspot, one of the most biodiverse regions in the world, stretches across Georgia, Armenia and Azerbaijan, the north Caucasian part of the Russian Federation, the northeastern part of Turkey, and the northern slopes of the Alborz Mts. in Iran (Zazanashvili 2009; Katouzian et. al. 2016) (Fig. 2). The Irano-Anatolian biodiversity hotspot is an understudied hotspot with an extraordinary species endemism, stretching from Turkey, southern Georgia, Nakhchivan Autonomous Republic, western Armenia, northeastern Iraq, the southern slopes of the Alborz Mts. and along the Zagros Mts. in Iran to the northern Kopet Dagh in Turkmenistan (Katouzian et. al. 2016; Yousefi et al. 2022) (Fig. 2).

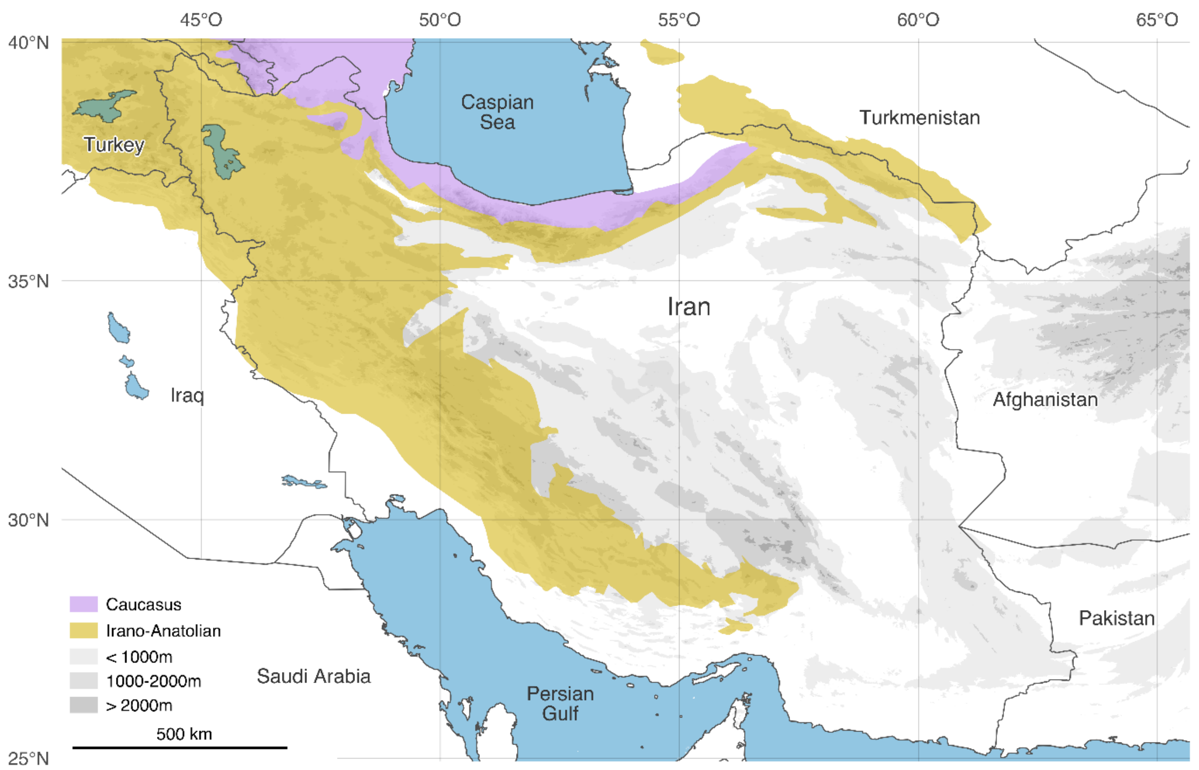

Figure 2. Two of the 36 global biodiversity hotspots, the Caucasus (purple) and Irano-Anatolian (yellow) hotspots, include parts of the western and northern regions of Iran.

As said, these two mountain ranges are essential for the floristic and faunistic diversity of Iran, and have been shown to play an important role in speciation (Rechinger 1963–2015; Mehrabian et al. 2021). Regarding the flora, the Iranian mountains have a high degree of endemism, with a rate of 32% for alpine plants in the Alborz Mts. and 46% in the Zagros Mts., with increasing endemism rates in relation to increasing altitude (Vetaas & Grytnes 2002; Noroozi et al. 2008; Stein et al. 2014). Similar findings were made for the Iranian herpetofauna, for which the highest rates of endemism are found in the Zagros Mts. (Kazemi & Hosseinzadeh 2020), whereas various families of Lepidoptera show a high diversity along these mountain ranges (e.g., Nazari 2003; Keil 2014; Yakovlev 2015; Rajaei et al. 2023a).

Furthermore, during the glacial maxima, even though the Iranian mountains were only affected by dry and cold weather and not directly by glaciers, both the Alborz and Zagros mountain ranges played an important role as refugia for many organisms, from where species were able to disperse afterwards (Rajaei et al. 2013; Ashrafzadeh et al. 2016; Archaux et al. 2018; Malekoutian et al. 2020).

Iranian biodiversity in danger

For Iran, 253 protected areas (PAs) are defined, covering only 10.12% of the surface of this large country (Kolahi et al. 2012). The PAs are fragmented throughout the country, vary in size, and they are often evaluated by their total area rather than their effectiveness and usefulness (Kolahi et al. 2012). Within the mountain ranges in Iran, the important biodiversity hotspots, mainly small, fragmented PAs are present, with occasional larger ones like the Central Alborz Protected Area (Kolahi et al. 2012; Farashi & Shariati 2017; Otaghvar et al. 2022).

Presently, Iranian biodiversity is threatened by human impact and climate change (Jowkar et al. 2016; Farashi & Shariati 2017). The southern half of the country is also at risk of desertification due to its arid and semi-arid characteristics (Jowkar et al. 2016). Regarding anthropogenic activities, overgrazing, illegal hunting, infrastructures, and water and air pollution represent big threats biodiversity, as they are responsible for the extinction and strong decline of, for instance, the two large carnivore species: the Asiatic lion (*Panthera leo persica* (Meyer, 1826)) and the Asiatic cheetah (*Acinonyx jubatus venaticus* (Griffith, 1821)) (Jowkar et al. 2016). Overgrazing by sheep and goats and overcutting in areas with rare or endemic floral and faunal elements also threaten unique habitats (Jowkar et al. 2016). Furthermore, wildfires, either accidental or intentional, burn century-old oaks, and it takes many years for these areas to recover and grow again (Jowkar et al. 2016; Kheshti 2020). In the Zagros Mts. alone, 50,000 ha of oak forests burned down in 2020 and these fires alter the fauna and flora as well as the physico-chemical and biological properties of soil, which may result in a change in plant community composition in these areas (Heydari et al. 2016; Kheshti 2020).

Given this situation, it is clear that the largest group of herbivorous insects, the Lepidoptera, which have a variety of different adaptations to plants, are key indicators, as they are strongly affected by climate change and anthropogenic activities (Menken et al. 2010; Krämer et al. 2012; Pearse & Altermatt 2013; Münsch et al. 2019).

Within the Lepidoptera, species of the family Geometridae are valuable indicators for environments due to their restricted mobility (Scoble 1992; Minet & Scoble 1999; Hausmann 2001). However, organisms can only be used as indicators and conserved if we are able to identify each taxon and its habitat requirements; regarding geometrid moths, it is assumed that only about half of the species are known (Mace 2004; Rajaei et al. 2022a). Rajaei et al. (2022a) estimated that, at the current rate of species identification and description, it will take another

200 years to understand the world geometrid fauna. This is a time that taxonomists might not have due to climate change and human impact, as species are dying out before we get to know them (Lees & Pimm 2015).

Systematics, distribution and biology of Geometridae

Geometrid moths (loopers or inchworms) are distributed worldwide, and with about 24,000 known species they represent the second largest family of Lepidoptera (Nieukerken et al. 2011; Sihvonen et al. 2020). This family is classified in the superfamily Geometroidea together with Uraniidae, Sematuridae, Epicopeiidae and Pseudobistonidae, with Uraniidae being sister to Geometridae (Mitter et al. 2017; Rajaei et al. 2022a). The family is monophyletic, which is strongly supported by molecular data and both larval and adult morphological characters (synapomorphies) (Murillo-Ramos et al. 2019; Rajaei et al. 2022a).

In the larvae, the abdominal prolegs are reduced, causing the caterpillars to exhibit their typical looping or inching movement which gives this family its name (Minet & Scoble 1999; Hausmann 2001; van Griethuijsen & Trimmer 2014) (Fig. 3). There are also some exceptions, as some species of the subfamilies Archiearinae and Oenochrominae, but also some lineages in Ennominae, have weakly developed ventral prolegs (Common 1990; Hausmann 2001; Murillo-Ramos et al. 2021), even though the movement of these caterpillars is similar to that of other geometrid larvae (Hausmann 2001).

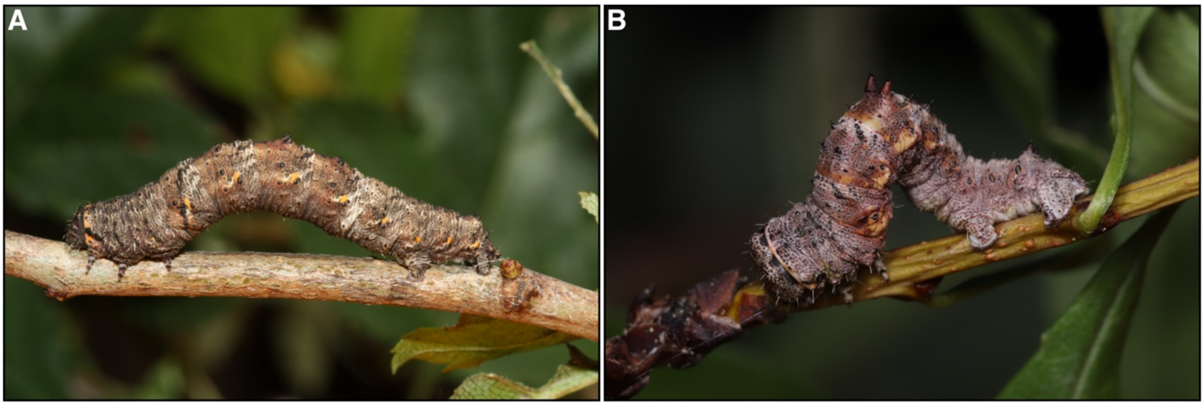

Figure 3. Larvae of two *Nychiodes* Lederer, 1853 species. **A:** *N. aphrodite* Hausmann & Wimmer, 1994. **B:** *N. subvirida* Brandt, 1938. The reduction of the abdominal prolegs in the larvae of the family Geometridae is diagnostic, and determines their typical looping movement.

Adult moths in this family are characterized by the presence of tympanal organs located on the ventral side of the abdomen, which are a modification of the first (A1) and parts of the second (A2) abdominal segments (Cook & Scoble 1992; Hausmann 2001; Rajaei et al. 2022a) (Fig. 4). Furthermore, the ansa is a structure unique to this family, the shape of which varies within the various subfamilies (Hausmann 2001) (Fig. 4).

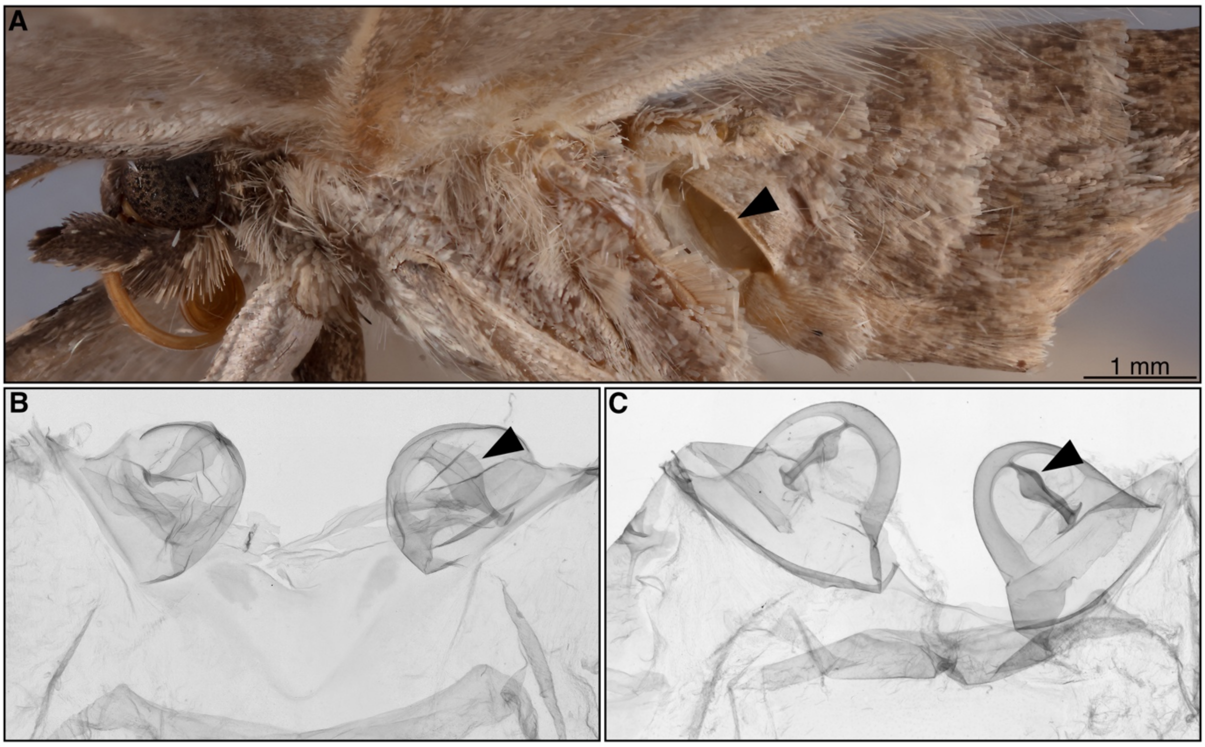

Figure 4. Characteristic tympanal organ of the Geometridae, located on the ventral side of the abdomen. **A:** Dry collection specimen of *Triphosa dubitata* (Linnaeus, 1758) (Larentiinae); arrow indicating the tympanal organ. **B, C:** Macerated and slide-mounted abdomen of (B) *Phaselia serrularia* (Eversmann, 1847) (Ennomionae) and (C) *Problepsis cinerea* (Butler 1886) (Sterrhinae); tympanal organs recognizable as paired capsule-like structures, arrows indicating the ansa. B and C are out of scale.

To date, the family consists of nine subfamilies: Sterrhinae, Larentiinae, Desmobathrinae, Archiearinae, Epidesmiinae, Ennominae, Eumeleinae, Oenochrominae and Geometrinae (Murillo-Ramos et al. 2023). Eumeleinae was recently regarded as a valid subfamily and the former subfamily Orthostixinae was considered a synonym of Desmobathrinae (Murillo-Ramos et al. 2023).

Almost half (47 %; 11,157 spp.) of all geometrid species belong to the Ennominae subfamily, followed by Larentiinae (27 %; 6,450 spp.), Sterrhinae (13 %; 2,993 spp.) and Geometrinae (11 %; 2,696 spp.) (Rajaei et al. 2022a). The remaining subfamilies each have less than 1% of the species assigned to them (Rajaei et al. 2022a). Most geometrid moths are nocturnal, but colorful day-flying species also exist, e.g., *Rheumaptera hastata* (Linnaeus, 1758) or *Heterusia atalantata* (Guenée, [1858]) (both Larentiinae) (Hausmann 2001; Hernández-Baz et al. 2016; Heidrich et al. 2018; Tammaru et al. 2018). In addition, diurnal species are not only active during cloudy weather or in the shade, but they can also be found at sunny sites and in open spaces (Bartsch et al. 2001; Hernández-Baz et al. 2016).

Geometridae larvae are mainly herbivorous, but also display uniquely evolved special diets, like in the genus *Eupithecia* Curtis, 1825, where larvae feed on living arthropods (Montgomery 1983; Hausmann 2001; van Griethuijsen & Trimmer 2014). Most geometrid larvae are perfectly camouflaged and most of them resemble plant stems, are unicolorous brown, resembling old twigs, or green, resembling fresh twigs, and have evolved dorsal or lateral markings (Montgomery 1983; Hausmann 2001). Many species have also developed all sorts of growths on their bodies, e.g., bristles and warts, and some have different colorations when hatching during autumn or spring (Montgomery 1983; Hausmann 2001). Moreover, some Geometrinae of use plants to cover their bodies, a behavior found also in other families (e.g., Psychidae) (Bartsch et al. 2001).

Regarding the species richness of geometrids across biogeographic regions, the Neotropics are the most species rich region, harboring 27.6 % (6,595 spp.) of all geometrid moths (Rajaei et al. 2022a). This is followed by the Oriental Region (20.8%), the Palearctic (19.9%), the Afrotropical Region (14%), the Australian Region (10.9%), the Nearctic (6%), the Malagasy Region (2.3%) and New Zealand (1%) (Rajaei et al. 2022a). Nevertheless, many species within the family have yet to be discovered and described, with estimations of their total diversity at about 40,000 species (Brehm et al. 2016; Rajaei et al. 2022a).

Today, several species are also assigned to wrong genera and tribes, resulting in non-monophyletic groups and uncertain systematic positions (Murillo-Ramos et al. 2019; Rajaei et al. 2022a). The phylogenetic relationships of geometrid moths have received stronger attention in recent years as molecular techniques have significantly accelerated our understanding of the classification of these moths (e.g., Abraham et al., 2001; Sihvonen et al. 2011; Õunap et al. 2016; Jiang et al. 2017; Ban et al. 2018; Murillo-Ramos et al. 2019; Sihvonen et al. 2020; Rajaei et al. 2022a). Still, in areas such as Europe, where Geometridae have been far better collected and studied than on other continents, there are genera in the subfamilies Larentiinae and Ennominae with uncertain tribal association (Müller et al. 2019; Rajaei et al. 2022a). It is therefore not a surprise that the systematic position of some genera or species distributed in the Middle East and Central Asia (especially the endemic ones) remains largely unresolved.

History of Geometridae research in Iran

Research on Iranian Geometridae dates back to the 19th century, when Ménétries described the first geometrid moth for the country: *Urapterix persica* Ménétries, 1832, today assigned to the genus *Ourapteryx* Leach, 1814. During the 19th century and the beginning of the 20th century, geometrid moths were not the target group of collectors and it is therefore not surprising that only a small number of publications on Geometridae exist from this period (Rajaei et al. 2012).

Consequently, it took nearly two more decades until Kollar (1850) described *Phorodesma graminaria*, an emerald moth (Geometrinae) from southern Iran (today assigned to the genus *Sabzia* Wanke & Rajaei, 2022). From 1869 to 1887, Lederer (1869, 1871), Bienert (1879), Christoph (1873, 1877, 1885, 1887) and Staudinger (1879) greatly increased the knowledge on the Iranian fauna of this family by describing a total of 17 new species and reporting more than 150 new taxa for the fauna of Iran. At the end of the 19th century, Butler & Hampson (1899) published a list of Lepidoptera from Lake Urmia, located in north-western Iran, which also included eight species of Geometridae.

From early 1900 to the beginning of World War I in 1914, seven new taxa for science and 52 reports for the country were published in six publications (Dietze 1904, 1910; Petersen 1910; Stichel 1911; Le Cerf 1913; Prout 1912–1915).

In the years immediately after the war, only one paper was published on Geometridae, including 15 further faunistic reports for northern Iran (Prout 1921). In the following years, Prout (1934) and Wehrli (1932–1953) complemented the Seitz series on the Geometridae.

In the late 1930s, knowledge of the Iranian geometrid fauna was greatly increased by extensive collecting and descriptive work by the Baltic-German Brandt brothers (Fred Hermann and Wilhelm Waidermar), as well as by the English lepidopterist Edward Parr Wiltshire (Rajaei et al. 2023b). Fred H. Brandt, who intensively collected Lepidoptera during his years in Iran (1937–1939), sent the material to his brother Wilhelm W. Brandt for spreading, identification and publication (Rajaei et al. 2023b). In his works, some of which he co-authored with Bytinski-Salz (Bytinski-Salz & Brandt 1937; Brandt 1938, 1939, 1941), Brandt described more than 80 new taxa and reported over 100 species for the Iranian fauna. Edward P. Wiltshire, on the other hand, traveled to Iran during his time as a consul, when he started to build his collection (Rajaei et al. 2023b). He published important articles on Iranian geometrids over half a century, authored over 20 new taxa with type locality in Iran, and provided over 150 records for the country (Wiltshire 1939, 1941, 1943a, 1943b, 1944, 1945, 1946a, 1946b, 1947, 1949a, 1949b, 1949c, 1952a, 1952b, 1966a, 1966b, 1966c, 1967, 1970a, 1970b, 1980, 1990).

Moreover, shortly before and during World War II, several authors contributed greatly to our knowledge of Geometridae of the country, with six new taxa and more than 50 additional reports (Wagner 1937; Schwingenschuss 1939a, 1939b). Eugen Wehrli described nine taxa new for science from Iran (Wehrli 1938, 1939, 1941).

In the period from 1941 to the end of World War II and in the early 1950s, it was Wiltshire who published on Iranian Geometridae. Towards the end of the 1950s, other researchers began to publish further reports on the fauna of Iran, which resulted in over 200 faunistic records and 21 new taxa by the end of the 1980s (Reisser 1958; Kuzntzov 1959; Farahbakhsh 1961; Fletcher 1963; Sutton 1963; Barou 1967; Mirzayans & Kalali 1970; Kalali 1976; Adeli & Knopf 1977; Vojnits 1986; Viidalepp 1988).

On the other hand, beside reports of new faunistic data, researchers started to provide the first taxonomic revisions of some genera. Ebert (1968) focused on the taxonomic revision of the genus *Gnophosema* Prout, 1912, Mentzer (1981) studied the genus *Aplocera* Stephens, 1827, and Schütze (1956, 1960, 1961) and Vojnits (1978, 1982, 1988) increased the knowledge of the genus *Eupithecia*.

In the 1990s, Axel Hausmann (1991, 1994a, 1994b, 1996) conducted research on Iranian Geometridae, and Jaan Viidalepp (1996) provided a checklist of this family for the former Soviet Union, which also included important faunistic data for the north-eastern areas of Iran, near the border to Turkmenistan.

The decade after the year 2000 was very fruitful for research on the Geometridae fauna of Iran, as various experts published several taxonomic revisions or faunistic papers (Trusch & Erlacher 2001; Wieser et al. 2002; László 2003; Rezbanyai-Reser 2003; Stangelmaier et al. 2003; Wieser & Stangelmaier 2005; Viidalepp & Mironov 2006). Special encouragement for research in Iran was also provided by Association Lepidoptera Iranica (A.L.I) between the years 2004 and 2006, a collaboration between Iranian and European lepidopterists (Petschenka et al. 2006; Barimani-Varandi 2006; Trusch & Hausmann 2007; Lehmann et al. 2009; Weisert 2009; Lehmann 2010; Lehmann & Zahiri 2011; Mironov & Ratzel 2012a, 2012b; Rajaei et al. 2023b). Unfortunately, this collaboration ended very soon, in 2006, but the interest in lepidopterological research in the country remained strong (Rajaei et al. 2023b). In recent years, Hossein Rajaei and his research team accelerated research on Iranian Geometridae with special focus on the subfamily Larentiinae (Rajaei et al. 2011; Rajaei & Stüning 2012; Rajaei & Stüning 2013; Rajaei & László 2014; Rajaei et al. 2017; Stadie et al. 2014; Wanke et al. 2019), but also on Sterrhinae (Rajaei & Trusch 2011; Feizpour et al. 2018a), Ennominae (Rajaei et al. 2012; Feizpour et al. 2018b), Desmobathrinae (Rajaei & Feizpour 2016) and Geometrinae (Feizpour et al., in prep.).

While this thesis was still in progress, important revisions were published on Larentiinae (Rajaei et al. 2019; Stadie et al. 2022), Ennominae (Rajaei et al. 2021) and Sterrhinae (Rajaei et al. 2022a). Finally, the recently published catalog of Iranian Lepidoptera (Rajaei et al. 2023c) marks an important step forward, summarizing the current state of knowledge and thus highlighting gaps where further research is needed.

Thesis aims

The unfortunate effects of climate change and anthropogenic activities in Iran and neighboring countries are causing unprecedented environmental disruptions and, consequently, a significant loss of species in this area of outstanding biodiversity. Thus, it is more urgent than ever to increase knowledge of the fauna of Iran, in this case of geometrids, and compile information on their species richness, distribution and habitats. The main study area for this work was Iran, but it was sometimes necessary to extend the area to neighboring countries or even other continents, if by doing so the knowledge of a particular taxon could be fully explored in order to assess characters unique for a taxon.

The first part of this thesis aims to uncover the biodiversity of Iranian geometrid moths using a comprehensive, integrative taxonomic approach. Therefore, genera which were in need of urgent revision were partly selected from the subfamilies Sterrhinae (*Problepsis* Lederer, 1853, *Scopula* Schrank, 1802, *Cinglis* Guenée, 1858, *Pseudocinglis* Hausmann, 1994, *Scopuloides* Hausmann, 1994, *Glossotrophia* Prout, 1913, *Zygophyxia* Prout, 1916), Geometrinae (*Xenochlorodes* Warren, 1897) and Ennominae (*Nychiodes* Lederer, 1853, *Synopsia* Hübner, 1825, *Synopsidia* Djakonov, 1935, *Eumera* Staudinger, 1892), for an investigation in the framework of this thesis.

Second, the tribal assignment or validity of taxonomically difficult genera targeted in the first part of thesis has been highly debated in the past; thus, genera as well as species have been misplaced. This part of the thesis helps clarify some of these systematic uncertainties by using multigene analyses including one mitochondrial gene and up to ten protein-coding nuclear genes extensively used in previous studies (e.g., Murillo-Ramos et al. 2019; Sihvonen et al. 2020). This part will represent a step forward towards a more stable classification and monophyletic groups.

Iran, due to its topographic and climatically heterogenetic character, has been shown to have a high biodiversity and also high numbers of endemic species. To understand the biogeographical patterns of the Iranian geometrid fauna, the third part of the thesis aims to highlight regions of high species richness and to point out areas with unique faunal elements. By using distribution data from the taxonomic works collected in the framework of this thesis, unpublished data from Feizpour's Ph.D. project and data collected during the Lepidoptera Iranica project (Rajaei et al. 2023b), a network-based method was used to classify the country into bioregions based on the geometrid fauna. Such bioregionalization analyses with high-resolution data are rare for Iran, but they are important for nature conservation as they identify potential protected areas to be established.

II Original research

Original research paper 1

Systematics of *Problepsis wiltshirei* (Prout, 1938), comb. nov. (Lepidoptera, Geometridae, Sterrhinae) – an endemic species to the Zagros Mountains in the Middle East

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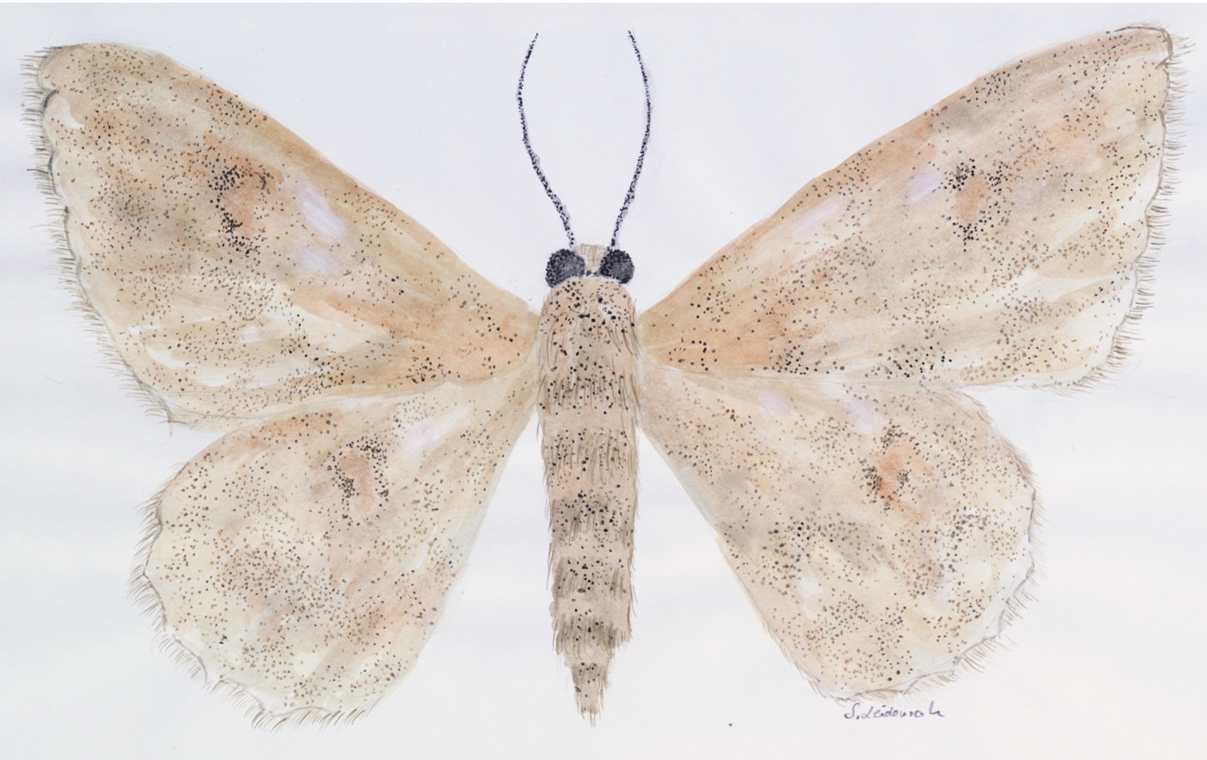
Published (2021) in Nota Lepidopterologica 44: 175–192

https://doi.org/10.3897/nl.44.67345



Painting of *Problepsis wiltshirei* by Susanne Leidenroth

Systematics of *Problepsis wiltshirei* (Prout, 1938), comb. nov. (Lepidoptera, Geometridae, Sterrhinae) – an endemic species to the Zagros Mountains in the Middle East

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http://zoobank.org/8E32131E-08AF-494B-9D94-2C239AA9A301

Received: 14 April 2021; accepted: 20 August 2021; published: 5 October 2021
Subject Editor: Sven Erlacher.

Abstract. Within Iran, the Zagros Mountains show high biodiversity, with a wealth of endemic species. One of these is the geometrid moth *Somatina wiltshirei* Prout, 1938, originally described from Iran and Iraq. In the present study, one mitochondrial and up to nine protein-coding nuclear gene regions were used along with a comparative morphological examination to investigate the systematic position of this species. The results support the reclassification of this species as *Problepsis wiltshirei* **comb. nov.** Since the original species description is superficial, we provide a re-description supported by rich illustrations of morphological characters and distribution. In addition, *Problepsis wiltshirei* **comb. nov.** is reported as a new species for the fauna of Turkey. The importance of the habitat for the conservation of this species is discussed.

Introduction

In the traditional classification of Scopulini (Geometridae: Sterrhinae), species were classified into genera based on the number of forewing areoles. Genera with one areole included *Problepsis* Lederer, 1853 and *Scopula* Schrank, 1802, and species with two areoles were classified in *Somatina* Guenée, [1858] (Prout 1934–1939). Sihvonen (2005) found evidence for the view that the number of areoles in the forewing is homoplastic and therefore not valuable as the only diagnostic character, as the state of two areoles also occurs in some *Problepsis* and *Scopula* species. Thus, even today, quite a few species are erroneously placed in the genus *Somatina*. Some of those have recently been reclassified (e.g., Sihvonen 2005; Xue et al. 2018; Sihvonen et al. 2020). However, the classification of other species within *Somatina* (sensu Sihvonen 2005) need to be re-examined.

The type species of *Somatina* is *S. anthophilata* Guenée, [1858] described from India. Scoble (1999) listed 50 species within the genus, mainly distributed in Africa, Asia and Australia. Recent phylogenetic studies showed that many *Somatina* species belong to other genera: In a morphological phylogenetic study, Sihvonen (2005) transferred four *Somatina* species to *Scopula*, namely *S. indicataria* (Walker, 1861), *S. mendicaria* (Leech, 1897), *S. microphylla* (Meyrick, 1889), *S. nucleata* (Warren, 1905) and two species to *Problepsis* (*P. centrophora* (Prout, 1915), *P.*

triocellata Bastelberger, 1908). *Scopula microphylla* and *P. triocellata* were classified in *Somatina* by Hausmann and Scoble (2007), who listed 46 species within this genus. Xue et al. (2018) transferred *Somatina transvehens* (Prout, 1918) to *Problepsis*.

In a multi-gene phylogenetic analysis, two more species were transferred from *Somatina* to *Problepsis* namely, *P. figurata* (Warren, 1897) and *P. vestalis* (Butler, 1875), consequently decreasing the number of *Somatina* species at present to 41 (Sihvonen et al. 2020).

Somatina species share the following morphological characters (after Sihvonen 2005, none of those are unique synapomorphies): weak discal spots on fore- and hindwing, forewing with two areoles. The male hind tibia is characterized by the presence of a hair pencil. The male genitalia are characterized by socii being not fused, and sacculi and valvuli being asymmetrical. The juxta bears wing-like processes on the anterior margin, with the apex fused to the sacculus of the valva. Sternite 8 in males is variable, x-shaped and with weakly developed or absent mappa, normally without cerata.

The genus *Problepsis* was described based on the type species *Caloptera ocellata* Frivaldszky, 1845 and belongs to Scopulini, the largest tribe within the subfamily Sterrhinae (Sihvonen 2005; Müller et al. 2019; Sihvonen et al. 2020). This genus currently comprises 53 species distributed in the Old World and Australia (Hausmann 2004; Sihvonen and Siljander 2005; Stadie and Stadie 2016; Feizpour et al. 2018; Xue et al. 2018).

Problepsis species share the following morphological characters (none of those are unique synapomorphies): ocellate discal spots on fore- and hindwing, forewing mainly with one areole, occasionally with two areoles (Hausmann 2004; Sihvonen 2005). The male hind tibia is laterally flattened, spoon-shaped and characterized by the presence of a hair pencil (Sihvonen 2005; Feizpour et al. 2018). The male genitalia are characterized by fused socii and a dentate or smooth ventral margin of the tegumen (Sihvonen 2005; Xue et al 2018). Sternite 8 in males is elongated, the cerata are absent, rudimentary or fully developed; if present, then often fused to the mappa (Sihvonen 2005).

Recently, *Problepsis cinerea* (Butler 1886) was reported from the south Iranian province Hormozgan as the only species belonging to the genus *Problepsis* in Iran (Feizpour et al. 2018). Additionally, *Somatina wiltshirei* Prout, 1938 is the only species of the genus *Somatina* described from the Zagros Mountains in Iran and Iraq. Wiltshire (1957) considered *S. wiltshirei* to be restricted to the Zagros woodland belt.

The Zagros Mountains cover an area of 533,543 km^2, extending with a length of 2000 km from Eastern Turkey and Northern parts of Iraq to the whole Western and Southwestern parts of Iran (Mouthereau et al. 2011; Kazemi and Hosseinzadeh 2020). In Iran, these mountains show a high rate of endemism, including reptiles, amphibians and plants (Gholamifard 2011; Safaei-Mahroo et al. 2015; Noroozi et al. 2018; Kazemi and Hosseinzadeh 2020). Additionally, due to its location in low and middle latitudes (between 25–40°N) and milder climate conditions during the Last Glacial Maximum (LGM), this area played an important role as refugia for many biota (van Zeist and Bottema 1977; Rajaei et al. 2013; Ashrafzadeh et al. 2016; Mohammadi et al. 2021).

As a part of the revision of Iranian geometrid moths, the present study aims to clarify the systematic position of *S. wiltshirei*, using an integrative approach; to illustrate species-specific characters, and to give an overview of its distribution in the Zagros Mountains. To achieve this, we used a multi-gene molecular analysis along with the examination of external and internal morphological characters and distribution data. We also discuss the importance of the habitat for the conservation of this species.

Material and methods

Type specimens, as well as additional specimens used in this study, were borrowed and studied from the following collections (acronyms after Evenhuis 2007):

IMCA	Insect and Mite Collection Ahvaz University, Iran;
NHMUK	Natural History Museum London, United Kingdom;
PCPS	Private Collection of Pasi Sihvonen, Veikkola, Finland;
PCWW	Private Collection of Werner Wolf, Bindlach, Germany;
SMNK	Staatliches Museum für Naturkunde Karlsruhe, Germany;
SMNS	Staatliches Museum für Naturkunde Stuttgart, Germany;
ZFMK	Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany;
ZSM	Zoologische Staatssammlung München, Germany.

Criteria for the selection of taxa

To test the combination of *Somatina wiltshirei* with the genus *Problepsis*, we studied type material of *S. wiltshirei*, type species of *Problepsis* (*P. ocellata*), and type species of *Somatina* (*S. anthophilata*) using morphological and molecular data, and additional specimens of both genera were used in the molecular analysis. Moreover, we included *P. cinerea* in our investigations, as it is the only species of the genus *Problepsis* in Iran (Feizpour et al. 2018). For the molecular analysis, already available other Scopulini data were used (Murillo-Ramos et al. 2019, Sihvonen et al. 2020). Lissoblemmini was proposed as sister to Scopulini in a previous phylogenetic study and therefore it was chosen as the outgroup in our study (Sihvonen et al. 2020).

Morphological examinations

Type material and original descriptions were used for the identification of specimens. Documentation and photography of external characters were carried out using a Visionary Digital photography system (LK Imaging System, Dun. Inc., equipped with a Canon EOS 5DSR) and an Olympus E3 digital camera. Preparation of the genitalia was carried out following standard methods (e.g., Robinson 1976). The vesica was everted following the method described by Sihvonen (2001). Photography of the genitalia characters before embedding took place following the methods proposed by Wanke and Rajaei (2018), Wanke et al. (2019) and Wanke et al. (2021) using a Keyence VHX-5000 digital microscope. Genitalia structures were finally embedded in Euparal and photographed using a Keyence VHX-5000 digital microscope.

The morphology of male and female antennae, as well as the male hind leg, were studied using a Zeiss Scanning Electron Microscope (SEM, EVO-LS15). Antennae and hind leg were mounted on holders and sputter-coated with 6 nm gold-palladium using a Leica coating system (EM ACE 200), before imaging with SEM.

For the drawing of the wing venation, wings were placed on a microscope slide and covered with a drop of ethanol (70–96%). In this setup, all venation is visible and can be photographed. For the photography, we used a Visionary Digital photography system (LK Imaging System, Dun. Inc., equipped with a Canon EOS 5DSR). In Graphic (vers. 3.1 for Mac) these photographs served as templates for the vector drawing of the wing venation by tracing the veins from it.

Molecular techniques

For the extraction of DNA, the whole abdomen and a leg from a single dry collection specimen were used following the manufacture's protocol of the DNeasy Blood and Tissue kits (Qiagen, Hilden, Germany). Amplification of DNA was conducted following Wahlberg and Wheat (2008) and Wahlberg et al. (2016). We attempted to amplify one mitochondrial (cytochrome oxidase subunit I, COI) and up to nine protein-coding nuclear gene regions: Ribosomal Protein S5 (RpS5), wingless (wgl), cytosolic malate dehydrogenase (MDH), glyceraldehydes-3-phosphate dehydrogenase (GAPDH), Elongation factor 1 alpha (EF-1alpha), Arginine Kinase (ArgK), Isocitrate dehydrogenase (IDH), sorting nexin-9-like (Nex9), sarco/endoplasmic reticulum calcium ATPase (Ca-ATPase). Sequences were sent to Macrogen for sequencing. The Genbank accession numbers are provided in Appendix 1.

Phylogenetic analysis

In addition to the data generated in this study, we retrieved sequences of Scopulini taxa from the dataset of Sihvonen et al. (2020). The final dataset comprises 29 taxa. The concatenated length of the alignment was 6800 bp including gaps.

We ran maximum likelihood analyses with a data set partitioned by codon using RAxML-HPC2 V8.2.12 (Stamatakis 2014) on the web-server CIPRES Science Gateway (Miller et al 2010). We implemented the GTR+CAT option, and support for nodes was evaluated with 1000 rapid bootstrap (RBS) (Stamatakis et al 2008). The final tree was rooted with species of Lissoblemmini (Sihvonen et al. 2020). Trees were visualized and edited in FigTree v1.4.3 software (Rambaut 2012).

Distribution patterns

Tracing of geographical coordinates was conducted using 'Google Earth Pro' (vers. 7.3.3.7786 for Mac). Distribution patterns were plotted and prepared in QGIS (vers. 3.16.0 for Mac). The elevation profile in QGIS was prepared using Global Multi-resolution Terrain Elevation Data 2010 (GMTED2010) downloaded from https://earthexplorer.usgs.gov.

Results

In total, five genes of a single specimen of *S. wiltshirei*, six genes of a single specimen of *P. cinerea* and eight genes of a single specimen of *S. anthophilata* were successfully amplified and sequenced (see Appendix 1). As a result, *S. wiltshirei* clustered within the genus *Problepsis*, supporting its affiliation to this genus (Fig. 1). Additionally, according to the results of our morphological examination, *S. wiltshirei* shows the generic characters of the genus *Problepsis* (e.g., ocellate discal spots on the fore- and hindwing, the spoon-shaped hind tibia and the presence of a hair pencil in the male hind legs). The following morphological characters of the male genitalia also support the affiliation with *Problepsis*: fused socii and a smooth internal margin of the tegumen (compared against morphological data in Sihvonen 2005; Feizpour et al. 2018; Xue et al. 2018; Sihvonen et al. 2020) (see Figs 15–17). A re-description of this species is given in the taxonomy part of the discussion.

Discussion

Systematics

In sense of the traditional classifications of the genera *Problepsis* and *Somatina*, the latter genus was regarded as polyphyletic (see Sihvonen 2005). Recent studies based on morphology (Sihvonen

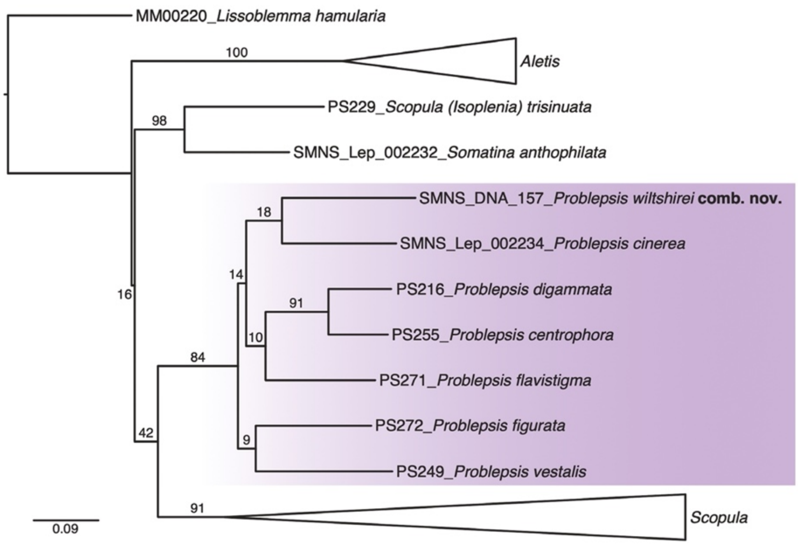


Figure 1. Phylogenetic position of *Problepsis wiltshirei* comb. nov. within the tribe Scopulini, supporting its combination in genus *Problepsis*. The numbers above the branches are Rapid Bootstrap support (RBS) on the best scoring ML tree (Stamatakis 2008). Values ≥ 85 (%) indicate supported clades.

2005; Xue et al. 2018), as well as multi-gene phylogenetic studies, resulted in the assignment of several *Somatina* species to *Problepsis* (Sihvonen et al. 2020). These results support the possibility of the monophyly of the genus *Somatina*, when non-*Somatina* species are reclassified (Sihvonen 2005; Xue et al. 2018; Sihvonen et al. 2020). In addition, Sihvonen (2005) identified three non-unique synapomorphies for *Somatina*, which support its monophyly (asymmetrical sacculi of valvae; asymmetrical valvuli of valvae; juxta with wing-like processes on anterior margin, with apex fused to sacculus of valva) (compare also Figs 15–17).

Our present results show *S. wiltshirei* nested within *Problepsis* (RBS = 84). Therefore, we transfer *S. wiltshirei* from *Somatina* to *Problepsis* comb. nov. Among the species included in our phylogenetic hypothesis, *P. cinerea* was recovered with low support as the sister species to *P. wiltshirei* (RBS = 18).

Additional *Problepsis* species and possibly more genetic data are needed to find the most closely related species of *P. wiltshirei*. Based on COI sequences, as available on BOLD database, the genetically closest neighbour of *P. wiltshirei* are *P. ocellata* and *P. cinerea*. Both with a genetic distance of 4.2%, calculated using K2P model: Kimura (1980) with MEGA X (Kumar et al. 2018; Stecher et al. 2020).

Taxonomy

Problepsis wiltshirei (Prout, 1938), comb. nov.

Figs 2–9, 14B, 15, 18, 21–25

Somatina wiltshirei Prout, 1938. In: Seitz, A. (Ed.), Die Großschmetterlinge der Erde. Supplement zu Band 4, 220. 2 ♂ Syntypes (Iraq: Kurdistan, Rowanduz [Rawanduz Gorge], Berserini [Berserini Gorge]) examined based on photo; 1 Syntype specimen [sex is not given in the original publication], [Iran]: Fars, Ardekan Talochosroe [Tall Khosrow, today in prov. Kohgiluyeh and Boyer-Ahmad]) (in NHMUK).

Material examined. 2 ♀, Iran, Esfahan, Gandoman S, Gerdeish-e, 200 m, 12./13.vi.2002, leg. J.-U. Meineke, A. Hofmann, Kallies et al., g.preps 0759, 0760/2020 D. Wanke; 1 ♀, Iran, Khuzestan [now Kohgiluyeh va Boyerahmad], Yassoudj [Yasuj], Sisakht, 2250 m, 13.vi.1972, leg. Ebert, Pazouki; 1 ♂, 2 ♀, same data, 13.–14.vi.1972, leg. Ebert & Falkner, g.prep. (♂) 0762/2020 D. Wanke; 2 ♂, same data, Sisakht 50 km NW, 15.–18.vi.1975, leg. Ebert, Falkner, g.prep. 0761/2020 D. Wanke; 1 ♂, same data, 15 km SE Yassudj [Yasuj], 2050 m, 15.vi.1972, leg. Ebert & Falkner, g.prep. 0907/2020 D. Wanke; 1 ♂, S-Iran, Prov. Fars, Tange Surkh, 50 km NW Ardekan, 2250 m NN, 12.–15.vi.1975, leg. Ebert, Falkner; 2 ♂, S-Iran, Fars, Daschte Ardjan, Kotal-Pirehsan, 2000 m, 18.vi.1972, leg. Ebert & Falkner; 1 ♀, S-Iran, Miyan-Kotal, östl. Kazerun, 51°40'E, 29°30'N, 1900 m, 4.–7.vi.1969, leg. G. Ebert; 1 ♀, S-Iran, Fars, Kaserun, Mian-Kotal, 1900 m, 11.vi.1972, leg. Ebert & Falkner; all in SMNK.

1 ♀, Iran, Kohkiluye va Boyerahmad, Yasuj, Sisakht, Dena, 2799 m, 30°57'23.6"N, 51°23'28.9"E, 30.vii.2016, leg. Sh. Feizpour, g.prep. 0712/2020 D. Wanke; in SMNS.

1 ♂/♀, Iran, Khuzestan, Emamzadeh, Abdollah-low altitude; Saite 4b, 31°22'24"N, 50°7'51"E, 1408 m, 23.ix.2018, Trap1, leg. Mohammad Ahmadi; 1 ♂/♀, Iran, Khuzestan, Emamzadeh, Abdollah-high altitude; Saite 4a, 31°23'10"N, 50°9'29"E, 2120 m, 13.vii.2018, Trap 2, leg. Mohammad Ahmadi; 1 ♂/♀, Iran, Prov. Khuzestan, Mal aqa, 1100 m, 31°35'57"N, 50°00'50"E, 30.vii.2011, leg. Mehdi Esfandiari; 1 ♂/♀, Iran, Prov. Fars, Bolhayat & Kotal-e-Pirzan, 2000 m, 29°36'48"N, 51°56'28"E, 2. & 9.vi.2011, leg. Mehdi Esfandiari; 1 ♂/♀, Iran, Prov. Fars, Kohmare Sorkhi, 1900 m, 29°28'11"N, 52°08'44"E, 28.iv.2011, leg. Mehdi Esfandiari; all in IMCA.

1 ♀, Türkei [Turkey], prov. Hakkari, Çığıl Suyu-Tal [Zap-Tal], 22 km SW Hakkari, 28.vi.1984, LF, leg. Werner Wolf; in PCWW.

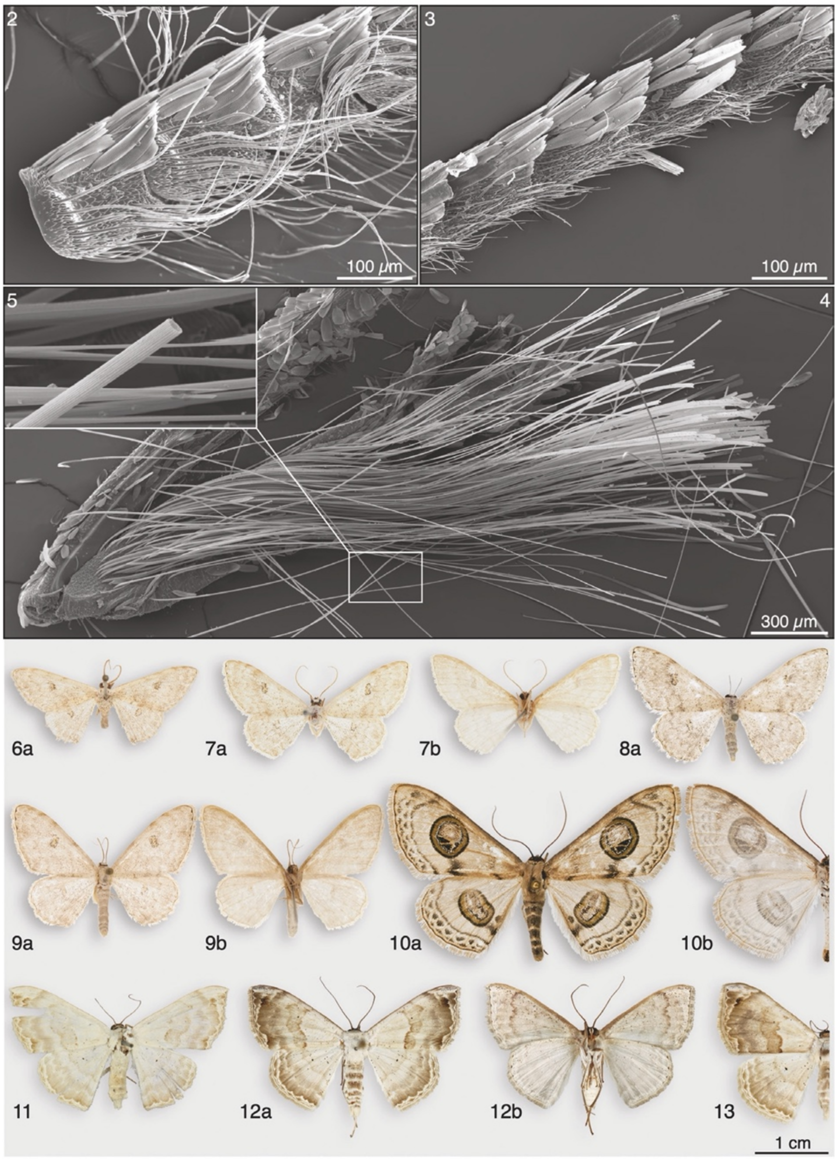
1 ♂, 1 ♀, Iran, Fars, Straße Ardekan-Talochosroe [Tall Khosrow, today in prov. Kohgiluyeh und Boyer Ahmad], Comé [Komehr], 7.viii.1937, 2600 m, coll. Brandt; in ZFMK.

1 ♂, Iran, Fars, Straße Ardekan-Talochosroe [Tall Khosrow, today in prov. Kohgiluyeh und Boyer Ahmad], Comèe [Komehr], 2600 m, viii.1937, coll. Brandt, ZSM g.prep. No. 1602; in ZSM.

Re-description. ***Wings and body*** (Figs 2–9). Wingspan ♂ 24–28 mm, ♀ 29–32 mm; females slightly larger than males. The proboscis well developed. The length of the labial palpi about equal to the diameter of the eye. Frons, thorax and abdomen concolorous with the wings. Chaetosemata arranged as two patches. Antennae ciliate-fasciculate in males and filiform in females (Figs 2, 3). Male hind tibia with reduced tarsal segments; flattened laterally; longitudinally spoon-shaped; with hair pencil. Hair pencil consisting of two types of differently modified scales as illustrated for *P. cinerea* by Feizpour et al. (2018). One type of scales apically flattened, while the other scales are tubular and hollow (Figs 4, 5). Ground colour of wings beige, intermixed with some slightly darker ochreous or brown scales; basal areas slightly lighter beige. Fore- and hindwing with a small, light yellowish ocellus, bordered with a thin dark outer line. Discal spots sometimes not visible; more pronounced in the forewings (Figs 6–9).

Venation (Fig. 14B). Two areoles present in forewing. Veins R1, the common stalk of R2–4 and R5 arising from the second areole. In hindwing Sc+R1 slightly curved in basal area, approximating to the cell in the postbasal area; A1+2 originating separately; A3 absent.

Male genitalia (Fig. 15). Uncus absent. Socii strongly developed fused at apex. Internal margin of tegumen smooth. Valva with two curved arms (dorsal and ventral arm of valva), both slerotized, narrow and long, apically pointed (Fig. 15a, d). Aedeagus strongly sclerotized, slender, tapering towards the apex; its basal part dorso-ventrally flattened; vesica without cornuti (Fig. 15b). Sternum A8: anterior margin with two indentations; lateroanteriorly on both sides pointed. Lateral sides towards posterior part concave; posterior margin curved. Cerata located in posterior half of sternum A8, directed towards centre (Fig. 15c).



Figures 2–13. Morphological characters of Iranian *Problepsis* species and *Somatina anthophilata*. **2–5.** SEM photos of *Problepsis wiltshirei* comb. nov.; **2.** Part of ciliate-fasciculate antennae of male (Iran, Yasuj, Sisakht, g.prep. 0762/2020 D. Wanke); **3.** Detail of filiform antennae of female (Iran, Fars, Mian-Kotal); **4.** Male hind tibia with hair pencil (Iran, Yasuj, Sisakht, g.prep. 0761/2020 D. Wanke); **5.** Close up on tubular and hollow modified scale of hair pencil (Iran, Yasuj, Sisakht, g.prep. 0761/2020 D. Wanke); **6–9.** Wing pattern of *Problepsis wiltshirei* comb. nov.; **6.** Male paratype (Iraq, Kurdistan, Berserini); **7.** Male (Iran, Fars, Straße Ardekan-Talochosroe, g. prep. 1602 ZSM); **8.** Female (Iran, Yasuj, Sisakht, g.prep. 0712/2020 D. Wanke); **9.** Male (Iran, Yasuj, Sisakht, g.prep. 0761/2020 D. Wanke); **10.** Female of *Problepsis cinerea* (Iran, Hormozgan, Geno protected area); **11–13.** Wing pattern of *S. anthophilata*; **11.** Paralectotype (India); **12.** Male (Thailand, Lampang, Muban Phichai); **13.** Female (Thailand, Lampang, Muban Phichai). a = upperside; b = underside.

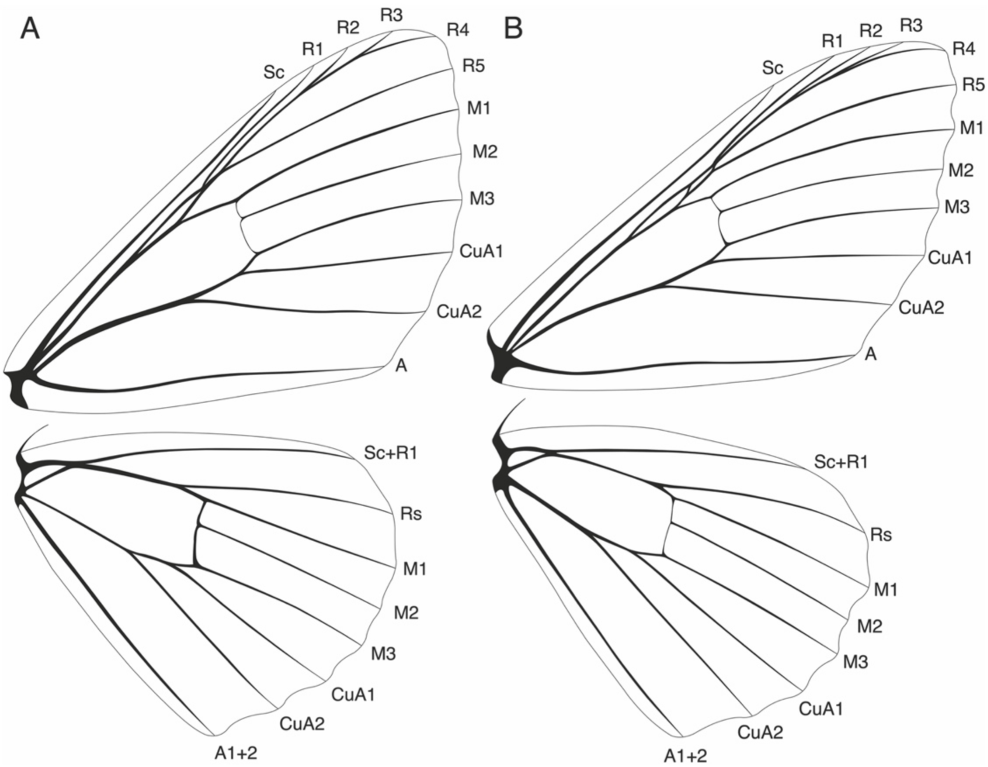


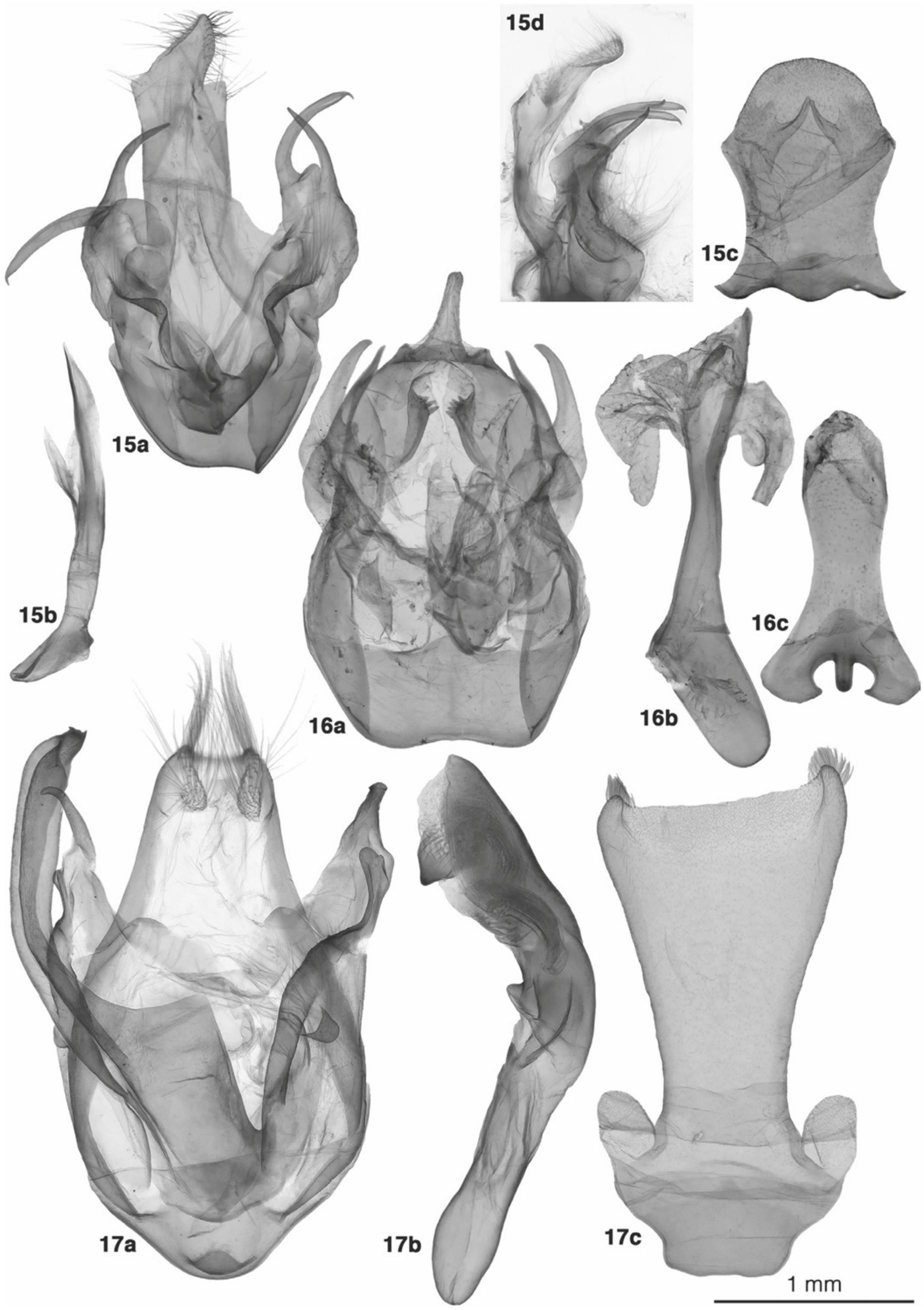
Figure 14. Wing venation of male specimens of *Problepsis* species; **A.** *Problepsis ocellata* (type species for the genus) and **B.** *Problepsis wiltshirei* comb. nov. Note: *Problepsis ocellata* (**A.**) with one areole in the forewing and *Problepsis wiltshirei* comb. nov. (**B.**) with two areoles in the forewing.

Female genitalia (Fig. 18). Papillae anales short and broad. Apophyses anteriores 2/3 length of apophyses posteriores. Antrum strongly sclerotized. Lamella antevaginalis strongly sclerotized; basal part broad, laterally extended; posteriorly curved, folded, tapered to lateral side. Ductus bursae short, strongly sclerotized. Corpus bursae membranous; signum present as a sclerotized, narrow and dentate ridge.

Diagnosis. *P. wiltshirei* cannot be confused with any other *Problepsis* or *Somatina* species within this region. In Iran only *Problepsis cinerea* is known from South Iran and it does not occur within the range of *P. wiltshirei* comb. nov. Additionally, it cannot be confused with this species, as it differs strongly by wing pattern (see Figs 6–10) and by genitalia (Figs 16, 19). *Somatina pythiaria nigrimacula* Hausmann, 2009; a species distributed in Oman has been shown differing by a greyer suffusion on wing pattern, the different structure of the sternum A8 and molecular data (Hausmann 2009).

Phenology. Flying from July to October, possibly in two generations (Wiltshire 1943). This coincides with the investigated specimens, but can be expanded from April to October.

Biology. Larva described by Wiltshire (1943) as grayish, intermixed with a complex pattern of grey dots and marks. Pale grey dorsal and ventral lines, the latter rather whitish on somites 4–8. Pupal period lasting 8 to 15 days. The cocoon is woven between leaves and litter (Wiltshire 1943).



Figures 15–17. Male genitalia of Iranian *Problepsis* species and *Somatina anthophilata*; **15.** *Problepsis wiltshirei* comb. nov. (**a.** Iran, Yasuj, Sisakht, g.prep. 0762/2020 D. Wanke; **b, c.** Iran, Yasuj, Sisakht, g.prep. 0761/2020 D. Wanke; **d.** Iran, Yasuj, g.prep. 0907/2020 D. Wanke); **16.** *Problepsis cinerea* (**a–c.** Pakistan, Kaghan-Tal, 375/2017, S. Feizpour); **17.** *Somatina anthophilata* (**a–c.** Thailand, Lampang, Chae Hom, g.prep. 1177/2021 D. Wanke). a = genitalia capsule; b = aedeagus; c = sternum A8; d = genitalia capsule lateral view.

Wiltshire (1943) noted *Fraxinus* sp. (Oleaceae) and *Acer* sp. (Sapindaceae) as food plants for *P. wiltshirei*. As *Problepsis* species have been observed feeding on Oleaceae species (Robinson et al. 2002; Stadie and Stadie 2016) *Acer* sp. is an exceptional food plant, which needs confirmation.

Habitat. This species occurs in the Middle Heights of the mountains, especially the woodland zone (Wiltshire 1957) and mountain steppe, at elevations from 1100 m up to 2800 m (Figs 21–25). The habitat is covered with different herbaceous plants and shrubs, dominated by *Prunus* sp. (Rosaceae), *Artemisia* sp. (Asteraceae), *Astragalus* sp. (Fabaceae) and *Acantholimon* sp. (Plumbaginaceae).

Distribution. So far recorded in the Zagros Mountains, from northern Iraq (Kurdistan) into south-western Iran (Kohgiluyeh-va-Boyer-Ahmad and across the border to the provinces, Khuzestan, Esfahan and Fars) (Fig. 25). Additionally, here we record this species for the first time for the fauna of Turkey (see examined material). The large gap between the populations in northern Iraq, Turkey and central Zagros in Iran is possibly caused by insufficient sampling in these areas.

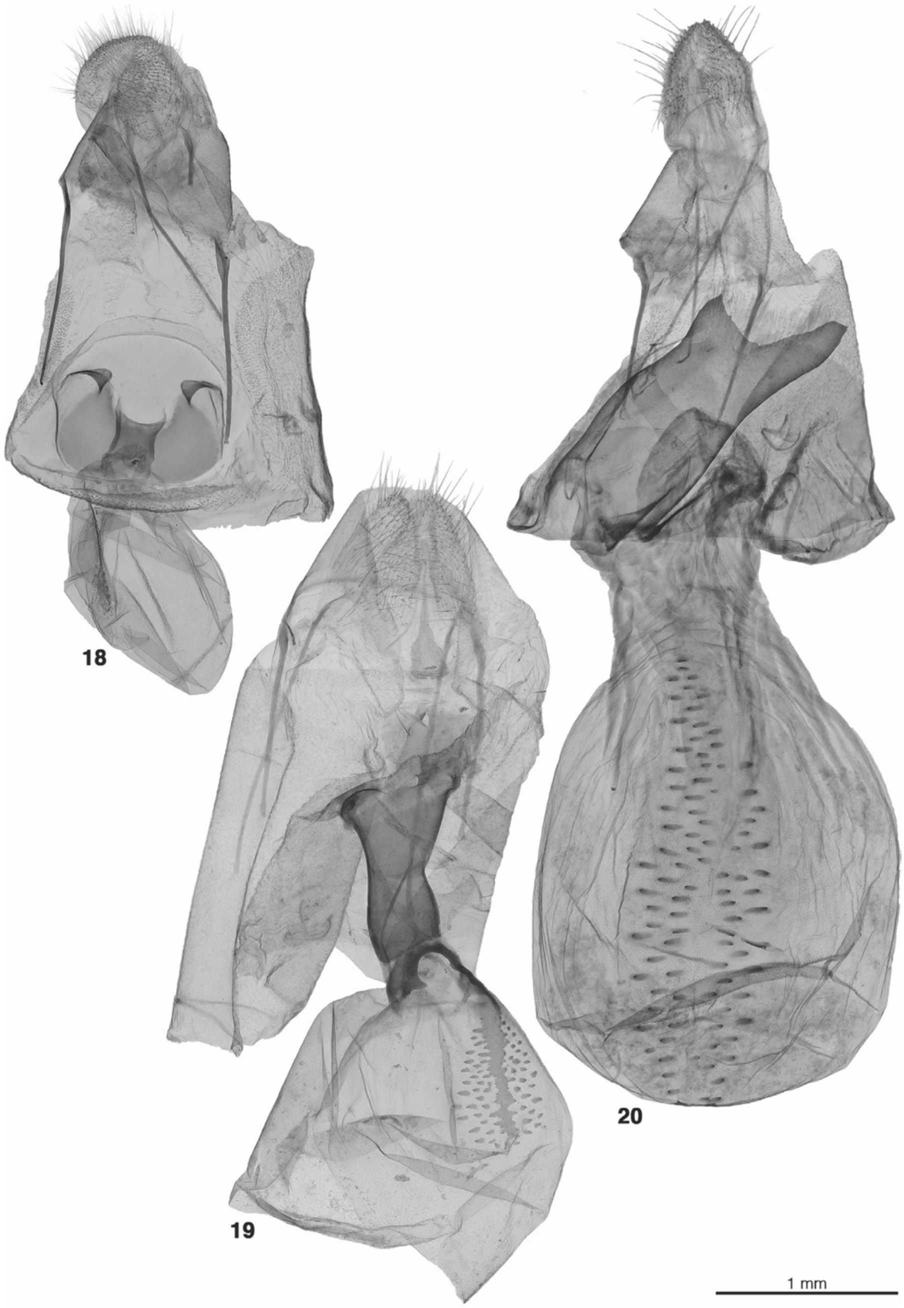
Zagros Mountains as a refuge for *Problepsis wiltshirei*

Major issues in conservation biology for protection efforts are the identification of areas with high biodiversity, high rates of endemism and past events, like glacial refugia or environmental changes (Médail and Diadema 2009; Cañadas et al. 2014; Noroozi et al. 2018; Kazemi and Hosseinzadeh 2020).

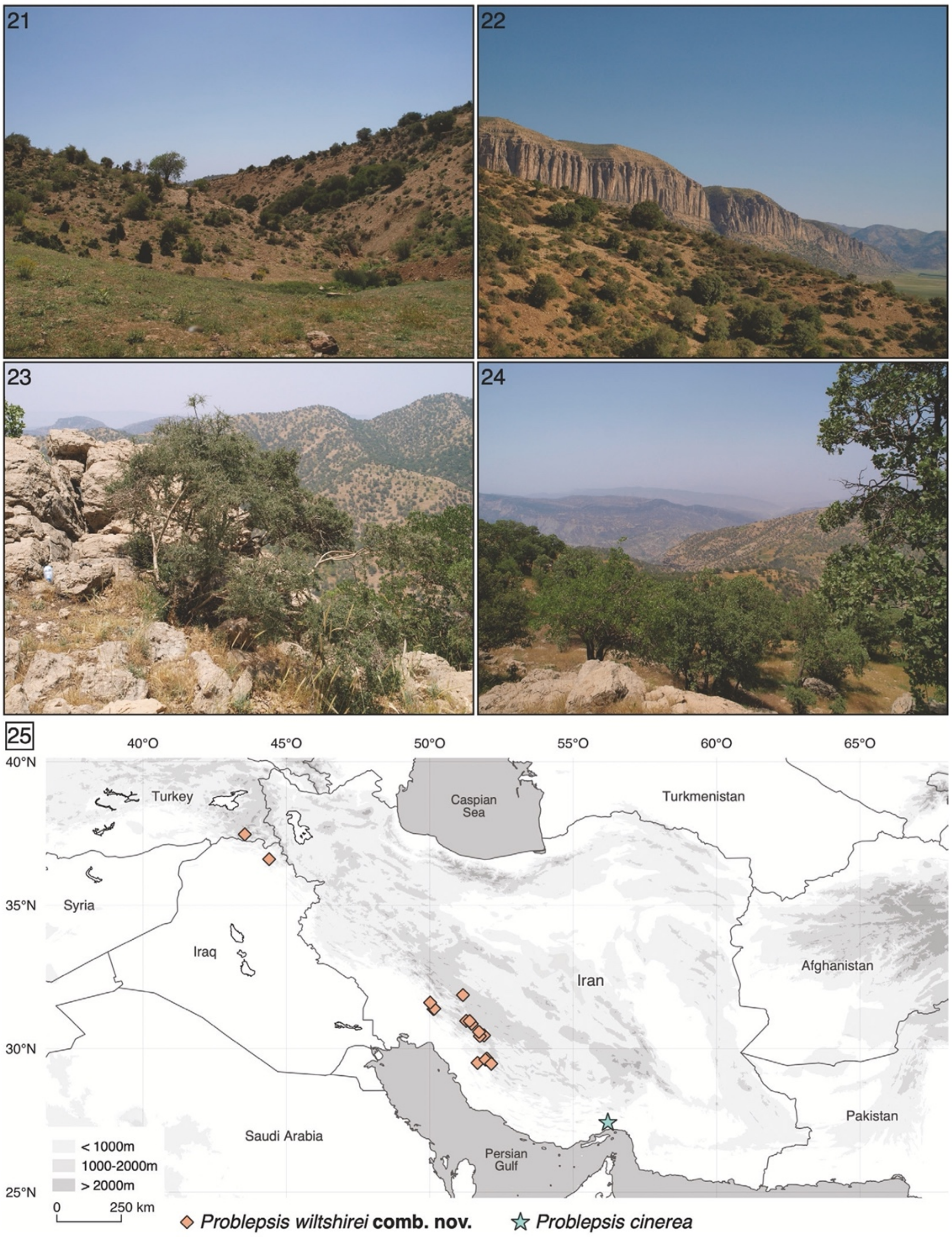
The Zagros Mountains have been identified as an area with a high species diversity of flora and fauna (Rechinger 1963–2015; Firouz 2005; Noroozi et al. 2008; Sayadi and Mehrabian 2016). Akbarirad et al. (2016) showed that brush-tailed mice of the genus *Calomyscus* (Calomyscidae: Rodentia) are highly diverse, due to the topography of these mountains which cause their geographic isolation. Similar findings were made for the Iranian herpetofauna, where the mountains and their diverse environmental conditions play an important role in the separation and isolation of species (Gholamifard 2011; Kazemi and Hosseinzadeh 2020). The important role of the Zagros Mountains can also be seen through various groups of arthropods (e.g., Paknia et al. 2008; Marusik and Zamani 2015; Zamani et al. 2018). For Lepidoptera, high species diversity of different families has been observed in the Zagros Mountains (e.g., Nazari 2003; Trusch and Hausmann 2008; Rajaei et al. 2012; Tshikolovets et al. 2014; Keil 2015; Yakovlev 2015; Wanke et al. 2020).

Regarding the endemism rate, the Zagros Mountains show the highest richness compared to other Iranian mountain ranges (Akhani 2004; Noroozi et al. 2016; Kazemi and Hosseinzadeh 2020; Khajoei Nasab and Khosavi 2020). It has been shown that 45% of Zagros vascular plants are restricted to this region (Noroozi et al. 2019). Additionally, this applies to endemic alpine plant species, where the highest rates of endemism were found in the Zagros (Noroozi et al. 2016). Comparably high endemism has been found in Lepidoptera (e.g., Rajaei 2012; Tshikolovets et al. 2014; Keil 2015).

Moreover, the Zagros Mountains have played a crucial role as a refuge for diverse fauna and flora during glaciation events. Malekoutian et al. (2020) found in a phylogeographic analysis, the occurrence of the Yellow-spotted Mountain Newt (*Neurergus derjugini*) derives from three different refugia in the Zagros mountains. Similar findings for the survival of Iranian Brown Bears (*Ursus arctos*) in Zagros refugia during the Last Glacial Maximum (LGM) were proved by Ashrafzadeh et al. (2016). Based on genetic and paleo-bioclimatic data, Rajaei et al. (2013) found this region to be a refuge for two *Gnopharmia* species and their host plants (*Prunus scoparia*) during the LGM 23,000–18,000 years ago). Furthermore, it has been shown that the highest haplotype diversity of these two *Gnopharmia* species is present in southwestern parts of the Zagros Mountains and served as a population source for the postglacial expansion of these species (Rajaei et al. 2013).



Figures 18–20. Female genitalia of Iranian *Problepsis* species and *Somatina anthophilata*; **18.** *Problepsis wiltshirei* comb. nov. (Iran, Esfahan, Gandoman, g.prep. 0759/2020 D. Wanke); **19.** *Problepsis cinerea* (g.prep. 374/2017, S. Feizpour); **20.** *Somatina anthophilata* (Thailand, Lampang, Muban Phichai, g.prep. 1176/2021 D. Wanke).



Figures 21–25. Habitat in the Zagros Mountains and distribution map of Iranian *Problepsis* species; **21, 22.** Iran, Fars, Dasht-e Arjan at 2158 m altitude; **23, 24.** Iran, Kohkiluye va Boyerahmad, Tange-Tamoradi at 2254 m altitude; **25.** Distribution pattern of Iranian *Problepsis* species.

The results of our study confirm that *P. wiltshirei* is an endemic species in the Zagros mountains and has so far been restricted to two areas of this mountain range. The first area in northern Iraq and south-eastern of Turkey falls into the Irano-Anatolian biodiversity hotspot, a region of remarkable species endemism, covering high elevations of central and eastern Turkey, Armenia, NE Iraq and Iran (Mittermeier et al. 1999; Noroozi et al. 2018). In its second area of distribution, *P. wiltshirei* inhabits the southwestern parts of the Zagros Mountains, a habitat outstanding for its rich biodiversity (e.g., Hosseinzadeh et al. 2014; Farashi and Shariati 2017; Noroozi et al. 2018).

Although several areas are protected in the Zagros Mountains (e.g., Arjan, Bakhtegan, Karkheh, Bamu etc.), this unique nature reserve is currently threatened, mainly by human activity. Every year 15,000 ha of Iranian forests burn (in 2020 wildfires burned down over 50,000 ha of oak forests in the Zagros Mountains) and centuries-old trees are destroyed in the process (Kheshti 2020). In ecosystems such as the Zagros Mountains, these high fire intensities threaten its species diversity and richness (Heydari et al. 2016). Further threats to biodiversity are overgrazing by sheep and goats in the marginal arid areas, as well as the land erosion caused by agriculture (Jowkar et al. 2016). Also, poaching and sporadic poisoning of animals occurs from time to time, even within protected areas, causing significant damage to its fauna (Jowkar et al. 2016). *P. wiltshirei* is distributed in this threatened area of high biodiversity and we still know only very little about its distribution and biology. Our study emphasizes the importance of further investigations of the Lepidoptera fauna of the Zagros, to better understand biodiversity hotspots and areas of endemism in the context of species conservation.

Acknowledgements

We would like to thank Robert Trusch, Michael Falkenberg (both Karlsruhe, Germany), Jörg-Uwe Meineke (Kippenheim, Germany), Axel Hausmann (Munich, Germany) and Marianne Espeland (Bonn, Germany) for the loan of specimens from their collections. Also, thanks to Mehdi Esfandiari and Mohammad Ahmadi (Ahvaz, Iran) for sending us new distribution data. Thanks to Gergely Petrányi for the photos of type specimens. We are grateful to Werner Wolf (Bindlach, Germany) for providing the important specimen from Turkey. Many thanks to Susanne Leidenroth (Stuttgart, Germany) for assisting with the SEM-imaging. We are thankful to Jessica Awad (Stuttgart, Germany) and David C. Lees (UK) for linguistic proofreading and valuable comments on the manuscript. We are grateful to the subject editor Sven Erlacher. Many thanks to Dirk Stadie, Gareth Edward King, Hector Vargas and two anonymous reviewers for the critical review of the submitted version of the paper and their constructive comments. This project was partially supported by the Research Incentive Grant of State Museum of Natural History, Stuttgart, Germany. This paper is part of the PhD project of Dominic Wanke at the University of Hohenheim.

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Appendix 1

Table A1. Sterrhinae taxa used in this study, with identification, process code, and GenBank accession numbers for each gene. Data from Sihvonen et al. (2020)[1] & Wanke et al. (current paper)[2].

Taxon identification	Code	ArgK	Ca-ATPase	COI-begin	COI-end	EFla-begin	EFla-end	GAPDH	IDH	MDH	Nex9	RpS5	WntGeo
Lissoblemma hamularia[1]	MM00220	–	–	JF784708	–	–	JF785331	–	–	–	–	–	–
Aletis helcita[1]	PS268	MK738556	MK738887	MK739619	–	MK740001	MK740001	MK740647	–	–	MK741674	MK742030	MK742585
Aletis monteironis[1]	PS270	MK738557	MK738888	MK739620	–	–	–	–	–	–	–	–	MK742586
Aletis variabilis[1]	0x17	–	–	MG767890	MG767890	–	MG768276	MG767671	–	–	–	MG767479	MG767344
Aletis forbesi[1]	0x28	–	–	MG767889	MG767889	–	MG768275	–	–	–	–	MG767478	MG767343
Scopulo (*Isoplenia*) *trisinuata*[1]	PS229	–	MK738851	MK739391	MK739391	MK739967	MK739967	MK740614	MK740872	MK741191	MK741640	MK742000	MK742550
Somatina anthophilata[2]	SMNS_Lep_002232	MZ798167	MZ798169	MZ753906	MZ753906	MZ798171	MZ798171	–	MZ798173	MZ798174	–	MZ798175	MZ798177
Problepsis wiltshirei[2]	SMNS-DNA-157	MZ798179	–	MW803363	–	MW803364	MW803364	–	–	–	–	MW803365	MW842913
Problepsis cinerea[2]	SMNS_Lep_002234	MZ798168	MZ798170	MZ753905	–	MZ798172	MZ798172	–	–	–	–	MZ798176	MZ798178
Problepsis vestalis[1]	PS249	MK738538	MK738869	MK739406	MK739406	MK739983	MK739983	MK740630	MK740881	–	MK741657	MK742014	MK742568
Problepsis figurata[1]	PS272	MK738559	MK738890	MK739424	MK739424	MK740003	MK740003	MK740649	–	–	MK741676	MK742032	MK742588
Problepsis flavistigma[1]	PS271	MK738558	MK738889	MK739423	MK739423	MK740002	MK740002	MK740648	MK740896	–	MK741675	MK742031	MK742587
Problepsis digammata[1]	PS216	MK738512	MK738839	MK739614	–	MK739958	MK739958	MK740605	MK740860	MK741179	MK741628	MK741990	MK742538
Problepsis centrophora[1]	PS255	MK738544	MK738875	MK739411	MK739411	MK739989	MK739989	MK740636	MK740886	–	MK741663	MK742019	MK742573
Scopula nemorivagata[1]	PS232	MK738524	MK738853	MK739616	–	MK739968	MK739968	MK740616	–	MK741193	MK741642	MK742001	MK742552
Scopula johnsoni[1]	R1872	–	–	MG767915	MG767915	–	MG768299	–	MG768488	MG768103	–	MG767500	MG767348
Scopula tenera[1]	SH1155	–	–	MG767781	MG767781	MG768176	MG768176	–	MG768396	MG768017	–	MG767408	–
Scopula immorata[1]	MM00586	–	–	GU828645	GU828443	GU828978	GU829261	–	GU830032	GU830351	–	GU830646	GU829536
Scopula nr *karischi*[1]	SH0432	–	–	MG767773	MG767773	MG768170	MG768170	MG767575	MG768391	MG768013	–	MG767404	–
Scopula punctilineata[1]	PS251	MK738540	MK738871	MK739407	MK739407	MK739985	MK739985	MK740632	MK740883	–	MK741659	MK742016	MK742570
Scopula nr *laevipennis*[1]	R1050	–	–	MG767897	MG767897	MG768281	MG768281	MG767677	–	MG768090	–	–	–
Scopula nr *vitellina*[1]	SH0448	–	–	MG767771	MG767771	MG768168	MG768168	MG767573	MG768389	MG768011	–	MG767402	–
Scopula sp[1]	PS241	MK738532	MK738861	MK739617	–	MK739976	MK739976	MK740623	–	MK741201	MK741650	MK742008	MK742560
Scopula nr *calcarata*[1]	SH0421	–	–	MG767770	MG767770	MG768167	MG768167	–	MG768388	MG768010	–	MG767401	MG767318
Scopula nr *serena*[1]	PS 243	MK738533	MK738863	MK739618	–	MK739978	MK739978	MK740625	–	MK741203	MK741652	MK742010	MK742562
Scopula amala[1]	USNM664273	–	–	KY370874	–	–	–	–	–	–	–	LT674233	LT674262
Scopula nr *nigrinotata*[1]	PS262	MK738550	MK738881	MK739417	MK739417	MK739995	MK739995	MK740642	MK740892	–	MK741668	MK742024	MK742579
Scopula ternata[1]	MM08463	–	–	MK739598	–	MK740231	–	MK740574	–	MK741142	–	MK741945	–
Scopula frigidaria[1]	MM10459	–	–	–	–	MK740233	–	–	–	MK741144	–	MK741947	MK742493

Original research paper 2

Systematics and integrative taxonomic revision of the tribe Scopulini Duponchel, 1845 in Iran (Lepidoptera: Geometridae: Sterrhinae)

Dominic Wanke, Axel Hausmann, Kyung Min Lee, Leidys Murillo-Ramos, Pasi Sihvonen, Hossein Rajaei

Published (2023) in Zootaxa 5359 (1): 1–96
https://doi.org/10.11646/zootaxa.5359.1.1

Painting of *Cinglis humifusaria* by Marina Moser

Zootaxa 5359 (1): 001–096
https://www.mapress.com/zt/

Monograph

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

https://doi.org/10.11646/zootaxa.5359.1.1
http://zoobank.org/urn:lsid:zoobank.org:pub:11CC5175-7CCE-453F-88EB-3490E82F4972

ZOOTAXA

5359

Systematics and integrative taxonomic revision of the tribe Scopulini Duponchel, 1845 in Iran (Lepidoptera: Geometridae: Sterrhinae)

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Magnolia Press
Auckland, New Zealand

Accepted by R. Zahiri: 6 Sept. 2023; published: 24 Oct. 2023

DOMINIC WANKE, AXEL HAUSMANN, KYUNG MIN LEE, LEIDYS MURILLO-RAMOS, PASI SIHVONEN & HOSSEIN RAJAEI
Systematics and integrative taxonomic revision of the tribe Scopulini Duponchel, 1845 in Iran (Lepidoptera: Geometridae: Sterrhinae)
(*Zootaxa* 5359)

96 pp.; 30 cm.

24 Oct. 2023

ISBN 978-1-77688-898-6 (paperback)

ISBN 978-1-77688-899-3 (Online edition)

FIRST PUBLISHED IN 2023 BY

Magnolia Press

P.O. Box 41-383

Auckland 1041

New Zealand

e-mail: magnolia@mapress.com

https://www.mapress.com/zt

ISSN 1175-5326 (Print edition)

ISSN 1175-5334 (Online edition)

Table of Contents

Abstract

The Iranian taxa of the tribe Scopulini are taxonomically revised. The systematic positions of the genera *Cinglis* Guenée, 1858, *Glossotrophia* Prout, 1913, *Pseudocinglis* Hausmann, 1994 and *Scopuloides* Hausmann, 1994, with uncertain validity and/or position within the tribe Scopulini Duponchel, 1845 (Lepidoptera: Sterrhinae), are further elucidated by use of one mitochondrial and up to nine protein-coding nuclear gene regions. Available type specimens of the described species and more than 2,600 additional specimens were morphologically investigated. In addition, over 400 genitalia preparations were made and examined together with distribution data and DNA barcodes. As a result of the multi-gene analysis, the genera *Cinglis* **stat. rev.** and *Scopuloides* **stat. rev.** are re-validated at the genus level. The genus *Pseudocinglis* **syn. nov.** is regarded as a junior synonym of the genus *Cinglis* **stat. rev.** and *Glossotrophia* **syn. nov.** is regarded as a junior synonym of the genus *Scopula*. *Cinglis eurata* (Prout, 1913) **comb. nov.** and *Cinglis benigna* (Brandt, 1941) **comb. nov.** are combined with the genus *Cinglis*. Additionally, *Cinglis benigna amseli* (Wiltshire, 1967) **syn. nov.** is regarded as a synonym of *C. benigna*. *Scopula adulteraria* (Erschov, 1874) **stat. nov.** is raised from subspecies to species rank; *Scopula iranaria* Bytinski-Salz & Brandt, 1937 **syn. nov.** is synonymized with *S. flaccidaria* (Zeller, 1852); *S. transcaspica taftanica* Brandt, 1941 **syn. nov.** is synonymized with *S. transcaspica* Prout, 1935; *S. diffinaria asiatica* (Brandt, 1938) **syn. nov.** is synonymized with *S. diffinaria* (Prout, 1913) and *Glossotrophia bullata* Vojnits, 1986 **syn. nov.** is synonymized with *Scopula sacraria ariana* (Ebert, 1965). The female genitalia of *Scopula lactarioides* Brandt, 1941 are described and illustrated for the first time. In total, the presence of 33 species of Scopulini in Iran is confirmed. Wing patterns, male and female genitalia and diagnostic characters of most Iranian Scopulini species are depicted and their distribution ranges are mapped.

Key words: *Cinglis*, DNA barcoding, Middle East, new combinations, new synonyms, *Problepsis*, *Pseudocinglis*, *Scopula*, *Scopuloides*, *Somatina*, *Zygophyxia*

Introduction

The tribe Scopulini, with over 900 described species worldwide, represents the largest tribe within the subfamily Sterrhinae in Geometridae (Hausmann 2004; Sihvonen 2005a; Sihvonen *et al.* 2020). In total, 794 of these species belong to the genus *Scopula* Schrank, 1802, making this genus the second largest genus in Geometridae after *Eupithecia* Curtis, 1825 (Covell 1970; Hausmann 2004; Sihvonen *et al.* 2020; Rajaei *et al.* 2022). Species of the genus *Scopula* are found on all continents except Antarctica and inhabit different habitat types (Sihvonen 2001).

Despite the high diversity of the Scopulini tribe, only a minority (~3.6%) of the species have been reported for Iran (Hausmann 2004; Sihvonen 2005a; Rajaei *et al.* 2022). However, Iran harbors some taxa that are endemic to the country (e.g., some species of the genera *Cinglis* and *Scopuloides*), representing an important part of this extraordinary fauna and highlighting that the country is an important biodiversity hotspot for these taxa compared to other countries in the Middle East. Similar patterns have been demonstrated for other geometrid genera, e.g., *Phaselia* Guenée, 1858, *Nychiodes* Lederer, 1853 and *Gnopharmia* Staudinger, 1892 (Rajaei *et al.* 2012; Wanke *et al.* 2020; Werner *et al.* 2023).

In the most updated list of Iranian Lepidoptera, Rajaei *et al.* (2023a) listed 42 species under the tribe Scopulini, classified within four genera: *Zygophyxia* Prout, 1916, *Cinglis* Guenée, 1858, *Scopula* Schrank, 1802 and *Problepsis* Lederer, 1853.

Sihvonen (2005a) regarded the genera *Cinglis*, *Pseudocinglis* Hausmann, 1994, *Scopuloides* Hausmann, 1994, *Zygophyxia* and *Glossotrophia* Prout, 1913 as junior synonyms of *Scopula*, and listed seven valid genera for the tribe Scopulini.

Among these genera, the status of *Glossotrophia* had been re-examined in the past by several authors (e.g., Hausmann 2004; Sihvonen 2005a; Õunap 2010; Müller et al 2019). Hausmann (1993; 2004) validated it at genus level based on the number of spurs on the female hindtibia, the extremely long proboscis in most species, the association with Caryophyllaceae as larval host plants and imaginal nectar source, the dark terminal line around the apex of the forewing, the long basal process of sternum A8 and the shape of the fibula in the male genitalia. Nonetheless, Hausmann (2004) recommended a large-scale analysis of this genus and its relatives for clarification of its status. Conducting a cladistic analysis of the tribe Scopulini based on morphology and a global taxon sampling, Sihvonen (2005a) regarded *Glossotrophia* and numerous other small genera as junior synonyms of *Scopula*, as the suggested synapomorphies appeared to be homoplastic. This classification also avoided paraphyly in the genus *Scopula* (Sihvonen 2005a). Õunap (2010) followed the treatment of Hausmann (2004) and stated the importance of molecular phylogenetic studies to solve this question. Müller *et al.* (2019) listed *Glossotrophia* as a subgenus of *Scopula* in the checklist of Geometrid moth of Europe, followed by Rajaei *et al.* (2022). In recent molecular phylogenetic studies on Sterrhinae moths by Sihvonen *et al.* (2020), material for *Glossotrophia*, *Cinglis*, *Pseudocinglis* and *Scopuloides* was not available. In order to better understand the systematics of these genera and to complement the morphological hypotheses, it is of great importance to include them in future molecular studies.

As the Scopulini genera *Cinglis*, *Glossotrophia*, *Pseudocinglis* and *Scopuloides* are represented in Iran, and as most Iranian species of this tribe, like its south-western Asiatic species need revision (Hausmann 2004), the present study has two aims: (1) to clarify the taxonomic status and systematic position of the genera *Glossotrophia*, *Cinglis*, *Pseudocinglis* and *Scopuloides* and (2) to conduct a taxonomic revision of the Iranian species of the Scopulini.

To achieve these goals, we (1) applied a multi-gene phylogenetic analysis, utilising mitochondrial and nuclear genes and (2) focused on morphological characters, combined with distribution data and DNA barcoding, to revise the species in the investigated region.

Material and Methods

Type material and additional specimens were borrowed from the following collections (acronyms are listed in Evenhuis 2007, as far as included):

IZBE—Institute of Zoology and Botany of the Academy of Sciences, Tartu, Estonia;
LSL—Linnean Society of London, United Kingdom;
MNCN—Museo Nacional de Ciencias Naturales, Madrid, Spain;
MNHU—Museum für Naturkunde der Humboldt-Universität, Berlin, Germany;
MSNT—Museo Regionale di Scienze Naturali, Torino, Italy;
NHMUK—Natural History Museum London, United Kingdom;
NHMV—Natural History Museum Vienna, Austria;
NHRS—Naturhistoriska Riksmuseet, Stockholm, Sweden;
NMSZ—National Museums of Scotland, Edinburgh, United Kingdom;
OUM—Oxford University Museum of Natural History, United Kingdom;
PCJM—Private collection of Jörg-Uwe Meineke, Kippenheim, Germany;
PCPS—Private collection of Peder Skou, vester Skerninge, Denmark;
SMNK—Staatliches Museum für Naturkunde Karlsruhe, Germany;
SMNS—Staatliches Museum für Naturkunde Stuttgart, Germany;
SNSB/ZSM—Zoologische Staatssammlung München, Germany;
TMB—Termeszettudomanyi Muzeum Allattara, Budapest, Hungary;
USNM—National Museum of Natural History, Smithsonian Institution, Washington DC, USA;
UZIU—Universitets Zoologiska Institut, Uppsala, Sweden;
ZFMK—Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany;
ZISP—Zoological Institute, Russian Academy of Sciences, Saint-Petersburg, Russia;
ZMUC—Zoological Museum, University of Copenhagen, Denmark.

Morphological examination. Type specimens and original descriptions were examined for a critical review and understanding of the diagnostic characters of each species. Additionally, large series of additional specimens from different localities were investigated and identified. For the documentation of external characters, a Visionary Digital photography system (LK Imaging System, Dun. Inc.) equipped with a Canon EOS 5DSR as well as an Olympus E3 digital camera, were used. Preparation of genitalia was carried out following standard techniques (e.g., Robinson 1976). The vesica was everted according to Sihvonen (2001) and embedded in Euparal on a permanent slide. When necessary, genitalia structures were investigated using the methods proposed by Wanke & Rajaei (2018) and Wanke *et al.* (2019, 2021a). A Keyence VHX-5000 was used for genitalia photography.

Distribution Map preparation. Geographical coordinates were traced using 'Google Earth Pro' (vers. 7.3.1.4507 for Mac). Obscure localities were traced using Noori *et al.* (2023). Distribution patterns were plotted and prepared in QGIS (vers. 2.18.15 for Mac). For the preparation of the elevation profile in QGIS, Global Multi-resolution Terrain Elevation Data 2010 (GMTED2010) was used (downloaded from https://earthexplorer.usgs.gov).

Molecular techniques. DNA extraction and amplification of the barcode fragment (658 base-pairs of the 5' terminus) of the mitochondrial Cytochrome-C Oxidase I (COI) gene of *Scopula* species were carried out at the Canadian Centre for DNA barcoding (CCDB, Guelph) in the framework of the Lepidoptera Campaign of the International Barcode of Life program (iBOL; www.lepbarcoding.org), using either a special protocol for old museum specimens based on Next-Generation-Sequencing (Prosser *et al.* 2016; Hausmann *et al.* 2016a) or using standard protocols (e.g., Ivanova *et al.* 2006).

Extraction of genomic DNA from the species *Cinglis humifusaria* (Eversmann, 1837), *Pseudocinglis benigna* (Brandt, 1941), *Scopuloides fucata* (Püngeler, 1909), *Scopula sacraria* (Bang-Haas, 1910), *Scopula diffinaria* (Prout, 1913) and *Scopula chalcographata* (Brandt, 1938) was carried out at the molecular laboratory of the State Museum of Natural History Stuttgart. The whole abdomen or a leg from a single dry specimen were used following the manufacturer's protocol of the DNeasy Blood and Tissue kits (Qiagen, Hilden, Germany). DNA amplification was conducted following the protocols of Wahlberg & Wheat (2008) and Wahlberg *et al.* (2016). Genomic DNA of a single specimen of *Scopuloides fucata* was extracted at the molecular laboratory of the Finnish Museum of Natural History "Luomus", Helsinki) using the same kit. DNA amplification and sequencing were carried out following protocols proposed by Wahlberg & Wheat (2008) and Wahlberg *et al.* (2016).

We amplified one mitochondrial COI gene and, when possible, up to nine protein-coding nuclear gene regions: Ribosomal Protein S5 (RpS5), wingless (wgl), cytosolic malate dehydrogenase (MDH), glyceraldehydes-3-phosphate dehydrogenase (GAPDH), Elongation factor 1 alpha (EF-1alpha), Arginine Kinase (ArgK), Isocitrate dehydrogenase (IDH), sorting nexin-9-like (Nex9) and sarco/endoplasmic reticulum calcium ATPase (Ca-ATPase).

COI data analysis. All specimens used for COI analysis are given in Supplementary Table S1 with their taxon identification, sample ID and process ID numbers. Their sequences and metadata are accessible on BOLD in the public dataset DS-SCOPIRAN (doi: https://dx.doi.org/10.5883/DS-SCOPIRAN). For calculation of the within-group mean distances of the available 86 taxa, the software MEGA X (Kumar *et al.* 2018) (K2P model: Kimura 1980) was used. Distances are given in Supplementary Table S2.

Phylogenetic analysis. We ran maximum likelihood analyses with a dataset partitioned by codon position. Best-fitting substitution models were selected by ModelFinder (Kalyaanamoorthy *et al.* 2017). The analyses were conducted in RAxML-HPC2 V.8.2.12 (Stamatakis 2014) and implemented on the Web-server CIPRES Science Gateway (Miller *et al.* 2010) using the GTR+CAT option. Support for nodes was evaluated with 1000 rapid bootstrap (RBS) in RAxML (Stamatakis 2008). The final data set included 35 taxa, with up to ten gene markers per taxon. The length of the alignment included 6,800 sites. Trees were visualized and edited in FigTree v1.4.3 software (Rambaut 2012). The final trees were rooted with *Lissoblemma hamularia* (Snellen, 1872), following previous hypotheses proposed by Sihvonen *et al.* (2020). GenBank accession numbers of the specimens used in this study are provided in the Supplementary Table S3.

Results & Discussion

Systematics

Three genes from a single specimen of *Cinglis humifusaria*, seven genes from a single specimen of *Pseudocinglis benigna*, six genes from a single specimen of *Scopuloides fucata*, six genes from a single specimen of *Scopula* (*Glossotrophia*) *diffinaria*, five genes from a single specimen of *Scopula* (*Glossotrophia*) *sacraria* and two genes from a single specimen of *Scopula* (*Glossotrophia*) *chalcographata* were successfully amplified and sequenced (see Supplementary Table S2). According to the results of the multi-gene molecular phylogenetic analysis, the species of *Glossotrophia* clustered within the genus *Scopula*, supporting the synonymy proposed by Sihvonen (2005a) (Plate 1). The topology of the phylogenetic tree (Plate 1) shows that species of *Glossotrophia* group together and do not intermix with other *Scopula* species, as was the case in a previous morphological analysis (Sihvonen 2005a).

The phylogenetic results from our analysis of the other genera (*Cinglis*, *Pseudocinglis* and *Scopuloides*) could be converted into a formal classification in a number of ways. One of these options could include a treatment of these three genera as part of *Scopula*, as the RBS support for considering these as separate lineages was poor (Stamatakis 2008), supporting the hypothesis of Sihvonen (2003, 2005a), who treated all three as synonyms of *Scopula*. Furthermore, the common branch of *Cinglis*, *Pseudocinglis*, *Scopuloides* and *Scopula*, with an RBS value of 73, is not well supported either (Stamatakis 2008). An alternative classification could be to treat *Cinglis* as a valid genus, with *Pseudocinglis* and *Scopuloides* as its junior synonyms. However, on the basis of morphological characters, *Cinglis* and *Pseudocinglis* have more in common than each of them has with *Scopuloides*, which allows a separation of these genera (e.g., Hausmann 1994).

The phylogenetic analysis allows the treatment of *Cinglis* **stat. rev.** as a valid genus, with *Pseudocinglis* **syn. nov.** as its junior synonym. This hypothesis is supported by morphology, as species of both genera share the following characters: wing venation; in the male genitalia: socii are connected by a sclerite; aedeagus bearing one cornutus; 8th sternite with concave anterior margin; in the female genitalia: sterigma with a circular sclerite around the ostium bursae; absence of a signum; presence of a lateral sclerite in the corpus bursae (Hausmann 2004).

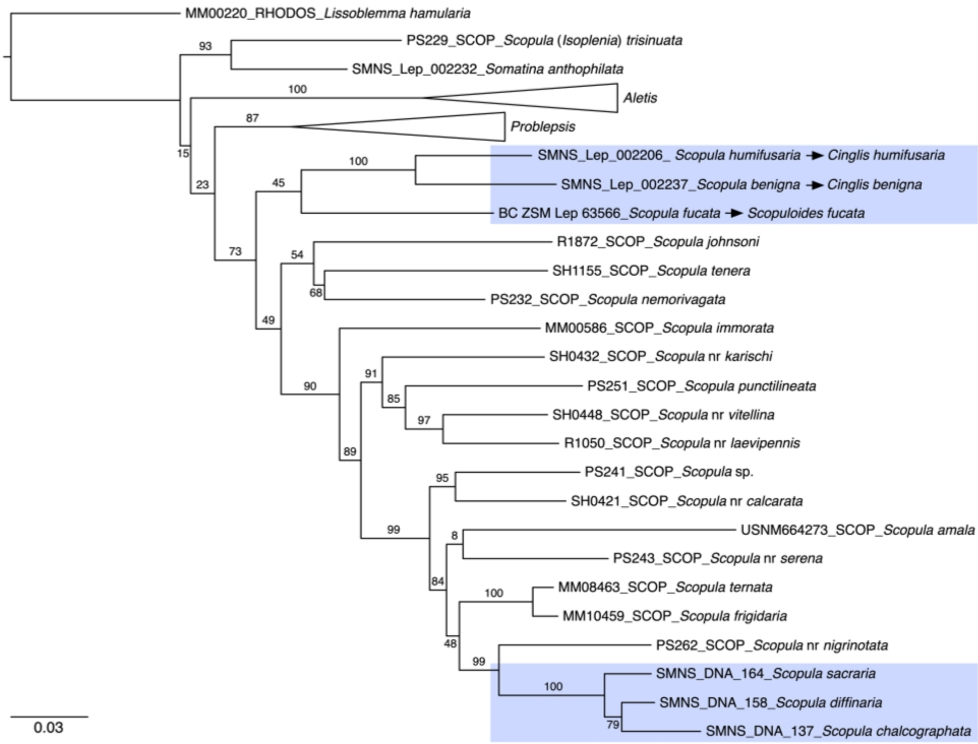


PLATE 1. Phylogenetic position of the focus taxa of this study (highlighted in blue): *Cinglis humifusaria* **stat. rev**. (*Cinglis* revived from synonymy under *Scopula*), *Cinglis benigna* **comb. nov**. (taxon *benigna* transferred from *Scopula* to *Cinglis*), *Scopuloides fucata* **stat. rev**. (*Scopuloides* revived from synonymy under *Scopula*), *Scopula sacraria*, *Scopula diffinaria* and *Scopula chalcographata* (data supports classification of these taxa in *Scopula*, not in *Glossotrophia*, and the latter is considered a junior synonym of *Scopula*) within the tribe Scopulini. The numbers above the branches are Rapid Bootstrap support (RBS) on the best scoring ML tree (Stamatakis 2008). Values ≥ 85 (%) indicate supported clades.

We consider *Scopuloides* **stat. rev.** as a valid genus since it groups as sister to *Cinglis*, but the morphological characters agree more with those of *Scopula* than with those of *Cinglis*. This genus was regarded as a synonym of *Scopula* based on morphological characters, as species of *Scopuloides* share many characters with *Scopula* such as wing venation and male and female genitalia (Hausmann 1994; Sihvonen 2005a). Furthermore, in the cladistic analysis by Sihvonen (2005a) all these genera were placed within *Scopula*, whereas in our tree they grouped as sister to *Scopula*. The present study focused on the genera that occur in Iran, but more molecular data and more taxa belonging to this global lineage are needed to fully resolve these difficult taxonomic questions within Scopulini.

A summarized morphological characterization of these genera is given hereunder, including an integrative taxonomic revision of the species distributed in Iran.

Taxonomy

Problepsis Lederer, 1853

Problepsis Lederer, 1853. Verhandlungen der Zoologisch-Botanischen Gesellschaft in Wien, 2: 74. Type species: *Caloptera ocellata* Frivaldszky, 1845.

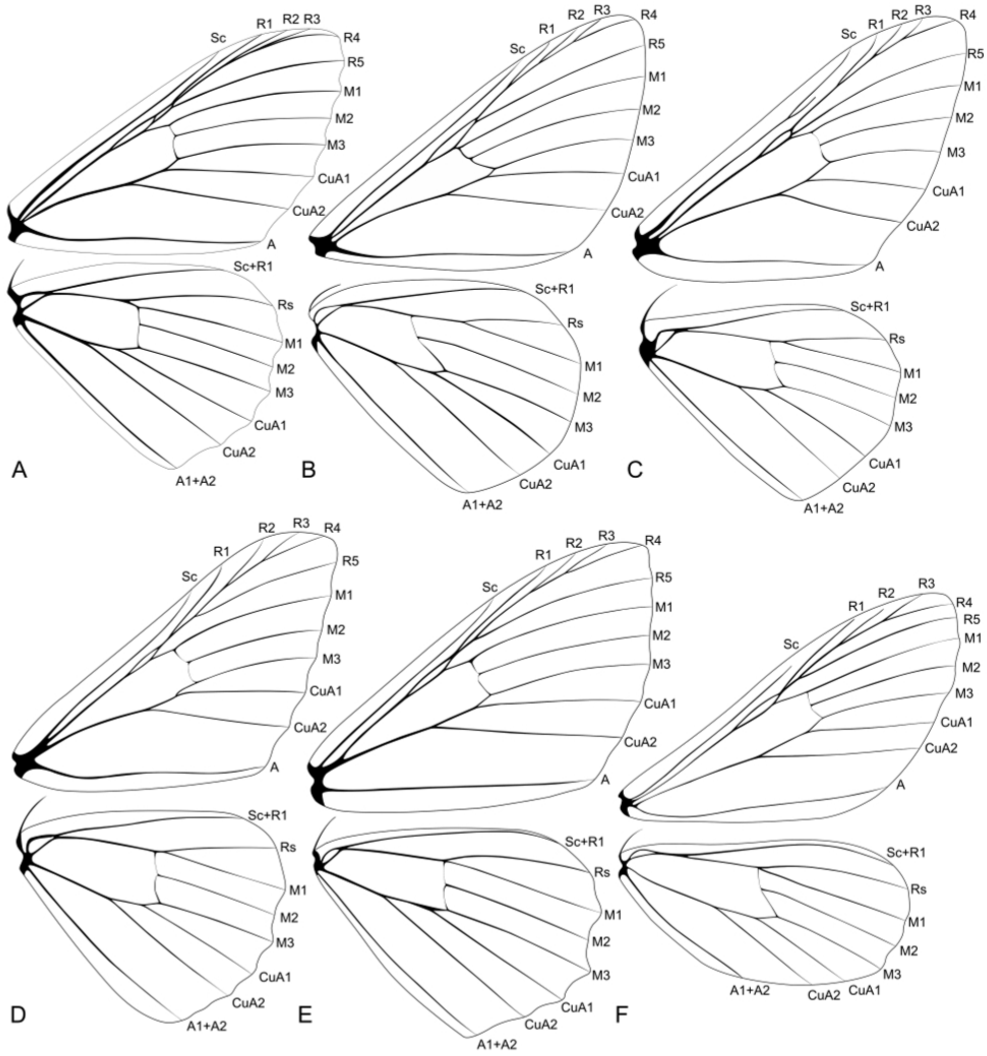


PLATE 2. Wing venation of Scopulini genera existent in Iran. A: *Problepsis wiltshirei*, **stat. rev.**, B: *Cinglis humifusaria* **stat. rev.**, C: *Cinglis benigna* **comb. nov.**, D: *Scopuloides origalis* **stat. rev.**, E: *Scopula ornata* and F: *Scopula relictata*.

Species within this genus are characterized by (after Hausmann 2004; Sihvonen 2005a; Feizpour *et al.* 2018; Wanke *et al.* 2021b): ocellate discal spots, variable in size on fore- and hindwing; spoon-shaped hind tibia and a hair pencil on the hindlegs of males.; venation with one or two areoles in the forewing; vein R1 and common stalk of R2–4 and R5 arising from the areole(s); hindwing with veins Rs and M1 separate, M3 and CuAl separate (see Plate 2A); male genitalia with fused socii and a smooth internal margin of the tegumen.

Only two species of this genus are reported in Iran: *Problepsis cinerea* (Butler, 1886) and *P. wiltshirei* (Prout, 1938). Those were dealt with in Wanke *et al.* (2021b) and we did not illustrate them again in the current paper.

Problepsis cinerea (Butler, 1886)

Argyria cinerea Butler, 1886, Proceedings of the Zoological Society of London 3, 387. Syntype (s) ([Pakistan], Campbellpore [near Rawal Pindee]) (in NHMUK).

Diagnosis. This species can be differentiated from *P. wiltshirei* by the large, prominent, rounded ocellus in the median area, which is small and light in *P. wiltshirei* (for further details see Wanke *et al.* 2021b).

Biology & Habitat. Most *Problepsis* species are known to feed on Oleaceae species (Stadie & Stadie 2016). Feizpour *et al.* (2018) suggested *Olea europaea cuspidata* as a potential natural host plant in southern Iran, as it is the only wild olive species found there. This species inhabits dry southern coastal plains and mountainous regions with higher humidity (Feizpour *et al.* 2018).

Distribution. This species is distributed from northern Oman and southern Iran in the west to eastern Afghanistan and Pakistan (Feizpour *et al.* 2018). In Iran it has only been recorded from one locality in Hormozgan province by Feizpour *et al.* (2018).

DNA-barcoding. Nearest species: *P. ocellata*, with a genetic distance of 1.8% (Wanke *et al.* 2021b).

Problepsis wiltshirei (Prout, 1938)

Somatina wiltshirei Prout, 1938. In: Seitz, A. (Ed.), Die Großschmetterlinge der Erde. Supplement zu Band 4, 220. 2 ♂ Syntypes (Iraq: Kurdistan, Rowanduz [Rawanduz Gorge], Berserini [Berserini Gorge]); 1 Syntype specimen [gender is not given in the original publication], [Iran]: Fars, Ardekan Talochosroe [Tall Khosrow, today in prov. Kohgiluyeh and Boyer-Ahmad]) (in NHMUK). Transferred to *Problepsis* by Wanke *et al.* (2021).

Remarks. This species was described in the genus *Somatina*, but was recently transferred to the genus *Problepsis* based on morphological and molecular data (see Wanke *et al.* 2021b).

Diagnosis. See diagnosis for *P. cinerea*.

Biology & Habitat. Possible host plants include *Fraxinus* sp. (Oleaceae) and *Acer* sp. (Sapindaceae) (Wiltshire 1943). The latter is atypical for this genus and needs further investigation (Wanke *et al.* 2021b).

Distribution. This species is distributed only in the Middle East (Iran, Iraq and Turkey) (Wanke *et al.* 2021b). It has been recorded from south-western Iran, from the provinces Kohgiluyeh-va-Boyer-Ahmad, Khuzestan, Esfahan and Fars (Wanke *et al.* 2021b).

DNA-barcoding. Nearest species: *P. ocellata* and *P. cinerea*, both with a genetic distance of 4.2% (Wanke *et al.* 2021b).

Cinglis Guenée, 1858 stat. rev.

Cinglis Guenée, 1858. Histoire naturelle des insectes. Spécies général des lépidoptères, 10: 114. Type species: *Fidonia humifusaria* Eversmann, 1837.

Pseudocinglis Hausmann, 1994 **syn. nov.** Nota Lepidopterologica 16: 203. Type species: *Glossotrophia eurata* Prout, 1913. Here regarded as synonym of *Cinglis* based on molecular and morphological examination.

Remarks. The genus was regarded as a synonym of *Scopula* by Sihvonen (2003, 2005a), but as a valid genus by other authors (e.g., Hausmann 2004; Lehmann & Zahiri 2011). The phylogenetic analysis in the present paper allows to classify *Cinglis* as a valid genus (see Systematics part and Plate 1). This result is further supported by the following morphological characters: venation with one areole in the forewing; vein R1–4 and vein R5 on a common stalk arising from the areole; hindwing with Rs and M1 stalked (see Plate 2B, C); male genitalia with socii connected by a sclerite; aedeagus bearing one cornutus; 8th sternite with a concave anterior margin (Hausmann 2004); female genitalia sterigma with a circular sclerite around the ostium bursae; signum absent, presence of a lateral sclerite (Hausmann 2004).

***Cinglis humifusaria* (Eversmann, 1837) stat. rev.**
(Plate 3, Figs 1–2; Plate 10, Fig. 1; Plate 21, Fig. 1; Map 1)

Fidonia humifusaria Eversmann, 1837. Bulletin de la Société impériale des naturalistes de Moscou, 10 (6): 57. Lectotype ♂, designated by Hausmann (2004) (southern European Russia: Lower Volga) (in ZISP).

Material examined: 8 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 18–23 mm (Hausmann 2004). Ground colour white, with broad, dark brown transversal lines (Plate 3, Figs 1–2). Due to its unique wing pattern, *Cinglis humifusaria* cannot be confused externally with other Scopulini in the Middle East and Central Asia. For additional diagnostic characters see generic part and Plate 3, Figs 1–2; Plate 10, Fig. 1; Plate 21, Fig. 1.

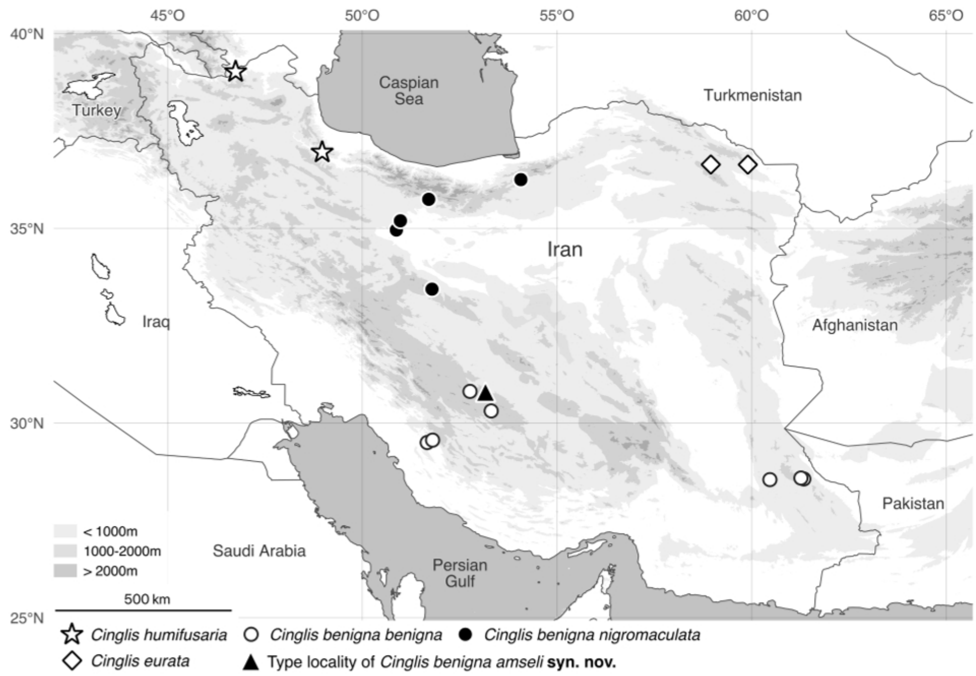
Phenology. A bivoltine species with a first generation from late April to mid-June and a second generation from mid-July to early August (Hausmann 2004). Available data and specimens from Iran indicate that this species is active from April to June (Viidalepp 1988; Lehmann & Zahiri 2011; current study).

Biology. Host plants unknown, but possibly feeding on *Artemisia* (Hausmann 2004).

Habitat. At altitudes from 0 m to 1000 m (Hausmann 2004). The available data and investigated specimens in Iran were collected at altitudes from 330 to 1053 m (Lehmann & Zahiri 2011; current study).

Distribution. Distributed in southern European Russia and from Turkey and Iran to the Central Asian mountains, as well as in the Iberian Peninsula and North Africa (Viidalepp 1996; Hausmann 2004). In north-western Iran, it has been reported from the provinces Azerbaijan-e Sharghi, Khorasan-e Shomali and Zanjan (Viidalepp 1988; Lehmann & Zahiri 2011; current study) (Map 1).

DNA-barcoding. Nearest species: *C. andalusaria* Wagner, 1935 with a genetic distance of 5.7 %. *Cinglis benigna* **comb. nov.** with a genetic distance of 10.8 % (see Supplementary Table S1).



MAP 1. Distribution patterns of the *Cinglis* species *C. humifusaria* **stat. rev.**, *C. benigna benigna* **comb. nov.**, *C. benigna amseli* **syn. nov.** of *C. benigna benigna* **comb. nov.**, *C. benigna nigromaculata* **comb. nov.** and *C. eurata* **comb. nov.** in Iran.

***Cinglis benigna* (Brandt, 1941) comb. nov.**
(Plate 3, Figs 3–8; Plate 10, Figs 2–5; Plate 21, Figs 2–4; Map 1)

Glossotrophia benigna Brandt, 1941. Mitteilungen der Münchner Entomologischen Gesellschaft, 31 (3): 868. Syntypes ♂, ♀ (Iran: Fort Sengan) (in NHRS, examined).
Pseudocinglis benigna nigromaculata Hausmann, 1994. Nota Lepidopterologica, 16 (3/4): 209. Holotype (Iran: north) (in SMNK, examined). Valid at subspecific rank.
Scopula (*Eucidalia*) *amseli* Wiltshire, 1967. Beiträge zur naturkundlichen Forschung in Südwestdeutschland, 26: (3). Holotype (Iran: Fars, Quli Kush) (in NHMUK, examined). Transferred to the genus *Pseudocinglis* and downgraded to subspecific rank of *Pseudocinglis benigna* by Hausmann & László (1999). Here regarded as synonym of *C. benigna benigna* based on sympatric occurrence of these forms.

Type material examined. *Glossotrophia benigna*: Paratypes 1 ♂, 1 ♀, Iran, Baloutchistan, Straße Khach–Zahedan, Fort Sengan, 1800 m, 30.iv.1938, coll. Brandt, (♂) NHRS-LEPI 000010310, g. prep. 11053, (♀) NHRS-LEPI 000010311, g. prep. 11054; in NHRS.

Pseudocinglis benigna nigtomaculata: Holotype ♂, N-Iran, 70 km s. Teheran, 1300 m, 29.v.1969, leg. G. Ebert, g. prep. 3796 ZSM HM [Axel Hausmann]; Paratype ♀, same data, g. prep. 3797 ZSM HM [Axel Hausmann]; all in ZSM.

Scopula (*Eucidalia*) *amseli*: Holotype ♂, Iran, Fars, Quli Kush, 8.vi.1949, leg. E.P. Wiltshire, g. prep. E. P. Wiltshire 1127 [genitalia slide couldn't be traced in the genitalia slide collection of Wiltshire in NHMUK], NHMUK 014173546; in NHMUK.

Paratype 1 ♂, N.-Afghanistan, Polichomri, 700 m, 28.v.1956, leg. H. G. Amsel, g. prep. 2262/2020 H. Rajaei; Paratype 1 ♂, O.-Afghanistan, Gulbahar, 1700 m, 25.vi.1956, leg. H. G. Amsel, g. prep. 2263/2020 H. Rajaei; Paratypes 1 ♂, 1 ♀, O.-Afghanistan, Gulbahar, 1700 m, 21.v.1956, leg. H. G. Amsel, g. prep. WM. 131 [♂ & ♀ are embedded on the same slide]; in SMNK.

Additional material examined: *Cinglis benigna benigna* 10 ♂/♀, *Cinglis benigna nigromaculata* 14 ♂/♀ (see appendix).

Diagnosis. Wingspan 15–25 ♂♀ mm. Ground colour (Plate 3, Figs 3–8) sandy to brown. In Iran, *Cinglis benigna* can externally be confused only with *C. eurata* (see Plate 3, Figs 3–10). However, *C. benigna* shows a unique combination of characters in the male genitalia for differentiation from *C. eurata*. In male genitalia, 8th sternite without cerata, basally notched, more stongly notched in *C. benigna benigna*, more weakly notched in *C. benigna nigromaculata* (8th sternite with a short right ceras, basally notched in *C. eurata*) (see Plate 10, Figs 2–6). The female genitalia show no strong differences from other species of this genus; probably corpus bursae more strongly sclerotized than *C. eurata* (see Plate 21, Figs 2–5).

Taxonomic remarks. The holotype and paratypes of *Scopula amseli* are not conspecific. Although the genitalia slide of the holotype of *Cinglis benigna amseli* could not be traced at the NHMUK, the type locality in the southern Iranian province Fars suggests that *C. benigna amseli* **syn. nov.** is a synonym of the nominotypical subspecies. The paratypes are from northern and eastern Afghanistan. The paratypes appear to belong to *Cinglis eurata*, as they show the typical short right ceras in the 8th sternite of the male.

Phenology. Specimens of *Cinglis benigna benigna* were collected from April to June, while *Cinglis benigna nigromaculata* was collected from May to September.

Biology. Unknown.

Habitat. Investigated specimens of *C. benigna benigna* collected at altitudes from 1200 to 3000 m; *C. benigna nigromaculata* at altitudes from 800 to 1700 m.

Distribution. Endemic to Iran. The nominotypical subspecies *C. benigna benigna* is distributed in southern Iran, *C. benigna nigromaculata* in northern Iran (Map 1).

DNA-barcoding. Nearest species: *Scopula risa* Wiltshire, 1982 with a genetic distance of 8.8%. Genetic distance from other *Cinglis* species: *Cinglis humifusaria* with 10.8 % and *C. andalusaria* with 11.1 %. (see Supplementary Table S1).

***Cinglis eurata* (Prout, 1913) comb. nov.**
(Plate 3, Figs 9–10; Plate 10, Fig. 6; Plate 21, Fig. 5; Map 1)

Glossotrophia eurata Prout, 1913. In: Seitz, A. (Ed.), Die Großschmetterlinge der Erde 4: 83. Holotype ([Turkmenistan]: Arwas, near Ashkhabad) (in MNHU).

Additional material examined: 9 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 15–23 mm. Ground colour (Plate 3, Figs 9–10) whitish-beige to brown. In Iran, *Cinglis eurata* can externally be confused only with *C. benigna* (see Plate 3, Figs 3–10). In male genitalia, 8th sternite with a short right ceras, basally notched (8th sternite without cerata, basally notched in *C. benigna*) (see Plate 10, Figs 2–6). The female genitalia show no strong differences from other species of this genus; probably corpus bursae more weakly sclerotized than in *C. benigna* (see Plate 21, Figs 2–5).

Phenology. Specimens from Iran collected in June.

Biology. Unknown.

Habitat. Investigated specimens collected at altitudes from 1210 to 1431 m.

Distribution. Species endemic to the Kopet Dagh mountains (Hausmann 1994). In Iran it is present in the northeastern provinces Khorazan-e Shomali and Khorazan-e Rhazavi (Viidalepp 1988) (see Map 1).

DNA-barcoding. No data available.

Remarks. The record from the province Semnan by Prout (1913) is possible but needs further confirmation, although confusion with *C. benigna nigromaculata* cannot be excluded.

Scopuloides **Hausmann, 1994 stat. rev.**

Scopuloides Hausmann, 1994. Nota Lepidopterologica, 16 (3/4): 196. Type species: *Acidalia fucata* Püngeler, 1909.

Remarks. This genus was regarded as a synonym of *Scopula* by Sihvonen (2003, 2005a), which is in concordance with its morphological characters: venation with one areole in the forewing venation; veins R1–5 on a common stalk arising from the areole; hindwing with veins Rs and M1 on a short stalk (see Plate 2D); male genitalia with socii short, strongly adjacent or crossed; sacculus broad; aedeagus with one cornutus; 8th sternite bend ventrally; left ceras long, right ceras short (Hausmann 1994); female genitalia with papillae anales with two lobes; lamella antevaginalis big (Hausmann 1994). The main criterion why this genus was considered different to *Scopula* is the number of spurs, which is not in accordance with *Scopula*.

The phylogenetic analysis in the present paper allows different classifications, but we decided to treat *Scopuloides* as valid genus (see Systematics part and Plate 1).

Scopuloides origalis **(Brandt, 1941) stat. rev.**

(Plate 3, Figs 11–16; Plate 10, Fig. 7; Plate 21, Fig. 6; Map 2)

Glossotrophia origalis Brandt, 1941. Mitteilungen der Münchner Entomologischen Gesellschaft, 31 (3): 869. Holotype ♂ (Iran) (in NHRS, examined).

Scopula danieli Wiltshire, 1966. Zeitschrift der Wiener Entomologischen Gesellschaft, 51: 127. Holotype ♂ (Afghanistan: Nuristan) (Types in NHMUK and SMNK, examined). Transferred to *Scopuloides* and regarded as subspecies of *S. origalis* by Hausmann (1994).

Scopula origalis safida Wiltshire, 1966. Zeitschrift der Wiener Entomologischen Gesellschaft, 51: 128. Holotype ♂ (Afghanistan: Nuristan) (Types in NHMUK). Originally described as subspecies by Wiltshire (1966). Transferred to *Scopuloides* by Hausmann (1994).

Scopula origalis vantshica Viidalepp, 1988. Fauna pyadenits gor Srednei Azii: 54. Holotype ♂ (Tadjikistan: Nuristan). Transferred to *Scopuloides* and regarded as subspecies of *S. origalis* by Hausmann (1994).

Type material examined. *Glossotrophia origalis* Holotype ♂, Iran, Laristan, Straße Bender-Abbas-Saidabad, Sardze Umgebung, ca. 200 m, Mitte November 1937, coll Brandt, NHRS-LEPI 000010185; Paratype ♂, same data, NHRS-LEPI 000010185, g. prep. 10878; all in NHRS.

Scopula danieli: Allotype ♀, Afghanistan, Bashgultal, Nuristan, 1100 m, 14.iv.[19]53, NHMUK 010317466, g. prep. NHMUK 010317466; in NHMUK.

Scopula danieli: Paratypes 1 ♀, Afghanistan, Sarobi, 1100 m, 28.vi.1956, leg. H. G. Amsel, g. prep. 2265/2020 H. Rajaei; 1 ♀, same data, but 3.vii,1956, g. prep. 2264/2020 H. Rajaei; all in SMNK.

Additional material examined: 22 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 16–20 mm. Ground colour (Plate 3, Figs 11–16) whitish-beige to brown. *Scopuloides origalis* can externally be confused with small specimens of the *Scopula transcaspica* (see Plate 3, Figs 11–16; Plate 6, Figs 1–6) (genitalia characters are therefore compared with *S. transcaspica*). In male genitalia, socii strongly shortened (broad in *S. transcaspica*); 8th sternite with a long left ceras, apically curved, right ceras short (sternite with both cerata long, left sometimes shortened in *S. transcaspica*) (Plate 10, Fig. 7; Plate 15, Figs 2–3). In female genitalia, lamella antevaginalis as flat trapezoidal sclerite (as flat sclerite, shape variable, rather wider than long in *S. transcaspica*) (Plate 21, Fig. 6; Plate 23, Figs 5–6).

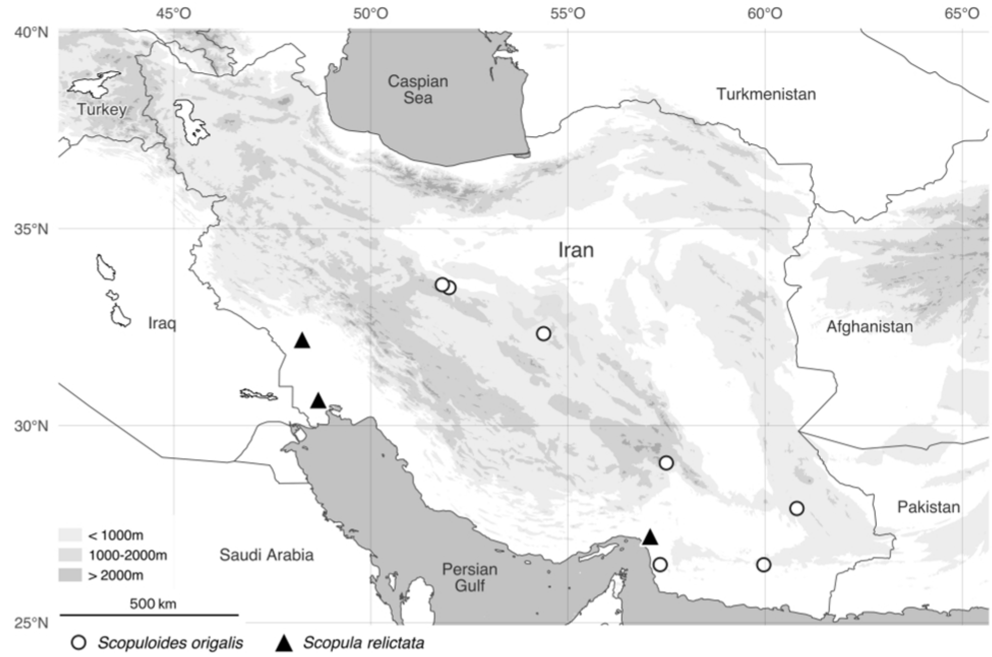
Phenology. Investigated specimens were collected from April to mid-November.

Biology. Unknown.

Habitat. Investigated specimens collected at altitudes from 200 m to 1700 m.

Distribution. Distributed in Tadjikistan, Afghanistan and Iran (Viidalepp 1988; Hausmann 1994). In Iran it is found from central to south-eastern of Iran (see Map 2).

DNA-barcoding. Nearest species: *Scopuloides fucata* **stat. rev.** at a distance of 6.6 % (see Supplementary Table S1).



MAP 2. Distribution patterns of *Scopuloides origalis* **stat. rev.** and *Scopula relictata* in Iran.

Scopula Schrank, 1802

Scopula Schrank, 1802. Fauna boica, 2 (2): 162. Type species: *Phalaena paludata* Linnaeus, 1767 (junior synonym of *Phalaena ornata* Scopoli, 1763).

Glossotrophia Prout, 1913. Systematische Bearbeitung der Schmetterlinge von Europa 3 (24): 21. Type species *Acidalia confinaria* Herrich-Schäffer, 1847. Here regarded as synonym to *Scopula* based on the phylogenetic results (see Fig. 1).

Remarks. Species within this genus are characterized by (after Hausmann 2004; Sihvonen 2005a): venation with one areole in the forewing; veins R1 and R2–5 on a common stalk, arising from the areole; hindwing with veins Rs and M1 usually separate (see Plate 2E, F); male genitalia with posterolateral appendices on the 8th sternite absent, sacculus and valvula of valva separated, juxta urceolate (see Sihvonen 2005a); female genitalia with signum spinous (see Sihvonen 2005a).

Scopula conscensa (Swinhoe, 1885)

(Plate 3, Figs 17–19; Plate 11, Figs 1–2; Plate 21, Fig. 7)

Eupithecia conscensa Swinhoe, 1885. Proceedings of the Zoological Society of London, 1885 (4): 863. Syntypes ([India], Poona) (in NHMUK, examined).

Type material examined. *Eupithecia conscensa*: Syntype, [India], Poona, NHMUK 014173526; in NHMUK.

Additional material examined: 2 ♂/♀ (see appendix).

Taxonomic note. This species was transferred from *Zygophyxia* to *Scopula* by Sihvonen (2005a). Hausmann *et al.* (2020) noted, for *Scopula ochrea* (Hausmann, 2006) a genetic distance of about 10% (DNA barcode, COI) to the nearest *Scopula* species, questioning the synonymy done by Sihvonen (2005a). Species earlier combined to the genus *Zygophyxia* need investigation based on a large integrative taxonomic revision.

In Iran, two species formerly combined with *Zygophyxia*, namely *Scopula conscensa* (Swinhoe, 1885) and *Scopula relictata* (Walker, 1866) occur, showing great morphological differences among themselves and with the other *Scopula* species studied.

Diagnosis. Wingspan ♂ 18 mm, ♀ 14.8 mm (Plate 3, Figs 17–19). Ground colour whitish-beige to brown, wings pointed towards the apex. *Scopula conscensa* can be confused externally with *S. relictata* (see Plate 3, Figs 20–23), but both species have a unique combination of characters on their male and female genitalia.

In the male genitalia, socii fused, short (similar in *S. relictata*). Lateral processi of anellus short, broad and rounded (long, tapered, needle-like in *S. relictata*). Aedeagus curved, vesica with one short cornutus (broad, slightly curved, apical half spined in *S. relictata*) (see Plate 11, Figs 1–3). 8th sternite not available on the genitalia preparation slide.

In the female genitalia, lamella antevaginalis triangular (rectangular, apically concave *S. relictata*). Corpus bursae globular, strongly spinulose (long, pear-shaped, without signum in *S. relictata*) (see Plate 21, Figs 7–9).

Phenology. The Investigated specimen was collected in February (n=1); other specimens without collection date on the label.

Biology & Habitat. Unknown.

Distribution. Distributed in India and Sri Lanka. No specimens from Iran were available (see Remarks).

DNA-barcoding. No data available.

Remarks. This species was reported by Brandt (1941) from southern Iran (Hormozgan province). We did not find any specimen of this species confirming its occurence in Iran. Most probably the report of Brandt is a misidentification with *Zygophyxia relictata*, which occurs in this province.

Scopula relictata (Walker, 1866)

(Plate 3, Figs 20–23; Plate 11, Fig. 3; Plate 21, Figs 8–9; Map 2)

Acidalia relictata Walker, 1866. List of the specimens of lepidopterous insects in the collection of the British Museum, 35: 1629. Syntypes ♂ (Hindostan [India]) (in OUM).

Lycauges relictata demissus Swinhoe, 1887. Proceedings of the Zoological Society of London, 1886 (4): 456. Syntypes (India, central) (NHMUK). Synonym of *Scopula relictata*.

Sterrha ooptera Turner, 1922. Transactions of the Royal Society of South Australia, 46: 267. Holotype ♀ (Australia, Queensland, Gayndah). Synonym of *Scopula relictata*.

Type material examined. *Lycauges relictata demissus*: Syntype 1 ♂♀, [India], Mhow, NHMUK 014173576; in NHMUK.

Additional material examined: 7 ♂/♀ (see appendix).

Taxonomic note. Combination of this species with the genus *Scopula* questionable, see taxonomic note of *Scopula conscensa*.

Diagnosis. Wingspan ♂♀ 16–19 mm. Ground colour beige to brown with some grey tinge, wings pointed towards the apex (Plate 3, Figs 20–23). *Scopula relictata* can be confused externally with *S. conscensa* (see Plate 3, Figs 17–23), but both species have a unique combination of characters on their male and female genitalia.

In the male genitalia socii fused, short. Fibula long, tapered needle-like. Lateral process of anellus long, tapered needle-like (short, broad rounded in *S. conscensa*). Aedeagus broad, slightly curved, apical half spined (curved, vesica with one short cornutus in *S. conscensa*) (see Plate 11, Figs 1–3). 8th sternite basally narrowing, apically notched.

In the female genitalia lamella antevaginalis rectangular, apically concave (triangular in *S. conscensa*). Corpus bursae long, pear-shaped, without signum (globular, strongly spinulose in *S. conscensa*) (see Plate 21, Figs 7–9).

Phenology. The investigated specimens from Iran were collected in March. Investigated specimens outside Iran were collected from March to October.

Biology & Habitat. Unknown.

Distribution. Distributed in Bahrain, Oman, Iran, India, Sri Lanka, and Australia. In Iran it is only known from the southwestern and southern provinces (see Map 2). Reported by Wiltshire (1980) for South Iran without more detailed information. Here we confirm the presence of this species in Iran.

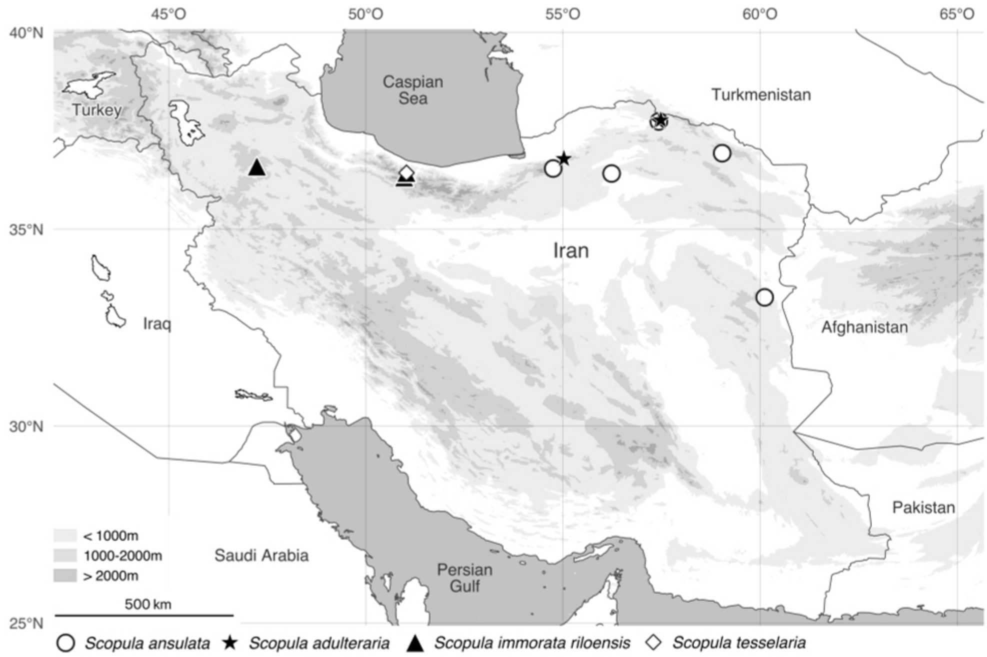
DNA-barcoding. Nearest species: *S. scalercii* with 7.1 % (see Supplementary Table S1).

Scopula ansulata **(Lederer, 1871)**

(Plate 4, Figs 1–4; Plate 12, Fig. 1; Plate 22, Fig. 1; Map 3)

Acidalia ansulata Lederer, 1871. Horae Societatis Entomologicae Rossicae, variis sermonibus in Rossia usitatis editae, 8, 19. Syntypes 2 ♂ 1 ♀ ([Iran]: Hadschyabad) (in MNHU, examined).

Type material examined. Syntypes [labeled with origin], 1 ♂, 1 ♀, Iran, [Hadschyabad], ex coll. Staudinger; in MNHU.



MAP 3. Distribution patterns of the *Scopula* species *S. ansulata, S. adulteraria, S. immorata riloensis* and *S. tesselaria* in Iran.

Additional material examined: 55 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 24–28 mm. Due to its unique wing pattern, *Scopula ansulata* cannot be confused with any other *Scopula* species in Iran. Ground colour (Plate 4, Figs 1–4) ivory to beige, with some grey-brown highlights; transverse lines well pronounced and characteristic curved (wings reddish brown in *S. adulteraria*) (see Plate 4, Figs 1–6). The male genitalia (Plate 12, Fig. 1) and the female genitalia (Plate 22, Fig. 1), show no diagnostic characters for differentiation from the sister species *S. adulteraria*.

Phenology. Investigated specimens in Iran were collected from April to July.

Biology. Unknown.

Habitat. Investigated specimens in Iran from 1000 m to 2900 m.

Distribution. This species is distributed from Iran and Central Asia (Turkmenistan, Afghanistan, Uzbekistan, Kazakhstan and Tadjikistan) to northwestern China (Viidalepp 1996, Sihvonen 2005b). In Iran it is distributed in the northeastern parts (see Map 3). It has also been reported in the literature for the provinces Golestan, Khorasan-e Shomali and Semnan.

DNA-barcoding. No data available.

Scopula adulteraria **(Erschov, 1874) bona sp.**

(Plate 4, Figs 5–6; Plate 12, Fig. 2; Plate 22, Fig. 2; Map 3)

Acidalia adulteraria Erschov, 1874. In Fedchenko, Puteshestvie v Turkestan, 2, 60. Syntypes ♂, ♀ (Turkestan: Kisilkum) (in MNHU, examined).

Type material examined. 1 ♂, 1 ♀ [Uzbekistan], Margilan, ex coll. Staudinger; in MNHU.

Additional material examined: 87 ♂/♀ (see appendix).

Remarks. Originally described as a species, and regarded as a bona species by several authors (e.g., Viidalepp 1996), it has been regarded as subspecies of *Scopula ansulata* by other authors (Scoble 1999; Sihvonen 2005a, 2005b; Scoble & Hausmann 2007). However, external differences as well as the sympatric occurrence of *Scopula ansulata* and *S. adulteraria* convinced us to raise this taxon to species rank.

Diagnosis. Wingspan ♂♀ 23–30 mm. Due to its unique wing pattern, *Scopula adulteraria* cannot be confused with any other *Scopula* species in Iran. Ground colour (Plate 4, Figs 5–6) reddish brown; transverse lines well pronounced and characteristic curved (wings ivory to beige, with some grey-brown highlights in *S. ansulata*) (see Plate 4, Figs 1–6).

The male genitalia (Plate 12, Fig. 2) and the female genitalia (Plate 22, Fig. 2), show no diagnostic characters for differentiation with the sister species *S. ansulata*.

Phenology. Investigated specimens in Iran were collected from March to May.

Biology. Unknown.

Habitat. Investigated specimens in Iran collected at altitudes from 50 m to 1240 m.

Distribution. This species is distributed from Iran to Central Asia (Uzbekistan, Kazakhstan and Tadjikistan) (Viidalepp 1996). In Iran it is only known for the province Khorasan-e Shomali (see Map 3).

DNA-barcoding. Nearest species: *S. rufomixtaria* (De Graslin, 1863) with 7.3 % (see Supplementary Table S1); this may change when data for *S. ansulata* is added to the dataset. However, no data for *S. ansulata* was available.

Scopula immorata **(Linnaeus, 1758)**

(Plate 4, Figs 7–9; Plate 12, Fig. 3; Plate 22, Fig. 3; Map 3)

Phalaena Geometra immorata Linnaeus, 1758. Caroli Linnaei...Systema naturae per regna tria naturae: secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis (Ed. 10) 1: 528 (Europe). Syntypes (Europe) (in LSL).

Scopula immorata duercki Sheljuzhko, 1955: Mitteilungen der Münchner Entomologischen Gesellschaft. 44/45: 289 (Spain, Castilla: Sierra de Gredos). Holotype ♂ (ZSM). Valid at subspecific rank.

Acidalia immorata L var. *riloensis* Züllich, 1936. Zeitschrift der Wiener Entomologischen Gesellschaft, 21: 55. (Bulgaria: Rilo Mts.) (deposition unknown). Valid at subspecific rank.

Synonymies (for more details on nomenclature see Scoble 1999 and Hausmann 2004): *Phalaena contaminata* Scopoli, 1763

(Slovenja: Carniolia); *Phalaena graminata* Hufnagel, 1767 (Germany: Berlin); *Phalaena festucaria* Brahm, 1791 (western Germany: near Mainz); *Phalaena fuscata* Fabricius, 1794 (Denmark: Seelandia); *Geometra immoraria* (according to Hausmann (2004: 256): incorrect subsequent spelling); *Acidalia serenata* Turati, 1905 (type locality not given).
For the list of unavailable names see Hausmann (2004).

Material examined: 9 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 22–28 mm. In Iran, *Scopula immorata* can externally be confused with *S. tessellaria*, therefore its characters are compared against this species. Wings chequered, ground colour (Plate 4, Figs 7–9) white to grey, with brown transverse lines; lines diffuse and wavy; bright ground-coloured areas blurred (similar but transverse lines darker and bright ground-coloured areas sharply defined in *S. tessellaria*) (see Plate 4, fig 7–11). The male genitalia with a broad and short aedeagus, its tip with lateral spines, vesica with terminal cornutus (similar but aedeagus tip with one lateral spine in *S. tessellaria*). 8th sternite with short left ceras and long right ceras (both cerata short in *S. tessellaria*) (see Plate 12, Fig.3; Plate 13, Fig.1). In the female genitalia lamella antevaginalis large, rounded (small, rounded in *S. tessellaria*). Ductus bursae broad (long and slender in *S. tessellaria*). Signum small, three times as long as wide, with lateral spines (small, five times as long as wide, with lateral spines in *S. tessellaria*) (see Plate 22, fig 3–4).

Phenology. Bivoltine species, with a first generation from mid-May to early July and a second generation from late July to late August (Hausmann 2004). Investigated specimens in Iran were collected in July.

Biology. Polyphagous, larvae feed on withered leaves of plants from different families e.g., Lamiaceae, Asteraceae, Ericaceae, Polygonaceae and Plantaginaceae (Hausmann 2004; Beljaev 2016; Makhov 2023).

Habitat. From 0 m to 2400 m in Europe, in Turkey and Iran to 3000 m (Hausmann 2004). Investigated specimens in Iran were collected from 19 m to 3200 m.

Distribution. This species is distributed from western Europe (Spain) to Russia, as well as in Turkey, the Caucasus, Transcaucasus, Kazahkhstan and Mongolia (Viidalepp 1996; Hausmann 2004; Makhov 2023). In Iran, this species is represented by the subspecies *S. immorata riloensis*, which is distributed in northern parts of the country (see Map 3).

DNA-barcoding. Nearest species: *S. tessellaria* with 1.8 % (see Supplementary Table S1).

Scopula tessellaria (Boisduval, 1840)

(Plate 4, Figs 10–11; Plate 13, Fig. 1; Plate 22, Fig. 4; Map 3)

Strenia tessellaria Boisduval, 1840. Genera et index methodicus Europæorum lepidopterum: 228 (northern Italy). Syntype(s) (ZFMK).
Synonymies (for more details on nomenclature see Scoble 1999 and Hausmann 2004): *Phalaena pellicea* Fourcroy, 1785 (France: Paris); *Eupisteria puluerulentaria* Sélys-Longchamps, 1844 (southern Italy: Caserta); *Acidalia tabianaria* Turati, 1905 (Italy, Parma Prov.: Tabiano; Salso Maggiore); *Scopula tessellaria proutiana* Sheljuzhko, 1955 (Kirghizstan, Semiretshje: river Maloje).
For the list of unavailable names, see Hausmann (2004).

Material examined: 6 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 22–28 mm. In Iran, *Scopula tessellaria* can externally be confused only with *S. immorata*, therefore its characters are compared against this species. Wings chequered, ground colour (Plate 4, Figs 10–11) white to grey, with dark brown transverse lines; lines diffuse and wavy; bright ground-coloured areas sharply defined (similar but transverse lines brighter, bright ground-coloured areas blurred in *S. immorata*) (see Plate 4, Figs 7–11). In the male genitalia aedeagus broad and short, tip with one lateral spine, vesica with terminal cornutus (similar but aedeagus tip with lateral spines in *S. immorata*). 8th sternite with both cerata short (with short left and long right ceras in *S. immorata*) (see Plate 12, Fig. 3; Plate 13, Fig. 1).

In the female genitalia lamella antevaginalis small (big, rounded in *S. immorata*). Ductus bursae long and slender (broad in *S. immorata*). Signum small, five times as long as wide, with lateral spines (small, three times as long as wide, with lateral spines in *S. immorata*) (see Plate 22, fig 3–4).

Phenology. Univoltine species, from late May to early July (Hausmann 2004). Investigated specimens in Iran were collected in July.

Biology. Larva on plant species of different families, e.g., Asteraceae, Ericaceae, Fabaceae and Ranunculaceae (Hausmann 2004).

Habitat. From 0 m to 1800 m in Europe and to 3000 m in Central Asia (Hausmann 2004). Investigated specimens in Iran were collected from 19 m to 2200 m.

Distribution. Distributed from Spain to the Urals, but rare and with local distribution in western, southern and eastern Europe (Hausmann 2004). Also distributed in Turkey, the Caucasus, Transcaucasus, Kazakhstan and southwestern China (Viidalepp 1996; Hausmann 2004; Sihvonen 2005b). In Iran it is only known from the province Mazandaran (Map 3).

Remarks. Schwingenschuss (1939) reported the presence of this species in the north Iranian provinces Mazandaran and Tehran. Hausmann (2004) stated that this awaits confirmation. Here we confirm the presence of this species in northern Iran.

DNA-barcoding. Nearest species: *S. immorata* with 1.8 % (see Supplementary Table S1).

Scopula nigropunctata **(Hufnagel, 1767)**

(Plate 5, Figs 1–2; Plate 13, Fig. 2; Plate 22, Fig. 5; Map 4)

Phalaena nigropunctata Hufnagel, 1767. Berlinisches Magazin, 4 (5): 526. Syntype(s) lost (Germany, Berlin).

Acidalia subcandidata Walker, 1862. List of the specimens of lepidopterous insects in the collection of the British Museum, 26: 1607. Holotype ♂ (eastern China: Shanghai) (NHMUK). Valid at subspecific rank.

Craspedia imbella Warren, 1901: Novitates zoologicae, 8: 22. Syntypes 3 ♀ (Japan) (NHMUK). Valid at subspecific rank.

Scopula nigropunctata chosensis Bryk, 1949: Arkiv för zoologi, 41A (1): 164. Holotype ♂ (Korea: Shuotsu) (NHRS). Valid at subspecific rank.

Scopula nigropunctata subimbella Inoue, 1958: Tinea, 4 (2): 243. Holotype ♂ (Japan: Hokkaido. Kushiro, Shibecha) (NHMUK). Valid at subspecific rank.

Synonymies (for more details on nomenclature see Scoble 1999 and Hausmann 2004): *Phalaena repandata*: sensu Scopoli, 1763 (north-western Slovenja: Carniolia) (according to Hausmann (2004: 269): misidentification, synonymy uncertain); *Geometra strigilata*: sensu Denis & Schiffermüller, 1775 (Austria: Vienna) (according to Hausmann (2004: 269): misidentification); *Phalaena tristriaria* Fabricius, 1794 (Italy); *Phalaena Geometra nemorata* Borkhausen, 1794 (Europe, probably Germany); *Geometra strigilaria* Hübner, 1799 (according to Hausmann (2004: 269): incorrect subsequent spelling of the misidentified *strigilata*: sensu Denis & Schiffermüller, 1775; *Phalaena inspersata* Schrank, 1802 (Germany, Bavaria: Ingolstadt); *Calothysanis exemptaria* Hübner, 1823 (Austria: Vienna) (according to Hausmann (2004: 269): unnecessary replacement name for *strigilaria*); *Acidalia prataria* Boisduval, 1840 (according to Hausmann (2004: 269): unnecessary replacement name for misidentified *strigilaria* Hübner); *Acidalia prataria* var. *catenaria* Bruand, 1846 (France: Doubs, Besancon).

For the list of unavailable names, see Hausmann (2004).

Material examined: 4 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂ 25–29 mm (Hausmann 2004). In Iran, *S. nigropunctata* can externally be confused only with *S. flaccidaria*, therefore its characters are compared against this species. Ground colour (Plate 5, Figs 1–2) beige, hindwings not pointed out (beige, hindwings pointed out in *S. flaccidaria*) (see Plate 5, Figs 1–2; Plate 8, Figs 3–6).

In the male genitalia 8th sternite very broad, square-like, basally straight, with thin cerata, left short, right long (not strongly broadened, basally convex, both cerata long in *S. flaccidaria*) (see Plate 13, Fig. 2; Plate 18, Figs 1–2).

In the female genitalia lamella antevaginalis big with irregular folds (ring-shaped, antrum with tulip shaped sclerite in *S. flaccidaria*) (see Plate 22, Fig. 5; Plate 25, Figs 5–6).

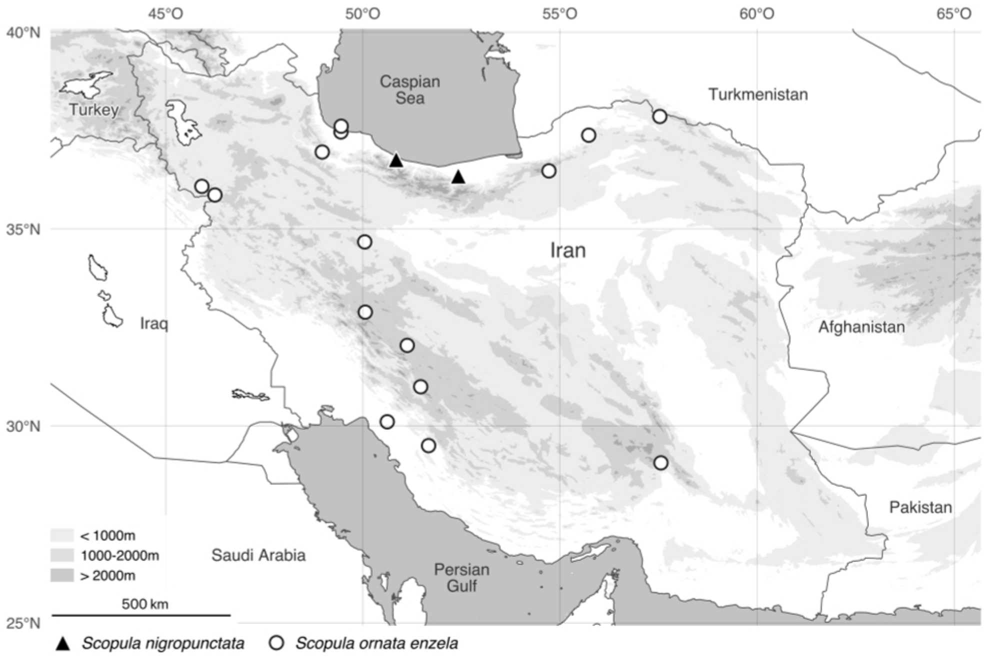
Phenology. Univoltine species, flying from mid-June to early August (Hausmann 2004). Investigated specimens in Iran were collected from August to October.

Biology. Larva polyphagous on a wide range of plant species of different families (see Hausmann 2004; Beljaev 2016; Makhov 2023).

Habitat. From 0 m to 1800 m in Europe and to 2200 m in Turkey and Transcaucasus (Hausmann 2004). Investigated specimens in Iran were collected in 250 m.

Distribution. Widely distributed from Portugal to the Urals, Mongolia, and throughout the Far East of Asia, including Korea and Japan (Hausmann 2004; Sihvonen 2005b; Choi & Kim 2016; Makhov 2023). Also distributed in Turkey, the Caucasus, Transcaucasus and Iran (Viidalepp 1996; Hausmann 2004). In Iran distributed in the northern parts (see Map 4). Reported in the literature also for the provinces Gilan, Golestan, Mazandaran (Lederer 1871; Prout 1912–1915; Prout 1921; Wiltshire 1966; Viidalepp 1996).

DNA-barcoding. Nearest species: *S. incanata* with 7.1 % (see Supplementary Table S1).



MAP 4. Distribution patterns of the *Scopula* species *S. nigropunctata* and *S. ornata enzela* in Iran.

***Scopula caesaria* (Walker, 1861)**
(Plate 5, Figs 3–7; Plate 13, Fig. 3; Plate 22, Figs 6–7).

Acidalia caesaria Walker, 1861. List of the specimens of lepidopterous insects in the collection of the British Museum 22: 750. Syntypes 5 ♂ (Ceylon [Sri Lanka]) (in NHMUK, examined).
Scopula caesaria walkeros Wiltshire, [1981], The Journal of Oman Studies, Special Report, 2: 193. Holotype ♂ (northern Oman; Mu'askar al Murtafa'a) (NMSZ).
Synonymies (for more details on nomenclature see Scoble 1999): *Acidalia faeculentaria* Mabille, 1880 (Madagascar); *Acidalia obturbata* Walker, 1861 (Ceylon [Sri Lanka]); *Acidalia perfectaria* Walker, 1861 (type locality not given); *Craspedia rufimixtaria* Warren, 1900 (Tenimber [Tanimbar] Islands: Selaru).

Type material examined. Paratype ♀, Ceylon, NHMUK 014173570, g. prep. NHMUK 012821272; in NHMUK.

Additional material examined: 4 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 17–22 mm. *Scopula caesaria* has a unique wing pattern and externally cannot be confused with any other *Scopula* species in Iran. Ground colour (Plate 5, Figs 3–7) beige to yellow, with red transverse lines.

In the male genitalia (Plate 13, Fig. 3), fibula curved, tapering. Aedeagus basally thin, broadening to the tip, vesica with rear small cornutus. 8th sternite hat-shaped, cerata absent. In the female genitalia (Plate 22, Figs 6–7) lamella antevaginalis weakly developed, centrally notched. Ductus bursae short. Signum large, numerous spines around the corpus bursae.

Phenology. Investigated specimens were collected in April (North Oman), June (South Yemen), October (Oman) and December (South Africa).

Biology. Unknown.

Habitat. Investigated specimens were collected at altitudes from 1350 m to 1400 m (South Africa), at 1500 m (South Yemen).

Distribution. Investigated specimens in this study from Ceylon (Sri Lanka), Africa, Yemen and Oman. Reported for southern Iran by Wiltshire (1980).

Remarks. While the occurrence of this species in southern Iran has been reported by Wiltshire (1980), no specimens were found for for Iran in this study. Therefore, the presence of this species in Iran awaits further confirmation.

DNA-barcoding. Nearest species: *S. immorata* with 9.1 % (see Supplementary Table S1).

***Scopula ornata* (Scopoli, 1763)**
(Plate 5, Figs 8–9; Plate 14, Fig. 1; Plate 23, Fig. 1; Map 4)

Phalaena ornata Scopoli, 1763: Entomologica Carniolica exhibens insecta Carnioliae indigena et distributa in ordines, genera, species, varietates methodo Linnaeana 9: 219. Syntype(s) lost (north-western Slovenja, Carniolia 'Mts.').

Acidalia ornata subornata Prout, 1913. In: Seitz, A. (Ed.), Die Großschmetterlinge der Erde 4: 79. Syntype(s) (Japan: Oiwake, Yokohama) (NHMUK). Valid at subspecific rank.

Scopula ornata enzela Prout, 1935. In: Seitz, A. (Ed.), Die Großschmetterlinge der Erde 4 (Supplememt): 46. Syntype(s) (Iran, Enzeli) (NHMUK, examined). Valid at subspecific rank.

Synonymies (for more details on nomenclature see Scoble 1999 and Hausmann 2004): *Phalaena instilata* Hufnagel, 1767 (Germany: Berlin); *Phalaena Geometra paludata* Linnaeus, 1767 (Portugal); *Phalaena nivearia* Fabricius, 1775 (England); *Phalaena institata* Rottemburg, 1777 (Europe); *Phalaena Geometra interrupta* Goeze, 178 (France: Paris); *Phalaena intersecta* Fourcroy, 1785 (France: Paris); *Geometra ornataria* Hübner, 1799 (according to Hausmann (2004: 275): incorrect subsequent spelling); *Pyralis paludalis* Schrank, 1802 (according to Hausmann (2004: 275): emendation of *paludata*); *Scopula cinis* Inoue, 1946 (Japan: Nagano Prefecture, Yunomata).

For the list of unavailable names, see Hausmann (2004).

Type material examined. *Scopula ornata enzela* Type 1 ♂, N.W. Persia [Iran], Enzeli, sea level, NHMUK 014173555, g. prep. 12265; **in NHMUK.**

Additional material examined: 20 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 20–27 mm. In Iran, *Scopula ornata* can externally be confused with, *S. orientalis*, *S. decorata, S. subtilata* and in rare cases maybe *S. transcaspica*, therefore characters are compared against these species only. Ground colour (Plate 5, Figs 8–9) white (similar in *S. orientalis*; creamy white in *S. decorata* and *S. subtilata*; variable in *S. transcaspica*). Forewing apex white (similar in *S. orientalis*; spotted in *S. decorata*, *S. subtilata* and *S. transcaspica*). Dotted lines of the terminal area greyish-blue (similar in *S. subtilata* and *S. transcaspica*; grayish-brown in *S. orientalis*; dark grayish-brown in *S. decorata*). Double spots along postmedial line brown (similar in *S. decorata* and *S. subtilata*; grayish-brown in *S. orientalis*; absent in *S. transcaspica*) (see Plate 5, Figs 8–15; Plate 6, Figs 1–6).

In the male genitalia socii slender (broad, rounded in *S. orientalis*; long, crossed in *S. decorata*; crossed in *S. subtilata*; broad in *S. transcaspica*). Vesica without cornutus (similar in *S. orientalis*; with one small cornutus in *S. decorata*; with one straight cornutus in *S. subtilata*; with one cornutus in *S. transcaspica*). 8th sternite longish, posteriorly broad, both cerata long and thin (sternite stout, both cerata broad, stout and strongly curved in *S. orientalis*; sternite laterally concave, right ceras long and curved, left ceras short in *S. decorata*; sternite laterally concave, both cerata medium sized in *S. subtilata*; sternite laterally concave, both cerata long, left sometimes shortened in *S. transcaspica*) (see Plate 14, Figs 1–3; Plate 15, Figs 1–3).

In the female genitalia lamella antevaginalis, anterior margin smooth, central fold V-shaped (unspectacular sclerotized in *S. orientalis*; as flat rectangular sclerite, slightly longer than wide in *S. decorata*; as flat rectangular sclerite, laterally concave in the basal half in *S. subtilata*; as flat sclerite, shape variable, rather wider than long in *S. transcaspica*). Signum elongated and narrow, consisting of small spinules (as long sclerite in *S. orientalis*; absent in *S. decorata*, *S. subtilata* and *S. transcaspica*) (see Plate 23, Figs 1–6; Plate 24, Fig. 1).

Phenology. Depending on the conditions, bi- or trivoltine species (Hausmann 2004). First generation from early May to early July, second generation from mid-July to late August or mid-September (Hausmann 2004). Investigated specimens in Iran were collected from May to September.

Biology. Larva polyphagous feeding on a wide range of plant species from different families (see Hausmann 2004; Beljaev 2016; Makhov 2023).

Habitat. In Europe found at altitudes from 0 m to 1600 m, while in Morocco, Turkey and the central Asian mountains to 2000 m (Hausmann 2004). Investigated specimens from Iran were collected at altitudes from 0 m to 2800 m.

Distribution. Widely distributed from northern Africa to the Urals, Kazakhstan, Mongolia, as well as in northwestern China, Korea and Japan (Hausmann 2004; Sihvonen 2005b; Choi & Kim 2016; Makhov 2023). Also distributed In Turkey, the Caucasus, Transcaucasus and Central Asia and Iran (Viidalepp 1996; Hausmann 2004). In Iran this species is represented by the subspecies *S. ornata enzela* and distributed in the northern parts of Iran and along the Zagros in the western parts to southern Iran (Map 4). Reported in the literature also for the provinces Azerbaijan-e Shaghi, Fars, Gilan, Golestan, Khorasan-e Razavi, Mazandaran and Sistan-o Balouchistan (Bienert 1869; Christoph 1873; Prout 1921; Brandt 1939; Sutton 1963; Barou 1967; Viidalepp 1996; Hausmann 2004, Lehmann & Zahiri 2011).

DNA-barcoding. Nearest species: *S. transcaspica* with 9.2 % (see Supplementary Table S1).

***Scopula orientalis* (Alphéraky, 1876)**

(Plate 5, Figs 10–11; Plate 14, Fig. 2; Plate 23, Fig. 2; Map 5)

Acidalia decorata var. *orientalis* Alphéraky, 1876. Trudy Russkago entomologicheskago obshchestva, 8: 197. Lectotype ♂, designated by Hausmann (2004) (southwestern European Russia, Taganrog) (in ZISP).
For the list of unavailable names, see Hausmann (2004).

Material examined: 5 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 24–29 mm (Hausmann 2004). In Iran, *Scopula orientalis* can externally be confused with *S. ornata*, *S. decorata, S. subtilata* and in rare cases maybe *S. transcaspica* in Iran. Therefore, characters are compared against these species only. Ground colour (Plate 5, Figs 10–11) white (similar in *S. ornata*; creamy white in *S. decorata* and *S. subtilata*; variable in *S. transcaspica*). Forewing apex white (similar in *S. ornata*; spotted in *S. decorata*, *S. subtilata* and *S. transcaspica*). Dotted lines of the terminal area grayish-brown (greyish-blue in *S. ornata*, *S. subtilata* and *S. transcaspica*; dark grayish-brown in *S. decorata*). Double spots along postmedial line grayish-brown (brown in *S. ornata*, *S. decorata* and *S. subtilata*; absent in *S. transcaspica*) (see Plate 5, Figs 8–15; Plate 6, Figs 1–6).

In the male genitalia socii broad, rounded (slender in *S. ornata*; long, crossed in *S. decorata*; crossed in *S. subtilata*; broad in *S. transcaspica*). Vesica without cornutus (similar in *S. ornata*; with one small cornutus in *S. decorata*; with one straight cornutus in *S. subtilata*; with one cornutus in *S. transcaspica*). 8th sternite stout, both cerata broad, stout and strongly curved (sternite longish, posteriorly broad, both cerata long and thin in *S. ornata*; sternite laterally concave, right ceras long and curved, left ceras short in *S. decorata*; sternite laterally concave, both cerata medium sized in *S. subtilata*; sternite laterally concave, both cerata long, left sometimes shortened in *S. transcaspica*) (see Plate 14, Figs 1–3; Plate 15, Figs 1–3).

In the female genitalia lamella antevaginalis, unspectacular sclerotized (anterior margin smooth, central fold V-shaped in *S. ornata*; as flat rectangular sclerite, slightly longer than wide in *S. decorata*; as flat rectangular sclerite, laterally concave in the basal half in *S. subtilata*; as flat sclerite, shape variable, rather wider than long in *S. transcaspica*). Signum as long sclerite (elongated and narrow, consisting of small spinules in *S. ornata*; absent in *S. decorata*, *S. subtilata* and *S. transcaspica*) (see Plate 23, Figs 1–6; Plate 24, Fig. 1).

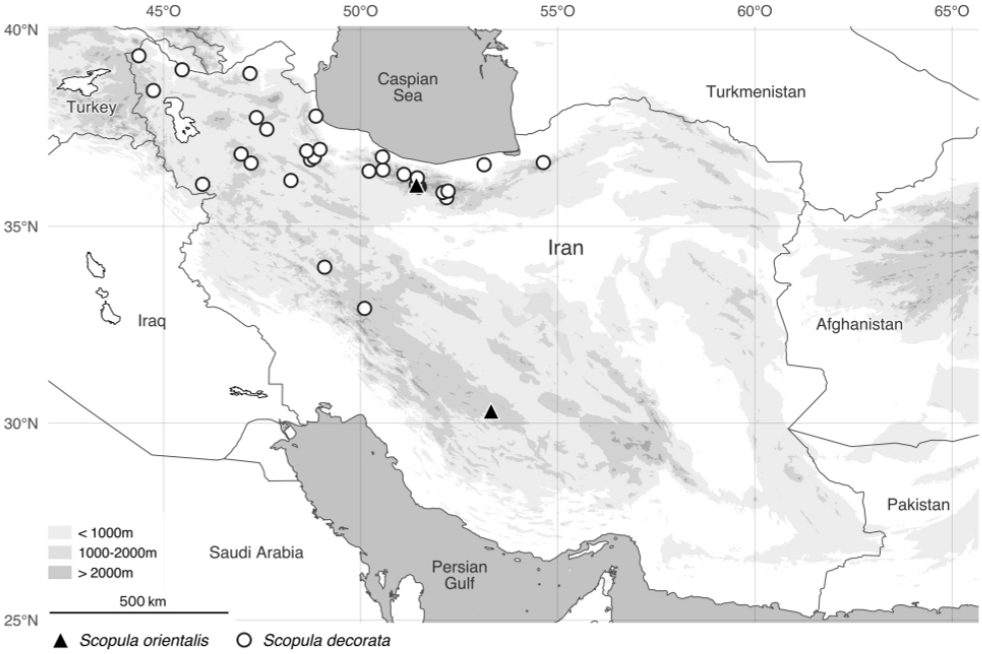
Phenology. Univoltine species, flying from mid-May to early July (Hausmann 2004). Investigated specimens in Iran were collected from June to July.

Biology. Unknown.

Habitat. In Europe from 200 m to 1100 m, in Turkey to 1800 m (Hausmann 2004). Investigated specimens in Iran were collected from 2000 m to 3200 m.

Distribution. In Europe with isolated populations in Macedonia and Bulgaria; Ukraine and south European Russia; southern Urals (Hausmann 2004). Distributed in Turkey, the Caucasus and Transcaucasus, Iran and Central Asia (Viidalepp 1996; Hausmann 2004). In Iran distributed in northern and southern parts (Map 5). Reported in the literature also for the provinces Fars, Mazandaran and Tehran (Prout 1912–1916; Brandt 1939; Schwingenschuss 1939; Wehrli 1939–1954; Sutton 1963; Lehmann & Zahiri 2011).

DNA-barcoding. Nearest species: *S. transcaspica* with 9.2 % (see Supplementary Table S1).



MAP 5. Distribution patterns of the *Scopula* species *S. orientalis* and *S. decorata* in Iran.

Scopula decorata (Denis & Schiffermüller, 1775)

(Plate 5, Figs 12–13; Plate 14, Fig. 3; Plate 23, Fig. 3; Map 5)

Geometra decorata Denis & Schiffermüller, 1775. Systematisches Verzeichniß der Schmetterlinge der Wienergegend / herausgegeben von einigen Lehrern am k. k. Theresianum: 117. Syntype(s) lost (Austria, Vienna distr.).

Geometra violata Thunberg, 1784. Diss. entomol. sistens insecta Suecica 1: 14. Lectotype ♂ (Sweden: Uppland) (UZIU). Valid at subspecific rank.

Idaea decorata congruata Zeller, 1847. Isis 1847 (7): 508. Syntypes (Sicily: Syracus) (MNHU, NHMUK). Valid at subspecific rank.

Acidalia violata var. *armeniaca* Thierry-Mieg, 1916. Misc. ent. 23: 52. Syntype(s) ♂ (Armenia: Kirghiz) (MNHN). Valid at subspecific rank.

Scopula decorata eurhythma Prout, 1935. In: Seitz, A. (Ed.), Die Großschmetterlinge der Erde 4 (Supplememt): 47. Holotype ♂ (China, Shantung Promontory: Wei-hai-wei) (NHMUK). Valid at subspecific rank.

Scopula decorata przewalskii Viidalepp, 1975. Nasekom. Mongol. 3 (6): 446. Holotype ♂ (Mongolia, central Aimak: 125 km S Ulan Bator). Valid at subspecific rank.

Synonymies (for more details on nomenclature see Scoble 1999 and Hausmann 2004): *Phalaena cinerata* Fabricius, 1787 (Germany); *Phalaena Geometra caerulata* Gmelin, 1790 (Sweden); *Geometra decoraria* Hübner, 1799 (according to Hausmann (2004: 280): incorrect subsequent spelling); *Idaea congruaria* Heydenreich, 1851 according to Hausmann (2004: 280): incorrect subsequent spelling); *Acidalia ornata* var.? *aequata* Staudinger, 1879 (northern Turkey, Pontus: Amasia); *Acidalia decorata* var. *leukiberica* Wehrli, 1927 (Spain. Castilia: Escorial); *Acidalia decorata* var. *rebeli* Drenowski, 1930 (Bulgaria: Alibotusch-Bereng); *Scopula decorata* f. *drenowskii* Sterneck, 1941 (Bulgaria: Alibotusch).

For the list of unavailable names, see Hausmann (2004).

Material examined: 105 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 20–29 mm. In Iran, *Scopula decorata* can externally be confused with *S. ornata*, *S. orientalis, S. subtilata* and in rare cases maybe with *S. transcaspica*. Therefore, characters are compared against these species only. Ground colour (Plate 5, Figs 12–13) creamy white (similar in *S. subtilata*; white in *S. ornata* and *S. orientalis*; variable in *S. transcaspica*). Forewing apex spotted (similar in *S. subtilata* and *S. transcaspica*; white in *S. ornata* and *S. orientalis*). Dotted lines of the terminal area, dark grayish-brown (greyish-blue in *S. ornata*, *S. subtilata* and *S. transcaspica*; grayish-brown in *S. orientalis*). Double spots along postmedial line brown (similar in *S. ornata* and *S. subtilata*; grayish-brown in *S. orientalis*; absent in *S. transcaspica*) (see Plate 5, Figs 8–15; Plate 6, Figs 1–6).

In the male genitalia socii long, crossed (slender in *S. ornata*; broad, rounded in *S. orientalis*; crossed in *S. subtilata*; broad in *S. transcaspica*). Vesica with one small cornutus (without cornutus in *S. ornata* and *S. orientalis*; with one straight cornutus in *S. subtilata*; with one cornutus in *S. transcaspica*). 8th sternite laterally concave, right ceras long and curved, left ceras short (sternite longish, posteriorly broad, both cerata long and thin in *S. ornata*; sternite stout, both cerata broad, stout and strongly curved in *S. orientalis*; sternite laterally concave, both cerata medium sized in *S. subtilata*; sternite laterally concave, both cerata long, left sometimes shortened in *S. transcaspica*) (see Plate 14, Figs 1–3; Plate 15, Figs 1–3).

In the female genitalia lamella antevaginalis as flat rectangular sclerite, slightly longer than wide (anterior margin smooth, central fold V-shaped in *S. ornata*; unspectacular sclerotized in *S. orientalis*; as flat rectangular sclerite, laterally concave in the basal half in *S. subtilata*; as flat sclerite, shape variable, rather wider than long in *S. transcaspica*). Signum absent (similar in *S. subtilata* and *S. transcaspica*; elongated and narrow, consisting of small spinules in *S. ornata*; as long sclerite in *S. orientalis*) (see Plate 23, Figs 1–6; Plate 24, Fig. 1).

Phenology. Bivoltine species from early May to early September, with a third generation under good conditions (Hausmann 2004). Investigated specimens in Iran were collected from May to August.

Biology. Larva feeding mainly on *Thymus*, *Melissa*, but also reared on *Origanum vulgare* (Sobczyk & Gelbrecht 2004; Hausmann 2004; Beljaev 2016; Makhov 2023).

Habitat. In Europe at altitudes from 0 m to 1600 m, to 2300 m in Morocco, to 3100 m in Turkey and Iran (Hausmann 2004). Investigated specimens in Iran were collected from 100 m to 3000 m.

Distribution. Widely distributed from northern Africa, and Portugal to the Urals, Kazhakhstan, Mongolia and the Far East of Asia, inculding Japan (Hausmann 2004; Makhov 2023). In Turkey, the Caucasus, Transcaucasus and the central Asian mountains, as well as in western and eastern China, northern Mongolia and Dahuria (Viidalepp 1996; Hausmann 2004; Sihvonen 2005b). In Iran distributed in the north-western parts (see Map 5). Reported in the literature also for the provinces Fars, Golestan, Semnan and Tehran (Christoph 1873; Lederer 1871; Lehmann & Zahiri 2011; Hausmann 2004).

DNA-barcoding. Nearest species: *S. incanata* with 7.4 % (see Supplementary Table S1).

Scopula subtilata **(Christoph, 1867)**

(Plate 5, Figs 14–15; Plate 15, Fig. 1; Plate 23, Fig. 4)

Acidalia subtilata Christoph, 1867. Stettiner Entomologische Zeitung, 28 (4–6): 236. Lectotype ♂ ([Russia]: Krasnoarmeysk, Sarepta [Volgograd]) (ZISP). Lectotype designated by Hausmann (2004).

Material examined: 3 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 22–27 mm (Hausmann 2004). In Iran, *Scopula subtilata* can externally be confused with, *S. ornata*, *S. orientalis, S. decorata* and in rare cases maybe *S. transcaspica*. Therefore, characters are compared against these species only. Ground colour (Plate 5, Figs 14–15) creamy white (similar in *S. decorata*; white in *S. ornata* and *S. orientalis*; variable in *S. transcaspica*). Forewing apex spotted (similar in *S. decorata* and *S. transcaspica*; white in *S. ornata* and *S. orientalis*). Dotted lines of the terminal area greyish-blue (similar in *S. ornata* and *S. transcaspica*; grayish-brown in *S. orientalis*; dark grayish-brown in *S. decorata*). Double spots along postmedial line brown (similar in *S. ornata* and *S. decorata*; grayish-brown in *S. orientalis*; absent in *S. transcaspica*) (see Plate 5, Figs 8–15; Plate 6, Figs 1–6).

In the male genitalia socii crossed (slender in *S. ornata*; broad, rounded in *S. orientalis*; long, crossed in *S. decorata*; broad in *S. transcaspica*). Vesica with one straight cornutus (without cornutus in *S. ornata* and *S. orientalis*;

with one small cornutus in *S. decorata*; with one cornutus in *S. transcaspica*). 8th sternite laterally concave, both cerata medium sized (sternite longish, posteriorly broad, both cerata long and thin in *S. ornata*; sternite stout, both cerata broad, stout and strongly curved in *S. orientalis*; sternite laterally concave, right ceras long and curved, left ceras short in *S. decorata*; sternite laterally concave, both cerata long, left sometimes shortened in *S. transcaspica*) (see Plate 14, Figs 1–3; Plate 15, Figs 1–3).

In the female genitalia lamella antevaginalis as flat rectangular sclerite, laterally concave in the basal half (anterior margin smooth, central fold V-shaped in *S. ornata*; unspectacular sclerotized in *S. orientalis*; as flat rectangular sclerite, slightly longer than wide in *S. decorata*; as flat sclerite, shape variable, rather wider than long in *S. transcaspica*). Signum absent (similar in *S. decorata* and *S. transcaspica*; elongated and narrow, consisting of small spinules in *S. ornata*; as long sclerite in *S. orientalis*) (see Plate 23, Figs 1–6; Plate 24, Fig. 1).

Phenology. Bivoltine species with a first generation from late May to late June and a second generation from August to September (Hausmann 2004).

Biology. Unknown.

Habitat. At altitudes from 0 to 300 m (Hausmann 2004).

Distribution. Distributed from southern Urals, southern European Russia and eastern Ukraine, northeastern Kazakhstan, Siberia and Turkmenia (Viidalepp 1996; Hausmann 2004). Reported to be present in northern Iran (see Remarks) (Viidalepp 1988; Hausmann 2004).

DNA-barcoding. Nearest species: *S. transcaspica* with 7.3 % (see Supplementary Table S1).

Remarks. The occurrence in province Khorasan-e Shomali has been reported by Viidalepp (1988). A possible confusion with *S. decorata* can´t be ruled out. The distribution of this species in Iran is awaiting further confirmation.

Scopula transcaspica Prout, 1935

(Plate 6, Figs 1–6; Plate 15, Figs 2–3; Plate 23, Figs 5–6; Map 6)

Scopula submutata transcaspica Prout, 1935. In: Seitz, A. (Ed.), Die Großschmetterlinge der Erde. Supplement zu Band 4: 40. Syntypes 2 ♀ (NHMUK) ([Turkmenistan]: Ashkhabad). Raised from subspecies to species rank by Hausmann & Lászlò (1999).

Scopula submutata taftanica Brandt, 1941. Mitteilungen der Münchner Entomologischen Gesellschaft, 31 (3): 867. Syntype(s) (Iran: Kouh i Taftan) (NHRS examined). Regarded as subspecies of *S. transcaspica* by Hausmann (2004). Here regarded as synonym based on morphological examination and sympatric occurrence of these forms.

Type material examined. *Scopula submutata transcaspica* 1 ♀, Aschabad [Ashkhabad], NHMUK 014173554, g. prep. NHMUK 010317468; **in NHMUK.**

Scopula submutata taftanica Holotype ♂, Iran, Balouchistan, Kouh i Taftan (Khach), 2500 m, 22.v.1938, coll. Brandt, NHRS-LEPI 000010274, g. prep. 11021; Paratype [labelled as Allotype] ♀, same data, but 6.vi.1938, coll. Brandt, NHRS-LEPI 000010275, g. prep. 11022.

Additional material examined: 239 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 18–27 mm. In Iran, *Scopula transcaspica* can externally be confused with *S. ornata*, *S. orientalis, S. decorata, S. subtilata* and also *Scopuloides origalis*, therefore characters are compared against these species only. Ground colour (Plate 6, Figs 1–6) variable from greyish- or creamy-white to yellowish-brown (similar in white in *S. ornata* and *S. orientalis*; creamy white in *S. decorata* and *S. subtilata*). Forewing apex spotted (similar in *Scopuloides origalis*; in *S. decorata* and *S. subtilata*; white in *S. ornata* and *S. orientalis*). Dotted lines of the terminal area greyish-blue (similar in *S. ornata*, *S. subtilata* and *Scopuloides origalis*; grayish-brown in *S. orientalis*; dark grayish-brown in *S. decorata*). Double spots along postmedial line absent (similar in *Scopuloides origalis*; brown in *S. ornata*, *S. decorata* and *S. subtilata*; grayish-brown in *S. orientalis*) (see Plate 3, Figs 11–16; Plate 5, Figs 8–15; Plate 6, Figs 1–6).

In the male genitalia socii broad (slender in *S. ornata*; broad, rounded in *S. orientalis*; long, crossed in *S. decorata*; crossed in *S. subtilata*, strongly shortened in *Scopuloides origalis*). Vesica with one cornutus (without cornutus in *S. ornata* and *S. orientalis*; with one small cornutus in *S. decorata*; with one straight cornutus in *S. subtilata*; with one small and thin cornutus in *Scopuloides origalis*). 8th sternite laterally concave, both cerata long, left sometimes shortened (sternite longish, posteriorly broad, both cerata long and thin in *S. ornata*; sternite stout, both cerata broad, stout and strongly curved in *S. orientalis*; sternite laterally concave, right ceras long and curved, left ceras short in *S. decorata*; sternite laterally concave, both cerata medium sized in *S. subtilata*; sternite with a long left ceras, apically curved, right cera short in *Scopuloides origalis*) (see Plate 10, Fig. 7; Plate 14, Figs 1–3; Plate 15, Figs 1–3).

In the female genitalia lamella antevaginalis as flat sclerite, shape variable, rather wider than long (anterior margin smooth, central fold V-shaped in *S. ornata*; unspectacular sclerotized in *S. orientalis*; as flat rectangular sclerite, slightly longer than wide in *S. decorata*; as flat rectangular sclerite, laterally concave in the basal half in *S. subtilata*; as flat trapezoidal sclerite in *Scopuloides origalis*). Signum absent (similar in *S. decorata*, *S. subtilata* and *Scopuloides origalis*; elongated and narrow, consisting of small spinules in *S. ornata*; as long sclerite in *S. orientalis*) (see Plate 21, Fig. 6; Plate 23, Figs 1–6; Plate 24, Fig. 1).

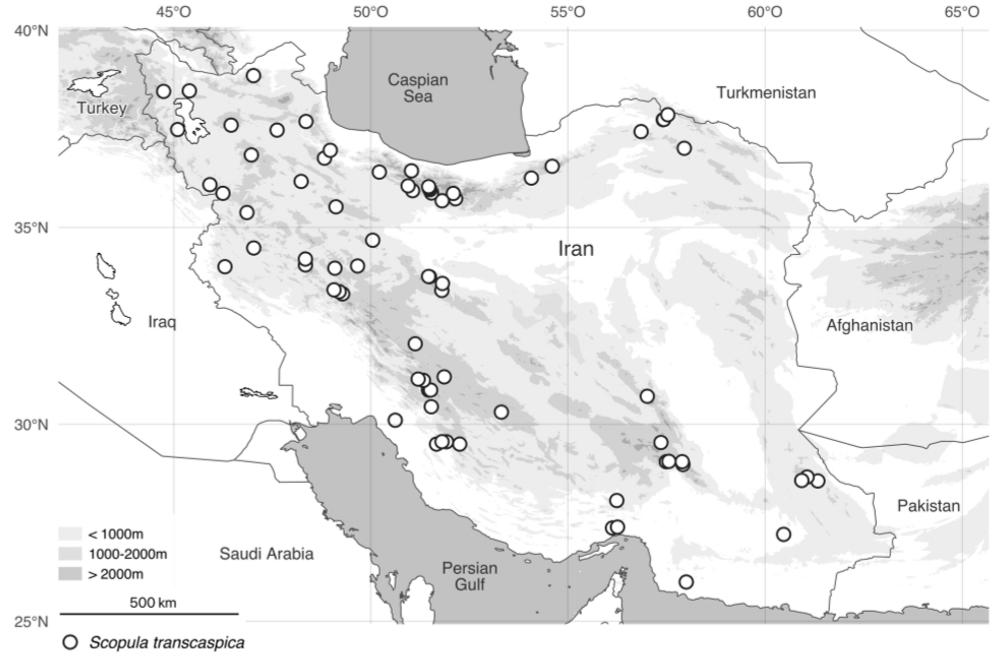
Phenology. Investigated specimens in Iran were collected from March to August.

Biology. Unknown, but most likely feeding on similar plants (*Thymus vulgaris*, *Dorycnium*) than its sister species *S. submutata* (Hausmann 2004).

Habitat. Investigated specimens in Iran were collected from 19 m to 3000 m.

Distribution. Distributed from Turkey to Transcaucasus to Turkmenia, Iran, Afghanistan and Pakistan (Viidalepp 1996; Hausmann 2004). Widely distributed in Iran, in the northern, western and southern parts (Map 6). Reported in the literature also for the provinces Azerbaijan-e Sharghi, Fars, Golestan, Hormozgan, Khorasan-e Razavi, Khorasan-e Shomali, Mazandaran, Semnan, Sistan-o-Baluchestan and Tehran (Christoph 1876–1877; Lederer 1871; Schwingenschuss 1939; Brandt 1939; Brandt 1941; Sutton 1963; Wiltshire 1966; Viidalepp 1988; Wieser *et al.* 2002; Hausmann 2004; Lehmann & Zahiri 2011).

DNA-barcoding. Nearest species: *S. vigilata* Prout, 1913 with 5.5 % (see Supplementary Table S1).



MAP 6. Distribution pattern of *Scopula transcaspica* in Iran.

Scopula rubiginata (Hufnagel, 1767)

(Plate 6, Figs 7–8; Plate 16, Fig. 1; Plate 24, Fig. 2)

Scopula rubiginata Hufnagel, 1767. Berlinisches Magazin, 4 (6): 610. Syntype(s) lost (Germany, Berlin).
Geometra rubricata Denis & Schiffermüller, 1775. Systematisches Verzeichniß der Schmetterlinge der Wienergegend: 110. Syntype(s) lost. (Austria: Vienna).

Synonymies (for more details on nomenclature see Scoble 1999 and Hausmann 2004): *Geometra vittata* Thunberg, 1784 (Sweden, Uppland: Uppsala); *Phalaena domialla* Fourcroy, 1785 (France: Paris); *Phalaena Geometra variata* Villers, 1789 (France, Bresse near Lyon); *Geometra rubricaria* Hübner, 1799 (according to Hausmann (2004: 292): incorrect subsequent spelling); *Idaea subangularia* Herrich-Schäffer, 1839 (Germany).
For the list of unavailable names, see Hausmann (2004).

Material examined: 5 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 16–22 mm (Hausmann 2004). In Iran *Scopula rubiginata* can externally be confused only with *S. turbulentaria*, therefore characters are compared against this species. Ground colour (Plate 6, Figs 7–8) ariable, from light brown to orange brown (variable beige or light ocher to darker ocher in *S. turbulentaria*) (see Plate 6, Figs 7–14). In the male genitalia this species can be confused with *S. turbulentaria* (see Plate 16, Figs 1–2). In the female genitalia triangular sclerite attached to antrum (without triangular sclerite in *S. turbulentaria*) (see Plate 24, Figs 2–3).

Phenology. Bivoltine species with overlapping generations from mid-May to mid-September (Hausmann 2004).

Biology. Larva oligophagous on a wide range of plant species of different families (e.g., Fabaceae, Lamiaceae, Ericaceae, Asteraceae) (see Hausmann 2004; Beljaev 2016; Makhov 2023).

Habitat. In Europe at altitudes from 0 to 1000 m and outside of Europe to 2200 m (Hausmann 2004).

Distribution. Widely distributed from Morocco, and Portugal to the Urals (Hausmann 2004). Distrubuted in Turkey, the Caucasus, Transcaucasus, the central Asian mountains and Mongolia (Viidalepp 1996; Hausmann 2004; Makhov 2023). In Iran reputedly reported from the province Azerbaijan-e Sharghi by Lehmann & Zahiri (2011).

DNA-barcoding. Nearest species: *S. halimodendrata* (Erschoff, 1874) with 5.5 % (see Supplementary Table S1).

Remarks. The occurrence in province Azerbaijan-e Sharghi has been reported by Lehmann & Zahiri (2011). However, it is possible that there is confusion with *Scopula turbulentaria steinbacheri* and the distribution of this species in Iran requires further confirmation.

***Scopula turbulentaria* (Staudinger, 1870)**
(Plate 6, Figs 9–14; Plate 16, Fig. 2; Plate 24, Fig. 3; Map 7)

Acidalia turbidaria var. *turbulentaria* Staudinger, 1870. Horae Societatis Entomologicae Rossicae, variis sermonibus in Rossia usitatis editae, 7: 151. Syntypes 1 ♂ 2 ♀ (Greece, Attika).
Scopula turbidaria steinbacheri Prout, 1935. In: Seitz, A. (Ed.), Die Großschmetterlinge der Erde 4 (Supplememt): 36. Syntype(s) 15 (Iran, Elburs Mts., Mazanderan, Sabatku, Darekeroudbar) (NHMUK, examined). Valid at subspecific rank.
Synonymies (for more details on nomenclature see Scoble 1999 and Hausmann 2004): *Craspedia collata* Warren, 1901 (Lebanon: Beirut); *Craspedia habenata* Warren, 1901(Lebanon: Beirut); *Acidalia immutata* var. *syriacata* Neuburger, 1904 (Lebanon); *Acidalia turbidaria syriturcica* Wehrli, 1934 (ZFMK).
For the list of unavailable names, see Hausmann (2004).

Type material examined. *Scopula turbidaria steinbacheri* Syntype 1 ♂, Iran, Darekeroudbar, Sabatku, Mazandaran, Elburs Mts., 21.v.1931, F. Steinbacher, NHMUK 014173562; Syntype 1 ♂, same data, but 17.v.1931, NHMUK 014173563, g. prep. NHMUK 010317469; Syntype 1 ♂, same data, but 23.vii.1931, NHMUK 014173564, g. prep. NHMUK 010317470; all in NHMUK.

Additional material examined: 28 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 18–23 mm. In Iran *Scopula turbulentaria* can externally be confused only with *S. rubiginata*, therefore characters are compared against this species. Ground colour (Plate 6, Figs 9–14) variable beige or light ocher to darker ocher (variable, from light brown to orange brown in *S. rubiginata*) (see Plate 6, Figs 7–14). In the male genitalia this species can be confused with *S. rubiginata* (see Plate 16, Figs 1–2). In the female genitalia without triangular sclerite (with triangular sclerite attached to antrum in *S. rubiginata*) (see Plate 24, Figs 2–3).

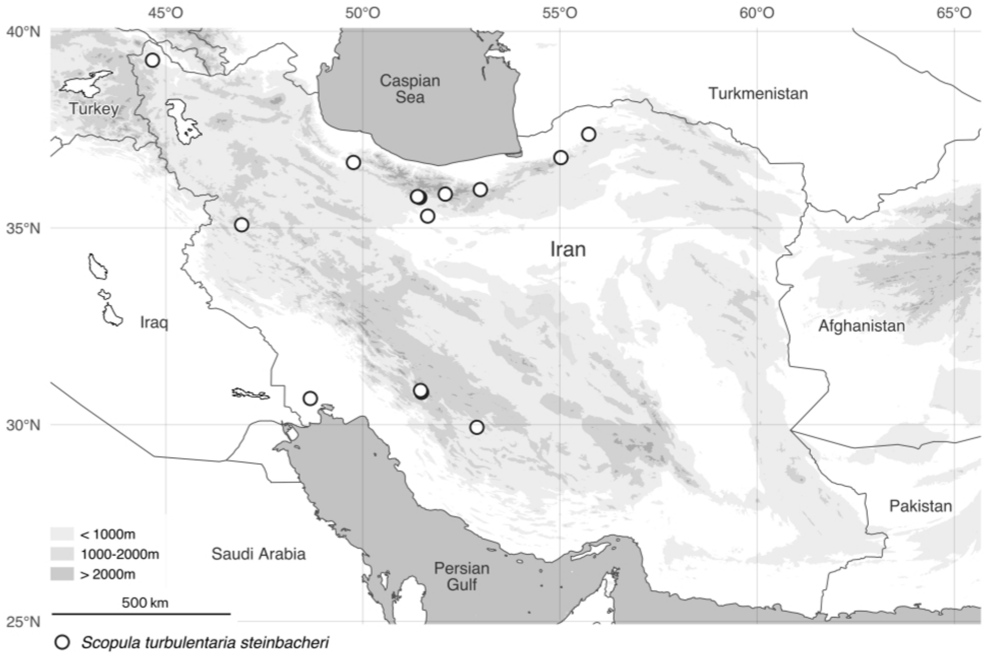
Phenology. Bi- or trivoltine in Europe (Hausmann 2004). In the Levant, bivoltine, with the first generation from late April to early July and a second generation from late October to later November (Hausmann *et al.* 2020). Investigated specimens in Iran were collected from March to October.

Biology. Food plants in Iran unknown. In Europe known to be a pest species on tobacco in southern Italy and reared on *Plantago lanceolata* (Sannino & Espinosa 1999). Pupation takes place in the ground (Hausmann 2004). In the Levant possibly polyphagous (Hausmann *et al.* 2020).

Habitat. In Levant from -400 m to 1000 m (Hausmann *et al.* 2020). Investigated specimens in Iran were collected from 510 m to 2800 m.

Distribution. In Europe with East-Mediterranean distribution (Hausmann 2004). In Tunisia, Turkey and southern Transcaucasus and central and northern parts of Israel (Hausmann 2004; Hausmann *et al.* 2020). In Iran this species is represented by the subspecies *S. turbulentaria steinbacheri* distributed in the northern, western and southern parts (Map 7). Reported in the literature also for the provinces Azerbaijan-e Sharghi, Mazandaran and Tehran (Prout & Wehrli 1932–1953; Schwingenschuss 1939; Lehmann & Zahiri 2011).

DNA-barcoding. Nearest species: *S. halimodendrata* with 5.2 % (see Supplementary Table S1).



MAP 7. Distribution pattern of *Scopula turbulentaria steinbacheri* in Iran.

Scopula imitaria (Hübner, 1799)

(Plate 6, Figs 15–16; Plate 16, Fig. 3; Plate 24, Fig. 4)

Geometra imitaria Hübner, 1799. Sammlung europäischer Schmetterlinge 5, Geometrae (1). Syntype(s) lost (Europe).

Acidalia syriacaria Culot, 1918: Noctuelles et Géomètres d'Europe 3: pl. 12, Fig. 246. Syntype(s) (Syria) (ZFMK). Valid at subspecific rank.

Synonymies (for more details on nomenclature see Scoble 1999 and Hausmann 2004): *Phalaena fimbriata* Fourcroy, 1785 (France: Paris).

For the list of unavailable names, see Hausmann (2004).

Material examined: 4 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 22–26 mm (Hausmann 2004). *Scopula imitaria* externally cannot be confused with any other Iranian *Scopula* species (see Remarks). Ground colour (Plate 6, Figs 15–16) variable, from beige, orange to light brown. Transversal lines well pronounced. In the male genitalia (Plate 16, Fig. 3) 8th sternite basally protruding, cerata variable in length. In the female genitalia (Plate 24, Fig. 4) antrum with trapezoid sclerite. Lamella antevaginalis strongly sclerotized. Signum long and narrow.

Phenology. Generally, bivoltine species, with a first generation from mid-May to early July and a second generation from early August to mid-September (Hausmann 2004). Depending on where the populations occur, with a different number of generations, e.g., tri- or plurivoltine in the Levant (Hausmann 2004, Hausmann *et al.* 2020).

Biology. Larva polyphagous on a wide range of plant species of different families (e.g., Ranunculaceae, Oleaceae, Fabaceae, Asteraceae) (see Hausmann 2004).

Habitat. Found at altitudes from 0 m to 1000 m, to 1400 m in southern Europe and Morocco and to 1500 m in the Levant (Hausmann 2004; Hausmann *et al.* 2020).

Distribution. A sub-mediterranean distribution from northern Africa, Portugal to Crimea, including the British Isles (Hausmann 2004). In Turkey, Cyprus and the Levant (Hausmann 2004; Hausmann *et al.* 2020). Although reported for the Caucasus, northern Transcaucasus and northern Iran, confirmation is still needed (Viidalepp 1996; Hausmann 2004). If this species occurs in Iran, it would be represented by the subspecies *Scopula imitaria syriacaria,* but we cannot confirm its occurrence in Iran (see Remarks).

DNA-barcoding. Nearest species: *S. flaccidaria* with 5.3 % (see Supplementary Table S1).

Remarks. Although Viidalepp (1996) reported this species as an element of the Iranian fauna, we were unable to trace any specimens during our investigation. It is possible that this species does not occur in Iran, and the report may be a confusion with *Timandra comae*.

***Scopula beckeraria* (Lederer, 1853)**

(Plate 7, Figs 1–6; Plate 16, Fig. 4; Plate 24, Fig. 5; Map 8)

Acidalia beckeraria Lederer, 1853. Verhandlungen der Zoologisch-Botanischen Gesellschaft in Wien 3: 258 (174). Syntypes 1 ♂ 2 ♀ (Sarepta), 2 (Elizabethpol) (MNHU).

Acidalia beckeraria assimilaria Prout, 1913. In: Seitz, A. (Ed.), Die Großschmetterlinge der Erde 4: 62. Holotype ♀ (Central Asia, Ferghana: Alai Mts.) (MNHU). Valid at subspecific rank.

Acidalia beckeraria amataria Wehrli, 1927. In Bang-Haas Horae macrolep. Reg. pal. 1: 92. Syntypes 2♂ (central Russia: Sajan Mts., Tunkinsk Weissgebirge SW Irkutsk) (ZFMK). Valid at subspecific rank.

Acidalia rebeli Prout, 1913. In: Seitz, A. (Ed.), Die Großschmetterlinge der Erde 4: 62. Lectotype ♂ (Croatia, Dalmatia, Zadar) (NHMV). Lectotype desiganted by Hausmann (2004). Valid at subspecific rank.

Scopula beckeraria hermonicola Hausmann, 1997. Entomofauna 18 (1): 6. Holotype ♂ (Northern Israel: Sede Nehamya) (ZSM, examined). Valid at subspecific rank.

Synonymies (for more details on nomenclature see Scoble 1999 and Hausmann 2004): *Scopula pseudoafghana* Ebert, 1965 (Afghanistan: Bamian).

For the list of unavailable names, see Hausmann (2004).

Material examined: 474 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 20–28 mm. In Iran *S. beckeraria* can be confused externally with *S. hoerhammeri*, and rarely also with *S. marginepunctata*. Therefore, characters are compared against these two species only. Ground colour (Plate 7, Figs 1–6) beige to darker yellowish-brown (yellowish-brown *S. hoerhammeri*; dirty grey white *S. marginepunctata*). Postmedial line well pronounced, medial line diffuse (similar in *S. hoerhammeri*; diffuse in *S. marginepunctata*) (see Plate 7, Figs 1–8, 11–15).

In the male genitalia 8th sternite basally convex, laterally concave, cerata medium sized (sternite basally convex, right ceras long, left ceras short in *S. hoerhammeri*; sternite basally shallow, cerata absent in *S. marginepunctata*) (see Plate 16, Figs 4–5; Plate 17, Fig. 2).

In the female genitalia antrum with sub-rectangular sclerite, apically notched (with sub-triangular sclerite, basally notched in *S. hoerhammeri*; with triangular or half-moon shaped sclerite in *S. marginepunctata*). Lamella antevaginalis strongly sclerotized, with transverse fold (strongly sclerotized, oval in *S. hoerhammeri*; with transverse fold in *S. marginepunctata*) (see Plate 24, Figs 5–6; Plate 25, Fig. 2).

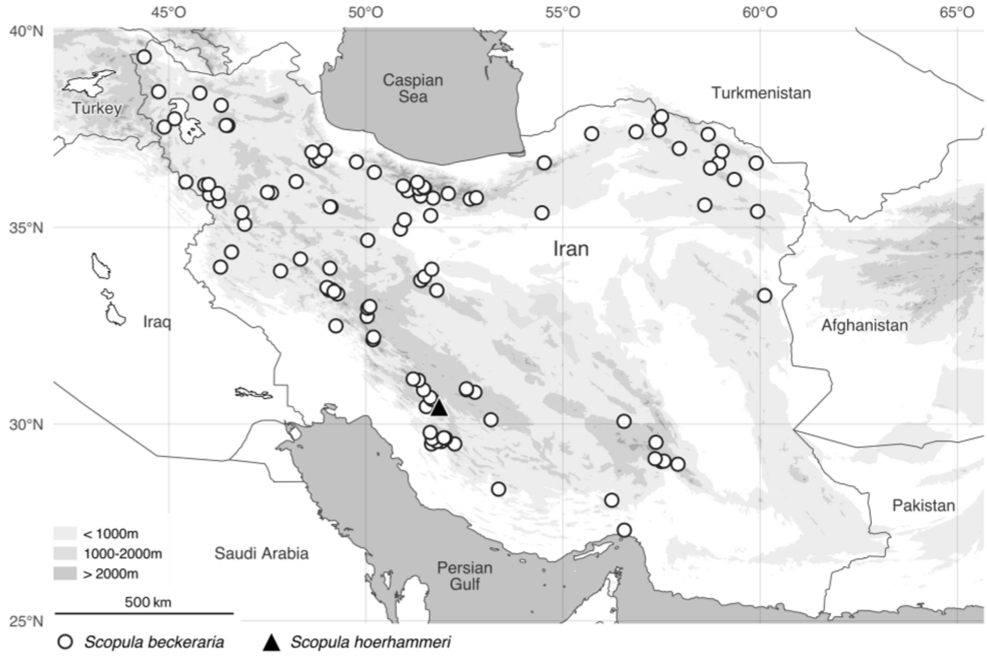
Phenology. Usually bivoltine, in Europe with a first generation from mid-May to early July and a second generation from late July to early September (Hausmann 2004). Rarely trivoltine from early April to mid-October (Hausmann 2004). Wiltshire (1943) reported two generations, one in spring and one in autumn and a mid-summer flight in the Iranian province Fars. Investigated specimens in Iran were collected from March to October.

Biology. Data for host plants rare. Larva on *Taraxacum officinale* (Hausmann 2004).

Habitat. From 0 m to 200 m in European Russia, to 1500 m in Israel and to 3500 m in Central Asia (Hausmann 2004, Hausmann *et al.* 2020). Investigated specimens in Iran were collected from 250 m to 3000 m.

Distribution. In Europe distributed in Macedonia, Greece, Bulgaria, southern European Russia and southern Urals (Hausmann 2004). Distributed in Turkey, Levant, Transcaucasus, northwestern India, the central Asian mountains and north western China (Viidalepp 1996; Hausmann 2004; Sihvonen 2005b; Hausmann *et al.* 2020; Makhov 2023). Widely distributed also in Iran, in the northern, western and southern parts (Map 8). Reported in the literature also for the provinces Ardabil, Fars, Kermanshah, Khorasan-e Razavi, Khorasan-e Shomali, Khuzestan, Mazandaran, Semnan and Tehran (Christoph 1873; Romanoff 1885; Schwingenschuss 1939; Brandt 1939; Brandt 1941; Wiltshire 1941; Sutton 1963; Wiltshire 1966; Barou 1967; Kalali 1976; Viidalepp 1988; Viidalepp 1996; Hausmann 2004; Lehmann & Zahiri 2011).

DNA-barcoding. Nearest species: *S. harteni* Hausmann, 2009 with 4.6 % (see Supplementary Table S1).



MAP 8. Distribution patterns of the *Scopula* species *S. beckeraria* and *S. hoerhammeri* in Iran.

Scopula hoerhammeri Brandt, 1941

(Plate 7, Figs 7–8; Plate 16, Fig. 5; Plate 24, Fig. 6; Map 8)

Scopula hoerhammeri Brandt, 1941. Mitteilungen der Münchner Entomologischen Gesellschaft, 31 (3): 867. Syntypes ♂, ♀ (Iran, Fars, Barm-i-Firus) (in NHRS, examined).

Type material examined. Paratype 1 ♂, Iran, Fars, Straße, Ardekan–Talochosroe [Ardakan–Talle Khosrow], Comé [Komehr], 3750 m, 4.vii.1937, coll. Brandt, NHRS-LEPI 000010272, g. prep. 11019; Paratype 1 ♀, same data, but 3700 m, NHRS-LEPI 000010273, g. prep. 11020; in NHRS.

Diagnosis. Wingspan ♂ 28 mm, ♀ 26 mm. In Iran *Scopula hoerhammeri* can be confused externally with *S. beckeraria*, and rarely also with *S. marginepunctata*, therefore here it is compared against these two species only. Ground colour (Plate 7, Figs 7–8) yellowish-brown (beige to darker yellowish-brown in *S. beckeraria*; dirty grey white *S. marginepunctata*). Postmedial line well pronounced, medial line diffuse (similar in *S. beckeraria*; diffuse in *S. marginepunctata*) (see Plate 7, Figs 1–8, 11–15).

In the male genitalia 8th sternite basally convex, right ceras long, left ceras short (sternite basally convex, laterally concave, cerata medium sized in *S. beckeraria*; sternite basally shallow, cerata absent in *S. marginepunctata*) (see Plate 16, Figs 4–5; Plate 17, Fig. 2).

In the female genitalia antrum with sub-triangular sclerite, basally notched (with sub-rectangular sclerite, apically notched in *S. beckeraria*; with triangular or half-moon shaped sclerite in *S. marginepunctata*). Lamella antevaginalis strongly sclerotized, oval (strongly sclerotized, with transverse fold in *S. beckeraria*; with transverse fold in *S. marginepunctata*) (see Plate 24, Figs 5–6; Plate 25, Fig. 2).

Phenology. Investigated specimens in Iran were collected in July.

Biology. Unknown.

Habitat. Investigated specimens were collected at altitudes from 3700 m to 3750 m.

Distribution. Endemic species to southern Iran (Fars province) (see Map 8).

DNA-barcoding. No data available.

***Scopula incanata* (Linnaeus, 1758)**

(Plate 7, Figs 9–10; Plate 17, Fig. 1; Plate 25, Fig. 1; Map 9)

Phalaena Geometra incanata Linnaeus, 1758. Caroli Linnaei...Systema naturae per regna tria naturae: secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis (Ed. 10) 1: 528 (Europe). Syntypes (Europe) (LSL).

Acidalia incanata ibericata Reisser, 1935. Entomologische Rundschau, 53 (5): 78. Syntypes ca. 50 ♂, 8 ♀ (central Spain: Sierra de Gredos) (in MNCN, NHMUK, NHMV, SMNK, ZSM). Valid at subspecific rank.

Acidalia incanata albida Silbernagel, 1944. Zeitschrift der Wiender entomologischen Gesellschaft, 29: 154. Syntypes ♂♀ (Macedonia: Istok). Valid at subspecific rank.

Scopula incanata rubeni Viidalepp, 1979. Uchen. Zap. Tartu gos. Univ. 12 (483): 85. Holotype ♂ (Russia: Tuva: Kyzyl) (IZBE). Valid at subspecific rank.

Synonymies (for more details on nomenclature see Scoble 1999 and Hausmann 2004): *Phalaena variegata* Scopoli, 1763 (north-western Slovenia: Carniolia); *Phalaena mediata* Fabricius, 1776 (Germany) (ZMUC); *Phalaena Geometra planata* Villers, 1789 (southern France); *Arrhostia incanaria* Hübner, 1825 (according to Hausmann (2004: 307): emendation, partly misidentified); *Idaea mutata* Treitschke, 1828 (Austria: Styria; Croatia; Hungary); *Acidalia mutataria* Duponchel, 1830 (according to Hausmann (2004: 307): emendation); *Acidalia adjunctaria* Boisduval, 1840 (Italy: Lombardian Alps); *Dosithea demutaria* Bruand, 1846 (France, Doubs: Besancon).

For the list of unavailable names, see Hausmann (2004).

Material examined: 12 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 24–30 mm (Hausmann 2004). Ground colour (Plate 7, Figs 9–10) light grey to darker grey, transversal lines diffuse. In Iran *Scopula incanata* can externally be confused only with *S. marginepunctata*. Therefore, here these two species are diagnosed based on their genitalia characters. In the male genitalia 8th sternite basally convex, cerata medium sized (sternite basally shallow, cerata absent in *S. marginepunctata*) (see Plate 17, Figs 1–2).

In the female genitalia antrum with triangular or pentagonal sclerite (with triangular or half-moon shaped sclerite in *S. marginepunctata*). Lamella antevaginalis strongly sclerotized, oval (with transverse fold in *S. marginepunctata*) (see Plate 25, Figs 1–2).

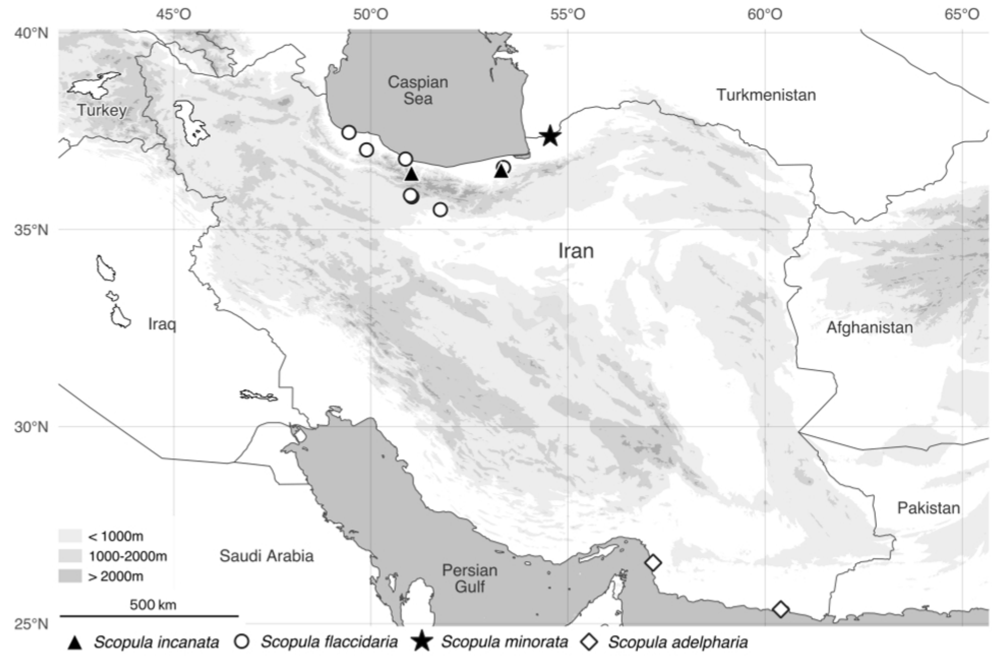
Phenology. In central Europe generally bivoltine species, from early-May to mid-September, depending on good conditions trivoltine (Hausmann 2004). Investigated specimens in Iran were collected from March to August.

Biology. Larva polyphagous on a wide range of plant species of different families (e.g., Polygonaceae, Rosaceae, Fabaceae) (see Hausmann 2004).

Habitat. From 0 m to 1400 m, to 2000 m in southern Alps and to 2300 m in southern Europe (Hausmann 2004). Investigated specimens in Iran were collected from 19 m to 2700 m.

Distribution. Widely distributed in Europe (Hausmann 2004). Also distributed in Turkey, the Caucasus, Transcaucasus, Siberia, northern Kazakhstan and Mongolia (Hausmann 2004; Makhov 2023). Report for northern Iran was still pending (Viidalepp 1996; Hausmann 2004) but here we can confirm the occurrence of this species for the northern parts of Iran (see Map 9). Reported in the literature also for the province Tehran (Schwingenschuss 1939).

DNA-barcoding. Nearest species: *S. scalercii* with 6.1 % (see Supplementary Table S1).



MAP 9. Distribution patterns of the *Scopula* species *S. incanata, S. flaccidaria, S. minorata* and *S. adelpharia* in Iran.

***Scopula marginepunctata* (Goeze, 1781)**
(Plate 7, Figs 11–15; Plate 17, Fig. 2; Plate 25, Fig. 2; Map 10)

Phalaena Geometra marginepunctata Goeze, 1781. Entomologische beyträge zu des ritter Linné 12. ausgabe des natursystems 3 (3): 385. Syntype(s) (Europe).
Scopula marginepunctata terrigena Prout, 1935. In: Seitz, A. (Ed.), Die Großschmetterlinge der Erde 4 (Supplememt): 39. Syntype(s) 26 (Iran, Elburs Mts., Mazanderan, Sabatku, Darekeroudbar) (NHMUK, examined). Valid at subspecific rank.
Scopula marginepunctata argillacea Reisser, 1933. EOS 9: 240. Syntype(s) (Morocco: Rif mountains). Valid at subspecific rank.
Synonymies (for more details on nomenclature see Scoble 1999 and Hausmann 2004): *Phalaena Geometra coniugata* Borkhausen, 1794 (Europe, probably Germany); *Phalaena aniculosata* Rambur, 1829 (southern France: Montpellier); *Acidalia puellaria* Boisduval, 1840 (Switzerland, 'Helvetia') 1825; *Acidalia promutata* Guenée, 1858 (Europe); *Acidalia apertaria* Walker, 1863 (no type locality stated); *Acidalia pastoraria* Joannis, 1891 (Turkey: 'Cesaree'); *Acidalia marginepunctata* var. *madoniata* Fuchs, 1901 (Sicily); *Acidalia marginepunctata* var. *britonaria* Oberthür, 1917 (France, Bretagne: Cancale); *Acidalia marginepunctata* var. *subatrata* Wagner, 1919 (Italy, Friuli: Udine, Cividale distr., Attimis); *Acidalia marginepunctata* 'f.' *insubrica* Vorbrodt, 1930 (Switzerland: Mixos);
For the list of unavailable names, see Hausmann (2004).

Type material examined. *Scopula marginepunctata terrigena* Type ♂, Iran, Darekeroudbar, Sabatku, Mazandaran, Elburs Mts., 22.v.1931, F. Steinbacher, NHMUK 014173548; in NHMUK.

Additional material examined: 516 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 23–27 mm. Ground colour (Plate 7, Figs 11–15) dirty grey white. In Iran *Scopula marginepunctata* can externally be confused only with *S. incanata*. Therefore, these two species are diagnosed based on genitalia characters here.

In the male genitalia 8th sternite basally shallow, cerata absent (sternite basally convex, cerata medium sized in *S. incanata*) (see Plate 17, Figs 1–2).

In the female genitalia antrum with triangular or half-moon shaped sclerite (with triangular or pentagonal sclerite in *S. incanata*). Lamella antevaginalis with transverse fold (strongly sclerotized, oval in *S. incanata*) (see Plate 25, Figs 1–2).

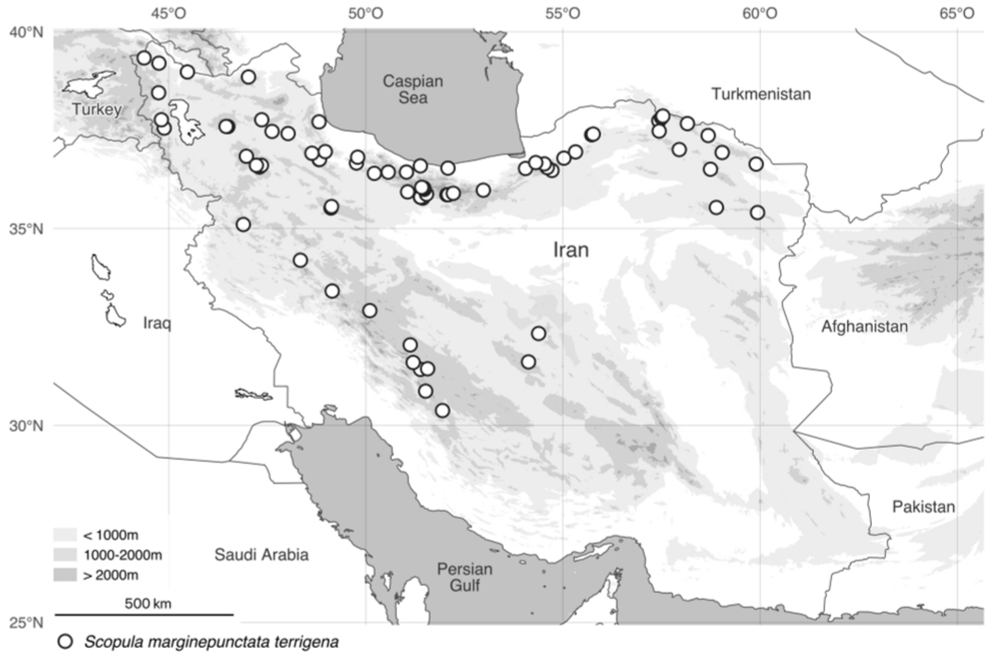
Phenology. Depending on the conditions from uni-, bi-, tri or plurivoltine species (Hausmann 2004, Hausmann *et al.* 2020). Investigated specimens in Iran were collected from April to October.

Biology. Larva polyphagous on a wide range of plant species of different families (e.g., Lamiaceae, Crassulaceae, Rosaceae, Fabaceae) (see Hausmann 2004).

Habitat. At altitudes from 0 m to 800 m north of the Alps, to 1700 m south of the Alps, to 2000 m in southern Europe and to 2700 m in Morocco and Central Asia (Hausmann 2004). In Israel to 1500 m (Hausmann *et al.* 2020). Investigated specimens in Iran were collected from 19 m to 3000 m.

Distribution. Widely distributed from northern Africa, and Portugal to the Urals, as well as in Middle East, Central Asia and Mongolia (Viidalepp 1996; Hausmann 2004; Hausmann *et al.* 2020). In Iran this species is represented by the subspecies *S. marginepunctata terrigena* and is widely distributed from in the northern, western and central parts of the country (see Map 10). Reported in the literature also for the provinces Ardabil, Azerbaijan-e Sharghi, Gilan, Mazandaran and Tehran (Schwingenschuss 1939; Wiltshire 1966; Lehmann & Zahiri 2011).

DNA-barcoding. Nearest species: *S. nigropunctata* with 7.7 % (see Supplementary Table S1).



MAP 10. Distribution pattern of *Scopula marginepunctata terrigena* in Iran.

***Scopula luridata* (Zeller, 1847)**
(Plate 7, Figs 16–17; Plate 17, Fig. 3; Plate 25, Fig. 3)

Idaea luridata Zeller, 1847. Isis, 1847 (1): 20. Syntype(s) (Greece, Rhodos) (NHMUK).
Acidalia distracta Butler, 1881. Proceedings of the Zoological Society of London 1881 (3): 616. Syntypes 3 (Pakistan: Karachi) (NHMUK, examined). Valid at subspecific rank.
Scopula luridata var. *sternecki* Prout, 1934. Lepidopterorum catalogus, 63: 198. No separate types (Corea). Replacement name for *chinensis* Sterneck, 1931. Valid at subspecific rank.
Acidalia distracta Butler, 1881: Proceedings of the Zoological Society of London, 1881 (3): 616. Syntypes (Pakistan: Karachi) (NHMUK). Valid at subspecific rank.

Synonymies (for more details on nomenclature see Scoble 1999 and Hausmann 2004): *Acidalia luridaria* Herrich-Schäffer, 1852 (according to Hausmann (2004: 312): emendation); *Acidalia luridaria* [syn.] *formosaria* Herrich-Schäffer, 1852 (Crete) (according to Hausmann (2004: 312): introduced in synonymy); *Acidalia coenosaria* Lederer, 1855 (Lebanon: Beirut; Cyprus); *Acidalia coenosaria chinensis* Sterneck 1931 (Corea); *Acidalia absconditaria* Butler, 1883 (India: Mhow); *Acidalia fulminataria* Turati, 1927 (Libya, Cyrenaica: Ain Mara).

For the list of unavailable names, see Hausmann (2004).

Type material examined. *Scopula luridata luridata* Syntype, 1 ♂/♀, [Greece], Rhod.[os], Febr.[uary], [18]42, NHMUK 014173561; in NHMUK.

Scopula luridata distracta Syntype 1 ♂/♀, Pakistan, Karachi, Febr.[uary], [18]79, NHMUK 014173549; in NHMUK.

Additional material examined: 8 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 18–24 mm (Hausmann 2004). Ground colour (Plate 7, Figs 16–17) sandy, with variable and diffuse wing pattern. In Iran, *Scopula luridata* can externally be confused with *S. transcaspica* and species of the subgenus *Glossotrophia*. Therefore, here we compare te genitalia characters of *Scopula luridata* against the genitalia of this species *S. transcaspica* and species of the subgenus *Glossotrophia*.

In the male genitalia 8th sternite basally protruding, cerata long (sternite basally slightly convex, both cerata long, left sometimes shortened in *S. transcaspica*; sternite basally stem-like elongated in *Glossotrophia*) (see Plate 15, Figs 2–3; Plate 17, Fig. 3; Plate 19, Figs 2–4; Plate 20, Figs 1–7).

In the female genitalia lamella antevaginalis with strongly sclerotized u-shaped (as flat sclerite, shape variable, rather wider than long *S. transcaspica*; with a large squared sclerite, variable in shape in *Glossotrophia*). Antrum with small transverse sclerite (without sclerite in *S. transcaspica*; with long sclerite variable in shape in *Glossotrophia*) (see Plate 23, Figs 5–6; Plate 25, Fig. 3; Plate 26, Fig. 6; Plate 27, Figs 1–7).

Phenology. Tri- or plurivoltine species with generations from late April to late November in Europe and generations in all months of the year in Levant and Arabia (Hausmann 2004; Hausmann *et al.* 2020).

Biology. Larva polyphagous on a wide range of plant species of different families often on Solanaceae (e.g., Caryophyllaceae, Liliaceae, Rosaceae) (see Hausmann 2004).

Habitat. Restricted to lowlands in Europe, and found in southwestern Asia at altitudes from 0 m to 2300 m, from -400 m to 1000 m in Israel, to 1200 m in Jordan and in the southern Arabian Peninsula from 1800 to 3100 m (Hausmann 2004; Hausmann *et al.* 2020).

Distribution. Distributed in southern Greece, southern Turkey, Cyprus, Levant, Libya and Egypt, Arabian Peninsula, Iran to western India, Yemen, Ethiopia and Somalia (Hausmann 2004). Also, in northwestern China and Korea (Sihvonen 2005b; Choi & Kim 2016). In Iran this species is represented by the subspecies *S. luridata distracta* (Prout 1912–1915; Brandt 1941; Hausmann 2004).

DNA-barcoding. Nearest species: *S. omana* Wiltshire, 1977 with 2.5 % (see Supplementary Table S1).

Remarks. No specimens from Iran were available for this study, though, the presence of this species in Iran has been reported by several authors (Prout 1912–1915; Brandt 1941; Hausmann 2004).

Scopula immutata (Linnaeus, 1758)

(Plate 8, Figs 1–2; Plate 17, Fig. 4; Plate 25, Fig. 4)

Phalaena Geometra immutata Linnaeus, 1758: Caroli Linnaei...Systema naturae per regna tria naturae: secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis (Ed. 10) 1: 528 (Europe). Syntypes (Europe) (LSL).

Synonymies (for more details on nomenclature see Scoble 1999 and Hausmann 2004): *Phalaena Geometra pallidata*: sensu Borkhausen, 1794 (according to Hausmann (2004: 316): misidentification); *Arrhostia immutaria* Hübner, 1825 (according to Hausmann (2004: 317): incorrect subsequent spelling and partly misidentification); *Acidalia caespitaria* Boisduval, 1840; *Acidalia myrtillata* Dadd, 1911 (Germany: Berlin, Spandau Forest).

For the list of unavailable names, see Hausmann (2004).

Material examined: 2 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 22–25 mm (Hausmann 2004). Due to its unique wing pattern, *Scopula immutata* cannot be confused externally with any other *Scopula* species in Iran. Ground colour (Plate 8, Figs 1–2) white to pale yellow.

In the male genitalia (Plate 17, Fig. 4) 8th sternite basally convex, cerata curved variable in size, often right ceras shortened.

In the female genitalia (Plate 25, Fig. 4) antrum with small circular sclerite. Lamella antevaginalis weakly sclerotized. Signum long and narrow.

Phenology. Uni- or bivoltine species depending on the region (Hausmann 2004).

Biology. Larva polyphagous on a wide range of plant species of different families (e.g., Primulaceae, Asteraceae, Lamiaceae, Rosaceae) (see Hausmann 2004; Beljaev 2016; Makhov 2023).

Habitat. Generally, at altitudes from 0 m to 700 m, occasionally to 900 m in southern Europe and rarely to 1850 m (Hausmann 2004).

Distribution. Widely distributed in Europe, from France to the Urals, and in the Caucasus, Kazakhstan, Siberia and Mongolia to Far East of Asia (Viidalepp 1996; Hausmann 2004; Makhov 2023). Reported for Siaret [Ziarat] in the Iranian province Golestan by Bienert (1869), but its occurrence in Iran has not been confirmed by Hausmann (2004). Here we also cannot confirm the occurrence of this species in Iran.

Remarks. Bienert (1869) reported this species as an element for the Iranian fauna. Though during our investigation no specimens from Iran could be traced. It can be assumed that this species does not occur in Iran.

DNA-barcoding. Nearest species: *S. hackeri* Hausmann, 1999 with 6.1 % (see Supplementary Table S1).

Scopula flaccidaria (Zeller, 1852)

(Plate 8, Figs 3–6; Plate 18, Figs 1–2; Plate 25, Figs 5–6; Map 9)

Geometra (*Acidalia*) *flaccidaria* Zeller, 1852. Stettiner entomologische Zeitung, 13 (6): 184. Syntypes (Turkey: Bursa (‘Brussa’)) (NHMUK, examined).

Scopula iranaria Bytinski-Salz & Brandt, 1937. The entomologist’s record and journal of variation, 49: (11). Holotype ♂ (Iran, Keredj) (ZFMK, examined). Here regarded as synonym based on morphological examination and sympatric occurrence of these forms.

For the list of unavailable names, see Hausmann (2004).

Type material examined. *Scopula iranaria* Cotype ♂, Iran, Keredj, 1400 m, 1933, leg. F. Brandt, Dr. H. Bytinski-Salz, g. prep. 2299/2020 H. Rajaei; in ZFMK.

Paratypes 1 ♂, 1 ♀, Iran, Elbursgebirge, Keredj, 1400 m, 12.v.1936, coll. Brandt, (♂) NHRS-LEPI 000010317, g. prep. 11060, (♀) NHRS-LEPI 000010318, g. prep. 11061; in NHRS.

Additional material examined: 14 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 18–24mm. In Iran *Scopula flaccidaria* can externally be confused only with *S. nigropunctata* in Iran, therefore it is compared here against this species. Ground colour (Plate 8, Figs 3–6) beige, hindwings pointed out (beige, hindwings not pointed out in *S. nigropunctata*) (see Plate 5, Figs 1–2; Plate 8, Figs 3–6).

In the male genitalia 8th sternite not strongly broadened, basally convex, both cerata long (very broad, square-like, basally straight, with thin cerata, left short, right long in *S. nigropunctata*) (see Plate 13, Fig. 2; Plate 18, Figs 1–2).

In the female genitalia lamella antevaginalis ring-shaped, antrum with tulip shaped sclerite (big with irregular folds in *S. nigropunctata*) (see Plate 22, Fig. 5; Plate 25, Figs 5–6).

Phenology. Generally, bivoltine, probably trivoltine, with a first generation from mid-May to mid-June and a second generation from mid-July to late August, the potential third generation from early to late September (Hausmann 2004). Investigated specimens in Iran were collected from March to September.

Biology. Larvae feed on *Polygonum*, *Plantago* and *Taraxacum officinale* (Hausmann 2004).

Habitat. In Europe at altitudes from 0 m to 300 m, in Turkey to 1200 m (Hausmann 2004). Investigated specimens in Iran were collected from 0 m to 1300 m.

Distribution. In Europe from eastern Austria to Ukraine and southern European Russia (Hausmann 2004). In Turkey, the Caucasus, Transcaucasus, Cyprus, Israel, northern Iraq and Central Asia (Wiltshire 1948; Wiltshire 1957; Viidalepp 1996; Hausmann 2004; Makhov 2023). In Iran distributed in the northern parts (Map 9). Reported in the literature also for the provinces Khorasan-e Shomali and Mazandaran (Schwingenschuss 1939; Prout 1912–1915; Sutton 1963; Wiltshire 1966; Viidalepp 1988; Hausmann 2004).

DNA-barcoding. Nearest species: *S. albidaria* (Staudinger, 1901) with 4.8 % (see Supplementary Table S1).

Scopula minorata (Boisduval, 1833)
(Plate 8, Figs 7–9; Plate 18, Fig. 3; Plate 26, Fig. 1; Map 9)

Geometra minorata Boisduval, 1833: Nouvelles annales du Muséum d'histoire naturelle Paris 2: 263. Syntype(s) (Mauritius).
Synonymies (for more details on nomenclature see Scoble 1999 and Hausmann 2004): *Acidalia ochroleucaria* Herrich-Schäffer, 1847 (southern Europe); *Acidalia inustaria* Herrich-Schäffer, 1847 (central Italy); *Acidalia colonaria* Herrich-Schäffer, 1852 (locality not stated); *Acidalia accessaria* Herrich-Schäffer, 1852 (locality not stated); *Acidalia mauritiata* Guenée, 1858 (Mauritius) (according to Hausmann (2004: 332): unnecessary replacement name for *minorata*); *Acidalia luculata* Guenée, 1858 (Reunion: Bourbon island); *Acidalia recessaria* Guenée, 1858 (Europe) (according to Hausmann (2004: 332): unnecessary replacement name for *accessaria*); *Acidalia ochroleucata* Guenée, 1858 (southern Europe, Cyprus); *Acidalia consentanea* Walker, 1861 (South Africa: Cape); *Acidalia hypochra* Meyrick, 1888 (Australia: Queensland, Duaringa; New South Wales, Sydney; South Australia, Mt. Lofty) (according to Hausmann (2004: 332): synonymy uncertain); *Cleta ochroleucata* var. *inustata* Gumppenberg, 1890; *Acidalia corcularia* Rebel, 1894 (Canary Islands); *Acidalia holobapharia* Mabille, 1900 (Madagascar: Diego Suarez); *Emmiltis* (*Craspedia*) *mombasae* Warren, 1904 (Kenya: Mombassa); *Acidalia tremula* Bastelberger, 1909 (Mozambique); *Acidalia turbidaria cheimerinaria* Rebel, 1928 (Cyprus: Limassol); *Ptychopoda medioumbraria* Turati, 1930(Libya, Tripolitania: Sidi Messri); *Acidalia* (*Ustocidalia*) *turbulentaria tripolitana* Sterneck 1933 (Libya: Tripoli); *Scopula ochroleucaria* ab. loc. *serrans* Prout, 1935 (Jordan: Ghor el Safieh); *Acidalia dresnayi* D. Lucas, 1937 (Morocco: Rabat).
For the list of unavailable names, see Hausmann (2004).

Material examined: 7 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 14–20 mm (Hausmann 2004). Ground colour yellowish-beige (Plate 8, Figs 7–9). *Scopula minorata* can externally be confused with *S. adelpharia* and *S. lactarioides*, but the genitalia of these three species are characteristic and can be used for species identification.

In the male genitalia 8th sternite with left ceras long, right ceras short (right ceras long, left ceras short and curved in *S. adelpharia*; both cerata long in *S. lactarioides*) (see Plate 18, Figs 3–4; Plate 19, Fig. 1).

In the female genitalia antrum with an oval sclerite, apically notched (with half-moon-shaped sclerite in *S. adelpharia*; with small rounded sclerite in *S. lactarioides*). Signum oval (weakly developed, elongated and narrow in *S. adelpharia*; absent *S. lactarioides*) (see Plate 26, Figs 1–2, 5).

Phenology. Plurivoltine species, generally active in all months of the year (Hausmann 2004). Investigated specimens in Iran were collected from March to May.

Biology. Larva polyphagous on a wide range of plant species of different families (e.g., Apocynaceae, Petuniaceae, Fabaceae) (see Hausmann 2004).

Habitat. At altitudes from 0 m to 200 m, rarely to 700 m (Hausmann 2004). Investigated specimen in Iran was collected in 17 m.

Distribution. Distributed along the Mediterranean coasts in Europe, Africa, Madagascar, Levant, Turkey, Afghanistan and Pakistan (Hausmann 2004). In Iran distributed in the northern province Golestan and the southern province Hormozgan (Map 9). Reported in the literature also for the provinces Khorassan-e Shomali and Qazvin (Wiltshire 1980; Hausmann 2004; Wieser & Stangelmaier 2005).

DNA-barcoding. Nearest species: *S. imitaria* with 8.0 % (see Supplementary Table S1).

Scopula adelpharia (Püngeler, 1894)
(Plate 8, Figs 10–13; Plate 18, Fig. 4; Plate 26, Fig. 2; Map 9)

Acidalia adelpharia Püngeler, 1894. Stettiner entomologische Zeitung, 55 (1–3): 76. Syntypes 2 ♂, 3 ♀ (Palestine: Jericho).
Scopula adelpharia pharaonis Sterneck, 1933. Zeitschrift des Österreichischen Entomologischen Vereins, 18: 9. Holotype (Egypt: Cairo). Valid at subspecific rank.

Material examined: 6 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 14–16 mm. Ground colour yellowish-beige (Plate 8, Figs 10–13). In Iran, *Scopula adelpharia* can externally be confused only with *S. minorata* and *S. lactarioides*, but the genitalia of these three species are characteristic and can be used for species identification.

In the male genitalia 8th sternite with right ceras long, left ceras short and curved (left ceras long, right ceras short in *S. minorata*; both cerata long in *S. lactarioides)* (see Plate 18, Figs 3–4; Plate 19, Fig. 1).

In the female genitalia antrum with half-moon-shaped sclerite (with an oval sclerite, apically notched in *S. minorata*; with small rounded sclerite in in *S. lactarioides*). Signum weakly developed, elongated and narrow (oval in *S. minorata*; absent *S. lactarioides*) (see Plate 26, Figs 1–2, 5).

Phenology. Plurivoltine species, generally active in all months of the year (Hausmann *et al.* 2020). Investigated specimens in Iran were collected in March.

Biology. Polyphagous, larva feeding on species of different families (e.g., Fabaceae, Asteraceae, Rosaceae) (Wiltshire 1990, Hausmann *et al.* 2020).

Habitat. In Israel from -400 m to 1100 m (Hausmann *et al.* 2020). Investigated specimens in Iran were collected in 50 m.

Distribution. Distributed in the Levant, the Arabian Peninsula, Sokotra, Sudan, Ethiopia, Djibouti, Mali and Tanzania (Hausmann *et al.* 2020). In Iran distributed in the southeastern parts (see Map 9) and has been reported in the literature also for southern Iran (Prout 1912–1915; Wiltshire 1980)

DNA-barcoding. Nearest species: *S. rhodinaria* (Rebel, 1907) with 8.0 % (see Supplementary Table S1).

Scopula albiceraria (Herrich-Schäffer, 1847)

(Plate 8, Figs 14–15; Plate 18, Fig. 5; Plate 26, Fig. 3)

Acidalia albiceraria Herrich-Schäffer, 1847. Systematische Bearbeitung der Schmetterlinge von Europa, 3 (24): 23 (non binominal). Syntypes (south-eastern European Russia, Krasnoarmeysk ('Sarepta'); erroneous locality southern Europe in original description).

Acidalia albiceraria vitellinaria Eversmann, 1851. Bulletin de la Société impériale des naturalistes de Moscou, 24 (2): 641. Syntypes ([Russia]: eastern Siberia). Valid at subspecific rank.

Synonymies (for more details on nomenclature see Scoble 1999): *Acidalia sulphuraria* Freyer, 1847 ([Russia]: Sarepta [Krasnoarmeysk]).

For the list of unavailable names, see Hausmann (2004).

Material examined: 2 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 22–24 mm (Hausmann 2004). Ground colour creamy yellowish- to reddish-white, strongly pronounced transversal lines and dark suffusion in the medial area. (Plate 8, Figs 14–15). *Scopula albiceraria*, if present in Iran (see Remarks), can externally be confused only with *S. immistaria*. A diagnosis can be made with certainty based on the genitalia characters.

In the male genitalia 8th sternite basally notched, laterally concave, cerata short, broad (basally notched, broad, cerata medium sized and thin in *S. immistaria*) (see Plate 18, Figs 5–6).

In the female genitalia antrum with small v-shaped sclerite (with very small notched sclerite in *S. immistaria*) (see Plate 26, Figs 3–4).

Phenology. Bivoltine species, flying from early June to late August (Hausmann 2004).

Biology. Unknown.

Habitat. In Europe at altitudes from 0 m to 300 m, and Asia from 500 m to 1700 m (Hausmann 2004). Investigated specimens from Mongolia were collected from 774 m to 2900 m.

Distribution. Southeastern Russia, Urals, Mongolia (Hausmann 2004). Turkmenia, Kazakhstan and southern Siberia (Viidalepp 1996; Hausmann 2004; Makhov 2023). The occurrence in the Caucasus, Transcaucasus questionable (Hausmann 2004).

Remarks. Prout (1912–1915) reported this species as an element for the Iranian fauna. Though during our investigation no specimens from Iran could be traced. It can be assumed that this species does not occur in Iran, and the report is probably due to confusion with *S. immistaria*.

DNA-barcoding. Nearest species: *S. latelineata* (Graeser, 1892) with 1.8 % (see Supplementary Table S1).

Scopula immistaria (Herrich-Schäffer, 1852)

(Plate 8, Figs 16–17; Plate 18, Fig. 6; Plate 26, Fig. 4; Map 11)

Acidalia immistaria Herrich-Schäffer, 1847: Systematische Bearbeitung der Schmetterlinge von Europa, 6 (55): 68 (non binominal). Syntypes (Azerbaijan, Kirowabad (Elisabethpor)) (MNHU).

Scopula immistaria beshkovi Gelbrecht & Hausmann, 1997. Linzer biologische Beiträge, 29 (2): 984. Holotype ♂ (Bulgaria: Pobitide Kamani near Varna) (ZSM). Valid at subspecific rank.
For the list of unavailable names, see Hausmann (2004).

Material examined: 165 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 22–28 mm. Ground colour creamy white, with finely drawn transversal lines (Plate 8, Figs 16–17). In Iran *Scopula immistaria* can externally be easily confused with *S. albiceraria*, if the latter species is present in Iran (see Remarks of *S. albiceraria*). A diagnosis is certain based on the genitalia characters.

In the male genitalia 8th sternite basally notched, broad, cerata medium sized and thin (basally notched, laterally concave, cerata short, broad in *S. albiceraria*) (see Plate 18, Figs 5–6).

In the female genitalia antrum with very small notched sclerite (with small v-shaped sclerite in *S. albiceraria*) (see Plate 26, Figs 3–4).

Phenology. Bivoltine species, with generations from mid-May to early September, overlapping in July (Hausmann 2004). Univoltine in high altitudes (Hausmann 2004). Investigated specimens in Iran were collected from May to August.

Biology. Possibly monophagous on *Silene* (Caryophyllaceae) (Hausmann 2004).

Habitat. At altitudes from 700 m to 2800 m (Hausmann 2004). Investigated specimens in Iran were collected from 510 m to 3000 m.

Distribution. In Europe in southern Russia, eastern Ukraine (Hausmann 2004). Also in Turkey, the Caucasus, Transcaucasus, northern Iraq and Turkmenia (Viidalepp 1996; Hausmann 2004). In Iran distributed in northern and western parts, with isolated populations in south-eastern province Kerman (Map 11) (Hausmann 2004). Reported in the literature also for the provinces Fars, Golestan, Kerman, Mazandaran and Tehran (Lederer 1871; Prout 1912–1915; Schwingenschuss 1939; Brandt 1939; Viidalepp 1996; Hausmann 2004; Lehmann & Zahiri 2011).

DNA-barcoding. Nearest species: *S.* with 4.3 % (see Supplementary Table S1).

Scopula lactarioides Brandt, 1941

(Plate 8, Figs 18–19; Plate 19, Fig. 1; Plate 26, Fig. 5; Map 11)

Scopula lactarioides Brandt, 1941. Mitteilungen der Münchner Entomologischen Gesellschaft, 31 (3): 867. Syntypes ♂, ♀ (Iran, Bender Tchahbahar) (in NHRS, examined).

Type material examined. Paratype 1 ♂, Iran, Baloutchistan, Bender Tchahbahar, 24.ii.1938, coll. Brandt, NHRS 000010314, g. prep. 11057; in NHRS.

Additional material examined: 1 ♀ (see appendix).

Description of the female genitalia. Papillae anales rounded, simple; apophyses anteriores 2/3 of apophyses posteriores; antrum with small rounded sclerite; signum absent (Plate 26, Fig. 5).

Diagnosis. Wingspan ♂ 16.8 mm, ♀ 16.6 mm. Ground colour beige (Plate 8, Figs 18–19). It can externally be confused with *S. minorata* and *S. adelpharia*, but the genitalia of these three species are characteristic and can be used for species identification.

In the male genitalia 8th sternite with both cerata long (left ceras long, right ceras short in *S. minorata*; right ceras long, left ceras short and curved in *S. adelpharia*) (see Plate 18, Figs 3–4; Plate 19, Fig. 1).

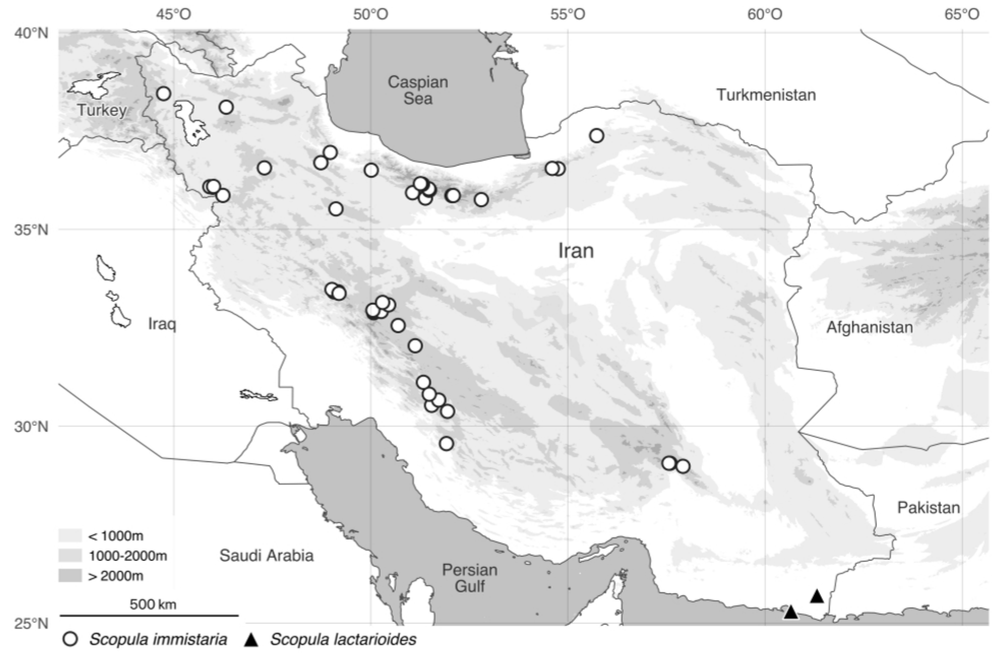
In the female genitalia antrum with small rounded sclerite (with an oval sclerite, apically notched in *S. minorata*; with half-moon-shaped sclerite in *S. adelpharia*). Signum absent (oval in *S. minorata*; weakly developed, elongated and narrow in *S. adelpharia*) (see Plate 26, Figs 1–2, 5).

Phenology. Specimens from Iran were collected end of February and end of March.

Biology & Habitat. Unknown.

Distribution. Endemic species to southeastern Iran (Sistan-o-Baluchestan province) (Map 11). Reported in the literature also for the provinces Bushehr, Hormozgan, Kerman, and Sistan-o-Baluchestan (Brandt 1941; Reisser 1958; Lehmann *et al.* 2009).

DNA-barcoding. No data available.



MAP 11. Distribution patterns of the *Scopula* species *S. immistaria* and *S. lactarioides* in Iran.

Scopula diffinaria (Prout, 1913)

(Plate 9, Figs 1–6; Plate 19, Figs 2–3; Plate 26, Fig. 6; Plate 27, Fig. 1; Map 12)

Glossotrophia diffinaria Prout, 1913. In: Seitz, A. (Ed.), Die Großschmetterlinge der Erde 4: 83. Syntype(s) (Asia minor) (NHMUK, examined).

Glossotrophia asiatica Brandt, 1938. Entomologische Rundschau, 55 (49): 574. Syntypes 6 ♂, ♀ (Iran, Fort Mian-Kotal) (NHRS, examined). Here regarded as synonym based on morphological examination and no clear geographical delimitation to the nominate subspecies.

Type material examined. *Glossotrophia asiatica* Paratypes 1 ♂, 1 ♀, Iran, Fars, Straße, Ardekan–Talochosroe [Ardakan–Talle Khosrow], Comé [Komehr], 2600 m, 5.viii.1937, coll. Brandt, (♂) NHRS-LEPI 000010178, g. prep. 10872, (♀) NHRS-LEPI 000010179, g. prep. 10873; in NHRS.

Additional material examined: 68 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 22–29 mm. In Iran, *Scopula diffinaria* can externally be confused with *S. orbeorum*, *S. chalcographata* and *S. sacraria*, therefore here we compare *S. diffinaria* only with these three species. Largest species of the subgenus *Glossotrophia* in Iran (size range similar but ground colour paler in *S. orbeorum*; *S. chalcographata* and *S. sacraria* smaller) (see Plate 9, Figs 1–12).

In the male genitalia 8th sternite, with polymorphic cerata, cerata short or right ceras long and slender, left ceras short or both cerata long (sternite, with both cerata of medium size in *S. orbeorum*; sternite, with right ceras of medium size, left ceras short in *S. chalcographata*; sternite basally strongly elongated, both cerata long and narrow in *S. sacraria*) (see Plate 19, Figs 2–4; Plate 20, Figs 1–2).

In the female genitalia lamella antevaginalis with a large squared sclerite (similar in *S. orbeorum* and *S. sacraria*; with a large sub-rectangular sclerite in *S. chalcographata*). Antrum with long sclerite, posteriorly notched (similar in *S. orbeorum*; long sclerite, posteriorly strongly notched in *S. chalcographata*; with long and narrow sclerite, posteriorly notched in *S. sacraria*) (see Plate 26, Fig. 6; Plate 27, Figs 1–5).

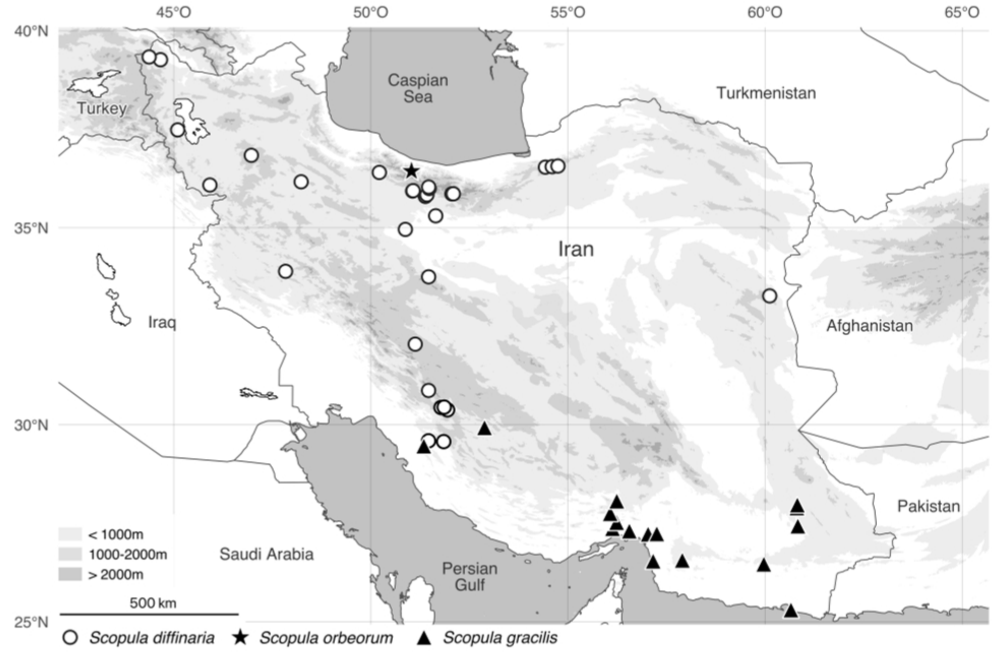
Phenology. Bivoltine species flying from May to September, second generation sometimes incomplete (Hausmann 2004). Investigated specimens in Iran were collected from March to October.

Biology. Larval host plants unknown. Adults feed on various Caryophyllaceae, *Linum catharticum* (Linaceae), and probably on *Polygonum* (Polygonaceae) (Hausmann & Dötterl 2004).

Habitat. At altitudes from 700 m to 1800 m (Hausmann 2004). Investigated specimens in Iran were collected from 700 m to 2800 m.

Distribution. Distributed from Turkey to Transcaucasus and northern Iraq (Viidalepp 1996; Hausmann 2004). In Iran distributed in the northern and western parts to the south Iranian province Fars (Map 12). Reported in the literature also for the province Tehran (Schwingenschuss 1939; Wiltshire 1966; Hausmann 2004).

DNA-barcoding. Nearest species: *S. alba* (Hausmann 1993) with 2.0 % (see Supplementary Table S1).



MAP 12. Distribution patterns of the *Scopula* species *S. diffinaria, S. orbeorum* and *S. gracilis* in Iran.

Scopula orbeorum **(Hausmann, 1996)**
(Plate 9, Figs 7–8; Plate 19, Fig. 4; Plate 27, Fig. 2; Map 12)

Glossotrophia orbeorum Hausmann, 1996. Spixiana Supplement, 22: 3. Holotype ♂ (Persia [Iran], Elburs Mts., Tacht i Suleiman, Särdaab Tal) (SNSB, examined).

Type material examined. Holotype ♂, Persia sept. [Iran], Elburs mts.c.s., Tacht i Suleiman, Särdab-Tal (Vanderban), 25-2700cm, 14.-18.vii.[19]37, E. Pfeiffer & W. Forster leg., München, g. prep. ZSM 1970; Paratype 1 ♀, same data as holotype, g. prep. ZSM 4248; all in ZSM.

Diagnosis. Wingspan ♂ 25 mm, ♀ 26.5 mm. In Iran, *Scopula orbeorum* can externally be confused with *S. diffinaria*, *S. chalcographata* and *S. sacraria*, therefore here we compare *S. orbeorum* only with these three species. Largest species of the subgenus *Glossotrophia* in Iran (size range similar but ground colour more colourful in *S. diffinaria*; *S. chalcographata* and *S. sacraria* smaller) (see Plate 9, Figs 1–12).

In the male genitalia 8th sternite, with both cerata of medium size (sternite, with polymorphic cerata, cerata short or right ceras long and slender, left ceras short or both cerata long in *S. diffinaria*; sternite, with right ceras of medium size, left ceras short in *S. chalcographata*; sternite basally strongly elongated, both cerata long and narrow in *S. sacraria*) (see Plate 19, Figs 2–4; Plate 20, Figs 1–3).

In the female genitalia lamella antevaginalis with a large squared sclerite (similar in *S. diffinaria* and *S. sacraria*; with a large sub-rectangular sclerite in *S. chalcographata*). Antrum with long sclerite, posteriorly notched (similar in *S. diffinaria*; long sclerite, posteriorly strongly notched in *S. chalcographata*; with long and narrow sclerite, posteriorly notched in *S. sacraria*) (see Plate 26, Fig. 6; Plate 27, Figs 1–5).

Phenology. Types collected in July (Hausmann 1996).

Biology. Unknown.

Habitat. Types collected at altitudes from 2500 m to 2700 m (Hausmann 1996).

Distribution. Endemic species to Iran, only known from northern Iran (Map 12)

DNA-barcoding. Nearest species: *S. uberaria* with 3.6 % (see Supplementary Table S1).

***Scopula chalcographata* (Brandt, 1938)**

(Plate 9, Figs 9–10; Plate 20, Fig. 1; Plate 27, Fig. 3; Map 13)

Glossotrophia chalcographata Brandt, 1938. Entomologische Rundschau, 55 (49): 574. Syntypes ♂, ♀ (Iran, Fort Mian-Kotal) (NHRS, examined).

Glossotrophia chalcographata sinaica Rebel, 1948. Zeitschrift der Wiener Entomologischen Gesellschaft, 32 (5–7): 57. Holotype ♀ (Egypt: Wadi Feran) (TMB). Valid at subspecific rank.

Type material examined. Paratypes 1 ♂, 1 ♀, Iran, Fars, Straße Chiraz–Kazeroun, Fort Mian-Kotal, ca. 2000 m, 7.-10.v.1937, coll. Brandt, (♂) NHRS-LEPI 000010181, g. prep. 10875, (♀) NHRS-LEPI 000010180, g. prep. 10874; in NHRS.

Additional material examined: 147 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 18–25 mm. In Iran, *Scopula chalcographata* can externally be confused only with *S. diffinaria*, *S. orbeorum* and *S. sacraria*, but these species could be easily diagnosed based on their genitalia characters.

In the male genitalia 8th sternite, with right ceras of medium size, left ceras short (sternite, with polymorphic cerata, cerata short or right ceras long and slender, left ceras short or both cerata long in *S. diffinaria*; sternite, with both cerata of medium size in *S. orbeorum*; basally strongly elongated, both cerata long and narrow in *S. sacraria*) (see Plate 19, Figs 2–4; Plate 20, Figs 1–3).

In the female genitalia lamella antevaginalis with a large sub-rectangular sclerite (with a large squared sclerite in *S. diffinaria*; *S. orbeorum* and *S. sacraria*). Antrum with long sclerite, posteriorly strongly notched (long sclerite, posteriorly notched in *S. diffinaria* and *S. orbeorum*; with long and narrow sclerite, posteriorly notched in *S. sacraria*) (see Plate 26, Fig. 6; Plate 27, Figs 1–5).

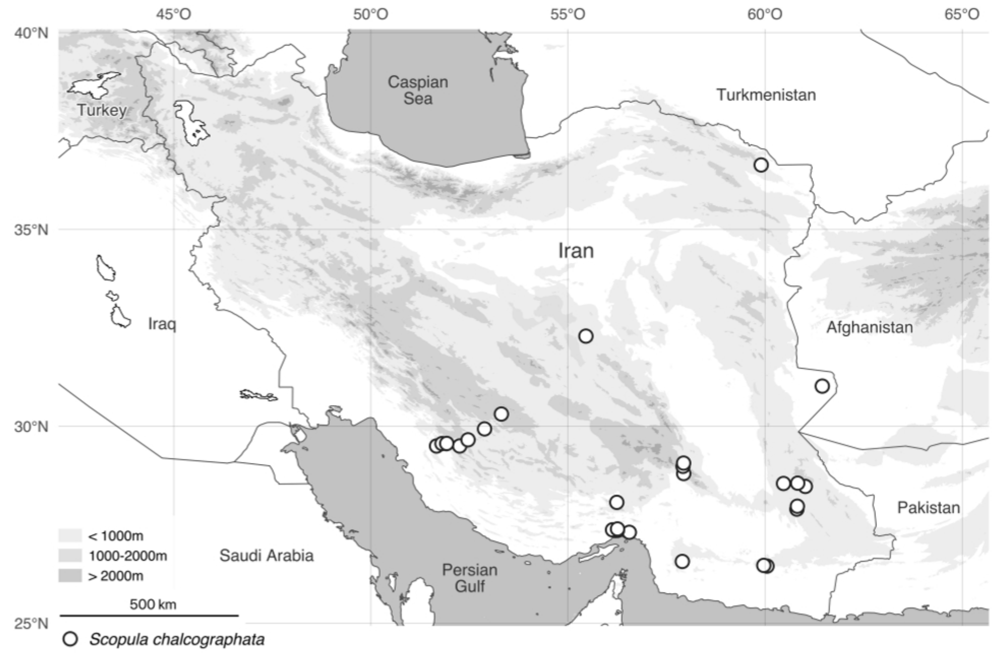
Phenology. Bivoltine species in the Levant and the Arabian Peninsula (Hausmann *et al.* 2020). Investigated specimens in Iran were collected from March to June.

Biology. Larva feeding on *Silene* and *Gypsophila* (Caryophyllaceae) (Hausmann *et al.* 2016b; Hausmann *et al.* 2020).

Habitat. In Israel at altitudes from -400 m to 200 m, and to 1000 m in Jordan (Hausmann *et al.* 2020). Investigated specimens in Iran were collected from 60 m to 2800 m.

Distribution. Distributed across Transcaucasus, from eastern Egypt to Jordan, Israel and the Arabian Peninsula (Viidalepp 1996; Hausmann *et al.* 2020). In Iran distributed in the north-eastern and south-eastern parts (Map 13). Reported in the literature also for the provinces Bushehr, Fars, Hormozgan, Kerman, and Sistan-o-Baluchestan (Brandt 1938; Brandt 1939; Brandt 1941; Reisser 1958; Kouznetsov 1959; Wiltshire 1980; Viidalepp 1996; Lehmann *et al.* 2009).

DNA-barcoding. Nearest species: *S. uberaria* with 3.3 % (see Supplementary Table S1).



MAP 13. Distribution pattern of *Scopula chalcographata* in Iran.

Scopula sacraria **(Bang-Haas, 1910)**
(Plate 9, Figs 11–12; Plate 20, Figs 2–3; Plate 27, Figs 4–5; Map 14)

Acidalia sacraria Bang-Haas, 1910. Deutsche entomologische Zeitschrift Iris 24 (3): 42. Syntypes ♂, ♀ (Russia, Uralsk) (MNHU).
Glossotrophia romanaria semitata Prout, 1913. In: Seitz, A. (Ed.), Die Großschmetterlinge der Erde 4: 83. Holotype ♂ (Lebanon, Baalbeck) (NHMUK, examined). Valid at subspecific rank.
Glossotrophia asellaria taurica Wehrli, 1930. Internationale Entomologische Zeitschrift, 23 (37/38): 430. Syntypes ♂, ♀ (Turkey, Maras) (NHMUK & ZFMK, examined). Valid at subspecific rank.
Glossotrophia ariana Ebert, 1965. Stuttgarter Beiträge zur Naturkunde, 142: 10. Holotype ♂ (Afghanistan: Sarobi) (SMNK, examined). Valid at subspecific rank.
Glossotrophia semitata fumata Hausmann, 1993: Mitteilungen der Münchner Entomologischen Gesellschaft, 83: 88. Holotype ♂ (Cyprus: Platres) (NHMUK). Valid at subspecific rank.
Glossotrophia bullata Vojnits, 1986. Annales Musei historico-naturalis hungarici, 78: 219. Holotype ♀ (Iran, Baloutchistan, Bendar Tchahabar) (SMNK). Here regarded as synonym to *S. sacraria ariana* based on morphological examination and the lack of clear geographical delimitation from this subspecies.
Synonymies (for more details on nomenclature see Scoble 1999 and Hausmann 2004): *Glossotrophia tangii* Ebert, 1965 (Afghanistan: Sarobi); *Glossotrophia ghirshmani* Wiltshire, 1966 (Afghanistan: Kabul).
For the list of unavailable names, see Hausmann (2004).

Type material examined. *Glossotrophia romanaria semitata* Holotype ♂, [Lebanon], Baalbeck, at light, v.05, [leg.] P. P. Graver, NHMUK 014173556; in NHMUK.

Glossotrophia asellaria taurica Paratype 1 ♂, [Turkey], Taurus c., Marasch, 10.v.[19]28, 700 m, leg. E. Pfeiffer, NHMUK 014173537, g. prep. NHMUK 010317462; Paratype 1 ♀, [Turkey], Taurus c., Marasch, 15-30.v.[19]29, 7-900 m, leg. E. Pfeiffer, NHMUK 014173538, g. prep. NHMUK 010317463; in NHMUK.

Glossotrophia ariana Paratype 1 ♂, O.-Afghanistan, Sarobi, 1100 m, 17.iv.1962, g. prep. G 40; Paratype 1 ♀, same data, but 19.iv.1962, g. prep. G 44; all in SMNK.

Glossotrophia tangii Holotype ♂, O.-Afghanistan, Sarobi, 1100 m, 29.x.1962, g. prep. G 43; Paratype 1 ♀, same data, but 16.ix.1963, g. prep. G 43; all in SMNK.

Glossotrophia ghirshmani Holotype ♂, Afghanistan, Kabul, 15.vii.[19]43, leg. Ghirshman for coll. Wiltshire, g. prep. E.P. Wiltshire 1165; in NHMUK. Paratype 1 ♀, O.-Afghanistan, Sarobi, 1100 m, 3.vii.1956, leg. H. G. Amsel, g. prep. 2259/2020 H. Rajaei; Paratype 1 ♂, N.-Afghanistan, Polichomri, 700 m, 28.v.1956, leg. H. G. Amsel, g. prep. 2260/2020 H. Rajaei; Paratype 1 ♂, same data, but 5.v.1956, leg. H. G. Amsel, g. prep. 2266/2020 H. Rajaei; all in SMNK.

Glossotrophia bullata Holotype ♀, Iran, Baloutchistan, Bender Tchahbahar, Dezember 1937 coll. Brandt [holotype, couldn´t be traced at SMNK, only genitalia preparation slide was available]; in SMNK.

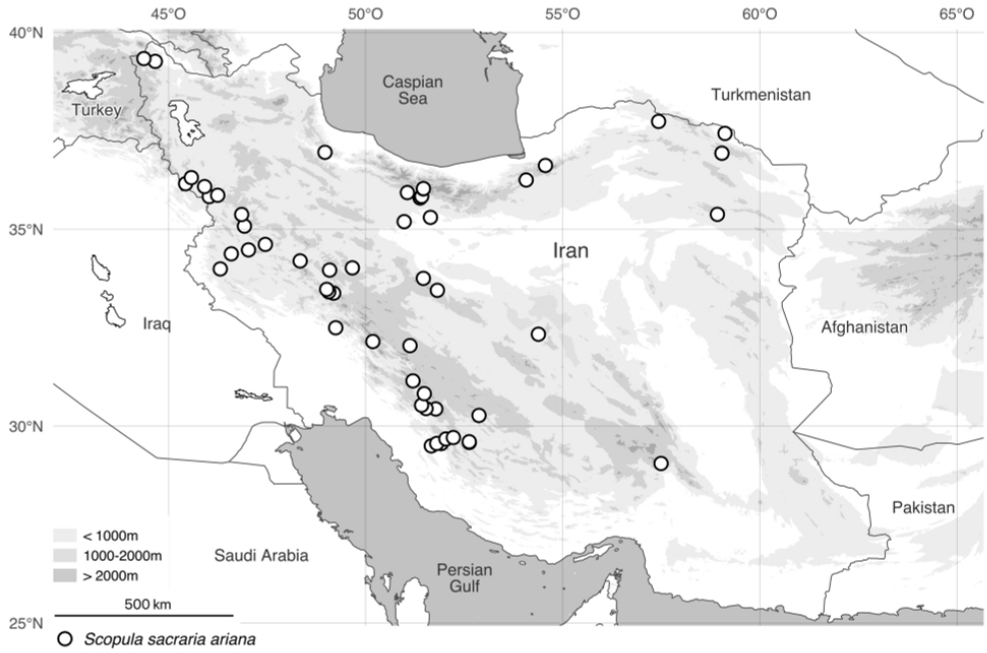
Additional material examined: 458 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 17–22 mm. In Iran, *Scopula sacraria* can externally be confused with *S. diffinaria*, *S. orbeorum* and *S. chalcographata*, but these species could be easily diagnosed based on their genitalia characters.

In the male genitalia 8th sternite basally strongly elongated, both cerata long and narrow (sternite, with polymorphic cerata, cerata short or right ceras long and slender, left ceras short or both cerata long in *S. diffinaria*; sternite, with both cerata of medium size in *S. orbeorum*; sternite, with right ceras of medium size, left ceras short in *S. chalcographata*) (see Plate 19, Figs 2–4; Plate 20, Fig. 1–3).

In the female genitalia lamella antevaginalis with a large squared sclerite (similar in with a large squared sclerite in *S. diffinaria* and *S. orbeorum*; with a large sub-rectangular sclerite in *S. chalcographata*). Antrum with long and narrow sclerite, posteriorly notched (long sclerite, posteriorly notched in *S. diffinaria* and *S. orbeorum*; long sclerite, posteriorly strongly notched in *S. chalcographata*) (see Plate 26, Fig. 6; Plate 27, Figs 1–5).

Phenology. Tri- or plurivoltine species, with generations between mid-February to mid-November, bivoltine in higher altitudes (Hausmann 2004; Hausmann *et al.* 2020). Investigated specimens in Iran were collected from April to September.



MAP 14. Distribution pattern of *Scopula sacraria ariana* in Iran.

Biology. Larva feeding on Caryophyllaceae (Hausmann *et al.* 2020). Adults feed on Caryophyllaceae, *Linum catharticum* (Linaceae), probably on *Polemonium* and *Polygonum* (Polygonaceae) (Hausmann & Dötterl 2004; Hausmann 2004).

Habitat. At altitudes from 0 m to 300 m, in the Middle East and Central Asia to 2200 m, and in Israel from -400 m to 1500 m (Hausmann 2004; Hausmann *et al.* 2020). Investigated specimens in Iran were collected from 700 m to 2860 m.

Distribution. In the Levant, Greece southern Turkey, northern Iraq, Syria, Transcaucasus, Turkmenia, Kazakhstan and Afghanistan (Hausmann 2004; Hausmann *et al.* 2020). In Iran this species is represented by the subspecies *S. sacraria ariana* and widely distributed from the northern, western and central parts of Iran to southern Iran (Map 14). Reported in the literature also for the province Azerbaijan-e Sharghi (Lehmann & Zahiri 2011; Hausmann 2004). Reports of the subspecies *semitata* from the provinces Bushehr, Fars and Khorasan-e Razavi by Brandt and Wiltshire (Brandt 1939; Brandt 1941; Wiltshire 1941; Wiltshire 1966) refer to the subspecies *ariana*.

DNA-barcoding. Nearest species: *S. rufotinctata* (Prout, 1913) with 3.5 % (see Supplementary Table S1).

Scopula gracilis (Brandt, 1941)

(Plate 9, Figs 13–15; Plate 20, Figs 4+6; Plate 27, Fig. 6; Map 12)

Glossotrophia gracilis Brandt, 1941. Mitteilungen der Münchner Entomologischen Gesellschaft 31 (3): 869. Syntype(s) ♂, ♀ (Iran, Bender Tchahbahar) (NHRS, examined).

Type material examined. Paratype ♂, Iran, Baloutchistan, Bender Tchahbahar, Dezember 1937, coll. Brandt, NHRS 000010182, g. prep. 10876; Paratype ♀, same data, but Februar 1938, NHRS 000010183, g. prep. 10877; in NHRS.

Additional material examined: 107 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 14–18 mm. In Iran, *Scopula gracilis* can externally be confused with large specimens of *S. alfierii* and small specimens of *S. chalcographata* and *S. sacraria*. However, these three species can be easily diagnosed based on their genitalia characters.

In the male genitalia 8th sternite, centrally broadened, without cerata (sternite, centrally not broadened, without ceras in *S. alfierii*; sternite, with right ceras of medium size, left ceras short or left ceras medium size, right ceras short in *S. chalcographata*; sternite basally strongly elongated, both cerata long and narrow in *S. sacraria*) (see Plate 20, Figs 1–7).

In the female genitalia antrum with triangular sclerite (similar in *S. alfierii*; long sclerite, posteriorly strongly notched in *S. chalcographata*; with long and narrow sclerite, posteriorly notched in *S. sacraria*) (see Plate 27, Figs 3–7).

Phenology. Investigated specimens in Iran were collected from January to June.

Biology. Unknown.

Habitat. Investigated specimens in Iran were collected from 10 m to 1600 m.

Distribution. Restricted to southern Iranian provinces Bushehr, Fars, Hormozgan and Sistan-o-Baluchestan (see Map 12). Reported in the literature also for the provinces Hormozgan and Sistan-o-Baluchestan (Brandt 1941; Lehmann *et al.* 2009).

DNA-barcoding. Nearest species: *S. harteni* with 4.0 % (see Supplementary Table S1).

Scopula alfierii (Wiltshire, 1949)

(Plate 9, Figs 16–19; Plate 20, Figs 5+7; Plate 27, Fig. 7)

Glossotrophia alfierii Wiltshire, 1949. Bulletin de la Société entomologique d'Égypte, 33: 416. Holotype ♂ (Egypt, Wadi Digla) (USNM).

Type material examined. Paratype [one label with Type, and one label with Paratype written on it], Egypt, Wadi Digla (desert arabique est de Maadi), le soir à la lampe, 22 Août 1925, Preparation E.P. Wiltshire 382, NHMUK 014173529; in NHMUK.

Additional material examined: 4 ♂/♀ (see appendix).

Diagnosis. Wingspan ♂♀ 12–14 mm. In Iran, *Scopula alfierii* can externally be confused with large specimens of *Scopula gracilis* and small specimens of *S. chalcographata* and *S. sacraria*. However, these three species can be easily diagnosed based on their genitalia characters

In the male genitalia 8th sternite, centrally not broadened, without ceras (sternite, centrally broadened, without cerata in *S. gracilis*; sternite, with polymorphic cerata, right ceras of medium size, left ceras short or left ceras medium size, right ceras short in *S. chalcographata*; sternite basally strongly elongated, both cerata long and narrow in *S. sacraria*) (see Plate 20, Figs 1–7).

In the female genitalia antrum with triangular sclerite (similar in *S. gracilis*; long sclerite, posteriorly strongly notched in *S. chalcographata*; with long and narrow sclerite, posteriorly notched in *S. sacraria*) (see Plate 27, Figs 3–7).

Phenology. Bivoltine species with a first generation from mid-March to early May and a second generation from mid-August to late October (Hausmann *et al.* 2020).

Biology. Unknown. Hausmann *et al.* (2020) suggested Caryophyllaceae as possible food plants.

Habitat. In the Levant from 0 m to 300 m (Hausmann *et al.* 2020).

Distribution. Distributed in Egypt, southern Jordan and southern Israel (Hausmann *et al.* 2020). In Iran reported for the province Hormozgan by Kuznetzov (1959), but confirmation is still pending (see Remarks).

Remarks. Kuznetzov (1959) reported this species as a faunal element for the south Iranian province Hormozgan. However, during our investigation no specimens from Iran could be found. It is assumed that this species does not occur in Iran, and the report is likely a confusion with *S. gracilis*.

DNA-barcoding. Nearest species: *S. harteni* with 5.3 % (see Supplementary Table S1).

An updated checklist of the taxa of the tribe Scopulini in Iran, with unconfirmed or endemic status.

Problepsis Lederer, 1853
- *P. cinerea* (Butler, 1886)
- *P. wiltshirei* (Prout, 1938)

Cinglis Guenée, 1858 **stat. rev.**
- *C. humifusaria* (Eversmann, 1837)
- *C. benigna benigna* (Brandt, 1941) **comb. nov.** (Endemic to Iran)
  - *C. benigna amseli* (Wiltshire, 1967) **syn. nov.**
- *C. benigna nigromaculata* (Hausmann, 1994) **comb. nov.** (Endemic to Iran)
- *C. eurata* (Prout, 1913) **comb. nov.**

Scopuloides Hausmann, 1994 **stat. rev.**
- *S. origalis* (Brandt, 1941) **comb. rev.** (Endemic to Iran)

Scopula Schrank, 1802
- *S. conscensa* (Swinhoe, 1885) (Unconfirmed for Iran)
- *S. relictata* (Walker, 1866)
- *S. ansulata* (Lederer, 1871)
- *S. adulteraria* (Erschov, 1874) **stat. nov.**
- *S. immorata riloensis* (Züllich, 1936)
- *S. tessellaria* (Boisduval, 1840)
- *S. nigropunctata* (Hufnagel, 1767)
- *S. caesaria* (Walker, 1861) (Unconfirmed for Iran)
- *S. ornata enzela* Prout, 1935
- *S. orientalis* (Alphéraky, 1876)
- *S. decorata* (Denis & Schiffermüller, 1775)
- *S. subtilata* (Christoph, 1867) (Unconfirmed for Iran)
- *S. transcaspica* Prout, 1935
  - *S. transcaspica taftanica* Brandt, 1941 **syn. nov.**

S. rubiginata (Hufnagel, 1767) (Unconfirmed for Iran)
S. turbulentaria (Staudinger, 1870)
S. imitaria syriacaria (Culot, 1918) (Unconfirmed for Iran)
S. beckeraria (Lederer, 1853)
S. hoerhammeri Brandt, 1941 (Endemic to Iran)
S. incanata (Linnaeus, 1758)
S. marginepunctata (Goeze, 1781)
S. luridata distracta (Butler, 1881)
S. immutata (Linnaeus, 1758) (Unconfirmed for Iran)
S. flaccidaria (Zeller, 1852)
S. iranaria Bytinski-Salz & Brandt, 1937 **syn. nov.**
S. minorata (Boisduval, 1833)
S. adelpharia (Püngeler, 1894)
S. albiceraria (Herrich-Schäffer, 1847) (Unconfirmed for Iran)
S. immistaria (Herrich-Schäffer, 1852)
S. lactarioides Brandt, 1941 (Endemic to Iran)
S. diffinaria (Prout, 1913)
S. diffinaria asiatica (Brandt, 1938) **syn. nov.**
S. orbeorum (Hausmann, 1996) (Endemic to Iran)
S. chalcographata (Brandt, 1938) (Endemic to Iran)
S. sacraria ariana (Ebert, 1965)
Glossotrophia bullata Vojnits, 1986 **syn. nov.**
S. gracilis (Brandt, 1941) (Endemic to Iran)
S. alfierii (Wiltshire, 1949) (Unconfirmed for Iran)

Conclusion

The present study provides an important step forward in our understanding of the classification of geometrid moths, by shedding light on the systematics of the tribe Scopulini. In recent years molecular phylogenies on Geometridae have become more prevalent (e.g., Õunap *et al.* 2016; Jiang *et al.* 2017; Ban *et al.* 2018; Brehm *et al.* 2019; Murillo-Ramos *et al.* 2019; Sihvonen *et al.* 2020) contributing valuable data on each subfamily for further classification. By incorporating additional taxa of questionable status into the Sterrhinae dataset published by Murillo-Ramos *et al.* (2019) and Sihvonen *et al.* (2020), the status of the genera once regarded as synonym to *Scopula* (Sihvonen 2005) were re-evaluated. Of several classification options available, we chose *Cinglis* **stat. rev.** as valid genus, *Pseudocinglis* **syn. nov.** of *Cinglis*, *Scopuloides* **stat. rev.** as valid genus, and *Glossotrophia* as a junior synonym of *Scopula*.

It provides a revision of the whole Scopulini tribe in Iran, a country that has been shown to possess remarkable biodiversity with high rates of endemism, due to its heterogenic abiotic factors (Gholamifard 2011; Noroozi *et al.* 2019; Noori *et al.* 2021; Rajaei *et al.* 2023a). For instance, 28 % of the known reptilians, 23 % of the reported amphibians and 30% of the recorded vascular plant species are endemic to this country (Eskandarzadeh *et al.* 2018; Noroozi *et al.* 2019). In terms of lepidopterans, 19.7% are endemic to Iran, and 24 % are endemic to the country when considering only geometrids (according to the data presented by Rajaei *et al.* 2023b). Due to new classifications introduced in the current paper, the number of valid Iranian Scopulini species is now 33.

In the future, more sampling is required, especially in parts of Iran that have been less explored (e.g., provinces Khorassan-e Jonubi, Qom, Ilam) (see Rajaei *et al.* 2023b). Furthermore, several transitional zones in this country (e.g., the Zagros Mountains and the desert plains of Iraq in the province Ilam) require further investigation to enhance our understanding of the actual diversity and distribution of the family Geometridae in Iran.

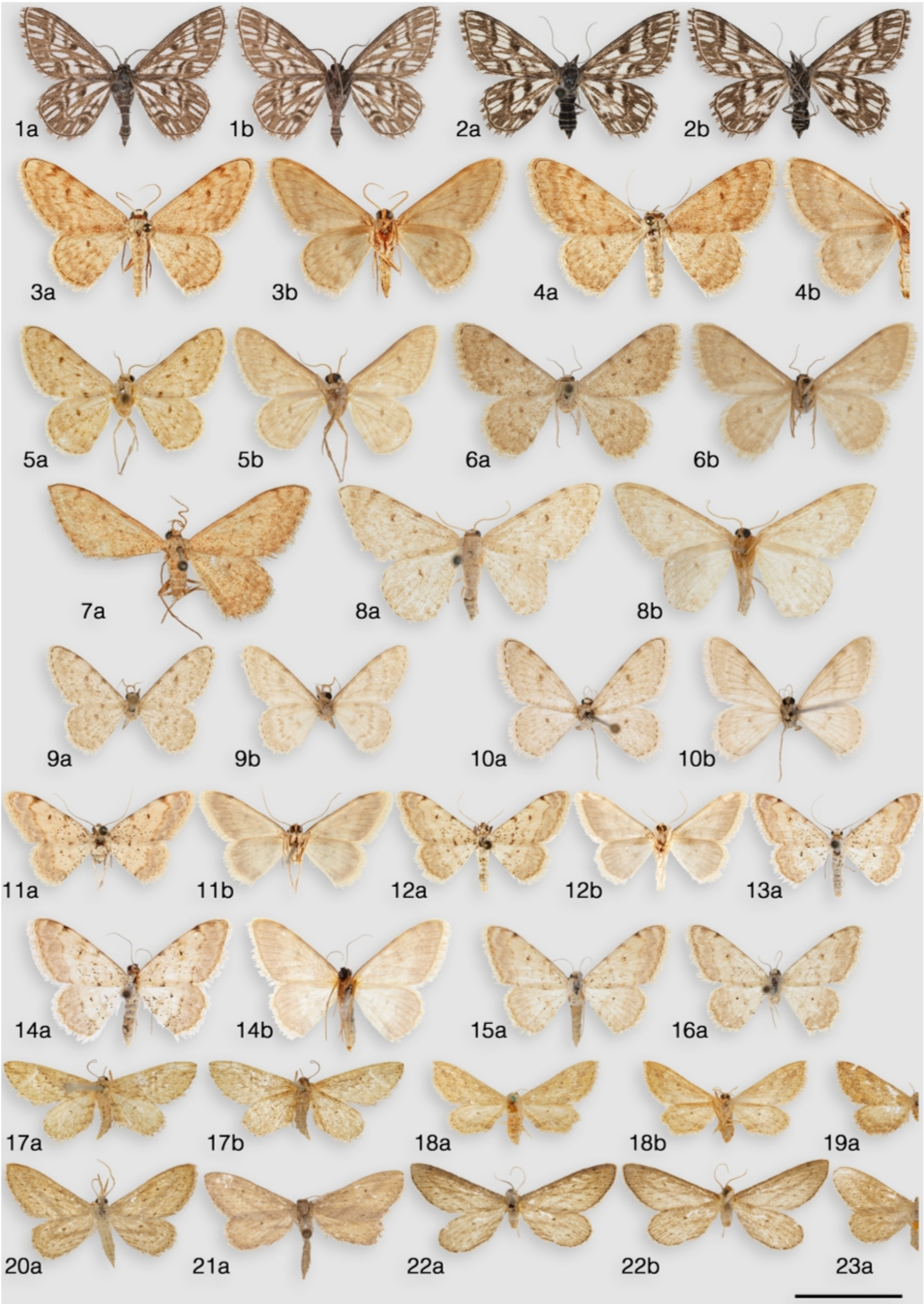

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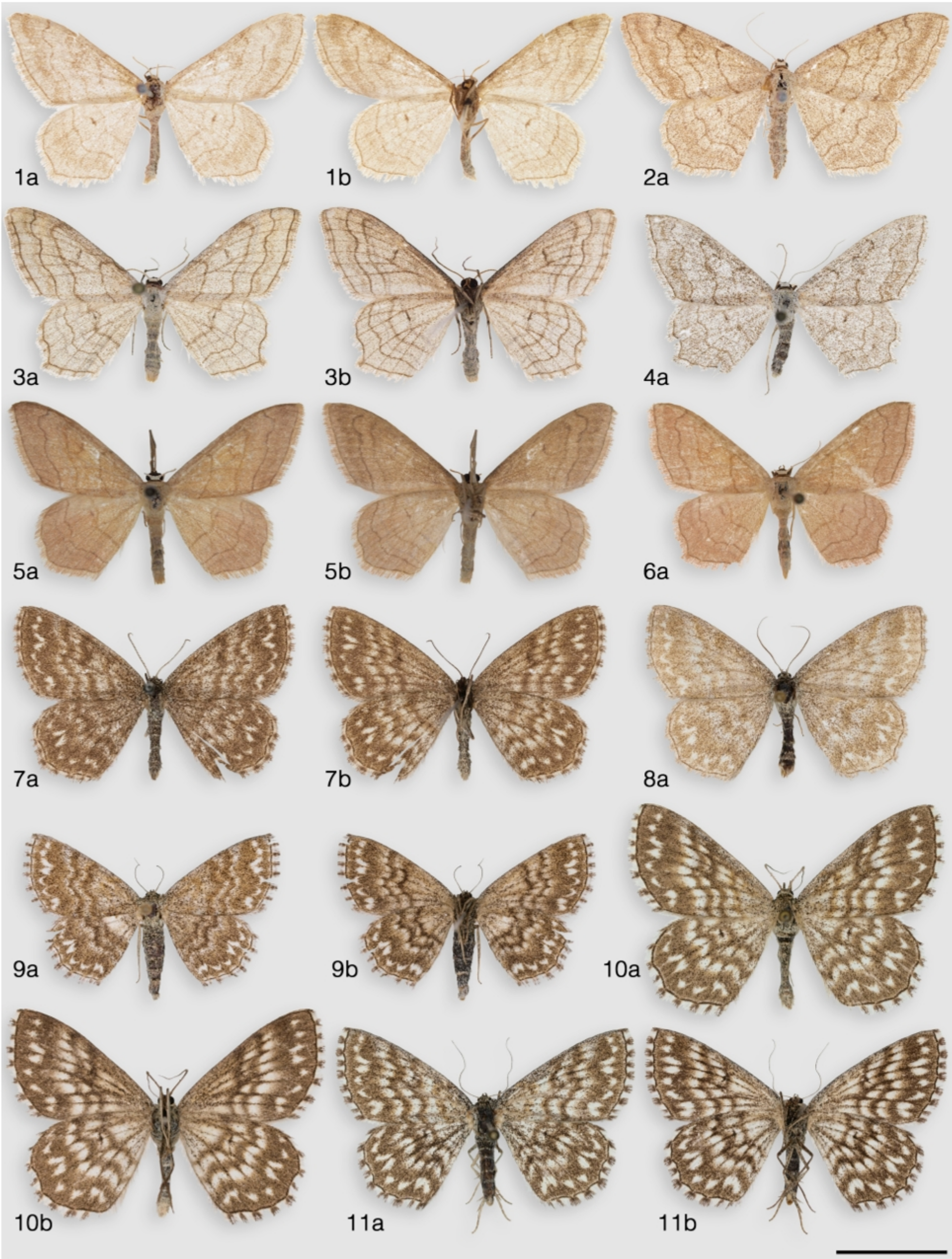
PLATE 3: Figures 1–23. Wing pattern of *Cinglis* and *Scopula* species. 1–2: *Cinglis humifusaria* (Iran, Zanjan, Ab-Dar, 1: g. prep. 1252/2022 D. Wanke; 2: g. prep. 1193/2022 D. Wanke); 3–4: *Cinglis benigna benigna* **comb. nov.** (Iran, Baloutchistan, Fort Sengan, 3: g. prep. 11053; 4: g. prep. 11054); 5–6: *Cinglis benigna nigromaculata* **comb. nov.** (Iran, Teheran, 5: Holotype, g. prep. 3796 Hausmann; 6: Paratype, g. prep. 3797 Hausmann); 7–8: *Cinglis benigna amseli* **syn. nov.** of *Cinglis benigna benigna* **comb. nov.** (7: Holotype, Iran, Fars, Quli-Kush, g. prep. 1127 E.P. Wiltshire; 8: Paratype, Afghanistan, Gulbahar, g. prep. 2263/2020 H. Rajaei); 9–10: *Cinglis eurata* **comb. nov.** (Turkmenistan, Kopet-Dagh, 9: g. prep. 894 Pasi Sihvonen; 10: g. prep. 895 Pasi Sihvonen); 11–16: *Scopuloides origalis* **stat. rev.** (11–13: Iran, Laristan, Straße Bender-Abbas-Saidabad, 11: Holotype, 12: Paratype, g. prep. 10878; 13: g. prep. 0587/2020 D. Wanke; 14: Iran, Balutschestan, Nikschar, g. prep. 0565/2020 D. Wanke; 15–16: Iran, Balutschestan, Khasch, 15: g. prep. 0626/2020 D. Wanke, 16: g. prep. 0617/2020 D. Wanke); 17–19: *Scopula conscensa* (17: Type, [India], Poona, NHMUK014173526; 18: Ceylon, NHMUK014173528; 19: [India], Pusa, NHMUK 014173527); 20–23: *Scopula relictata* (20: Bahrain, Jurdeh desert, NHMUK014173578; 21: Iran, Minab, g. prep. 0923/2021 D. Wanke; 22: Tainan, Formosa, NHMUK014173637; 23: Bahrain, Adari, NHMUK014173579). a = upperside; b = underside. Scale-bar 1 cm.

PLATE 4: Figures 1–11. Wing pattern of *Scopula* species. 1–4: *S. ansulata* (1–2: Syntypes, [Iran], [Golestan], Hadschyabad; 3: Iran, Ostan-e Khorasan, Dolmeh Olia, g. prep. 0695/2020 D. Wanke; 4: Iran, Ostan-e Khorasan, Kuh-e Mirza-e Arab, g. prep. 0697/2020 D. Wanke); 5–6: *S. adulteraria* **bona sp.** (Iran, Ostan-e Khorasan, Izmansufla, 5: g. prep. 0699/2020 D. Wanke, 6: g. prep. 1255/2022 D. Wanke); 7–9: *S. immorata* (7: [Iran], Tacht i Suleiman, g. prep. 1225/2021 D. Wanke; 8: Mongolia, Modoto Chentej Mts, g. prep. 1232/2021 D. Wanke; 9: Türkei, Erzurum, Askale, g. prep. 1226/2021 D. Wanke); 10–11: *S. tessellaria* (10: Kazakhstan, NE Kirova, g. prep. 1241/2021 D. Wanke; 11: Kazakhstan, S Kirgyzsay, g. prep. 1242/2021 D. Wanke). a = upperside; b = underside. Scale-bar 1 cm.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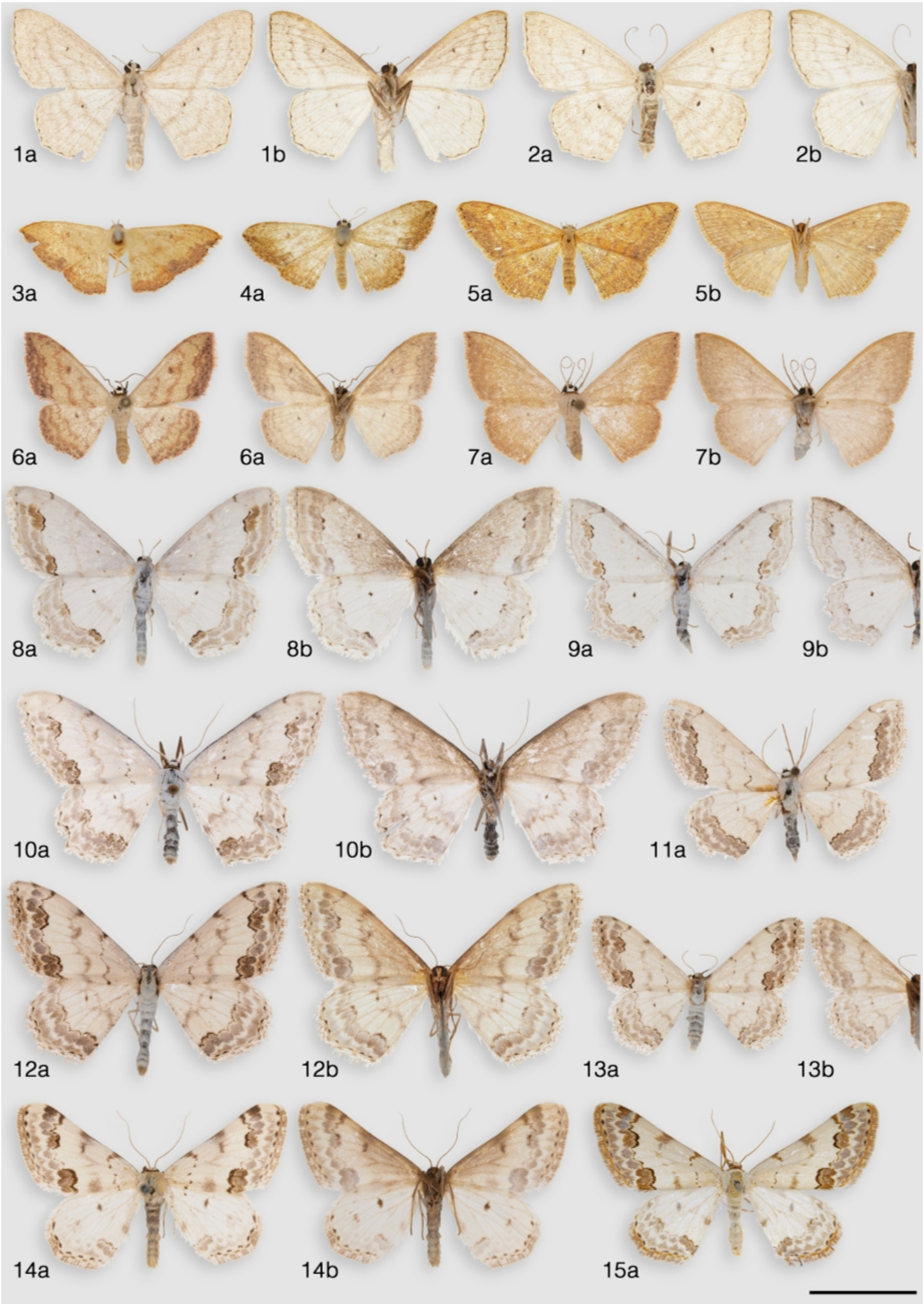
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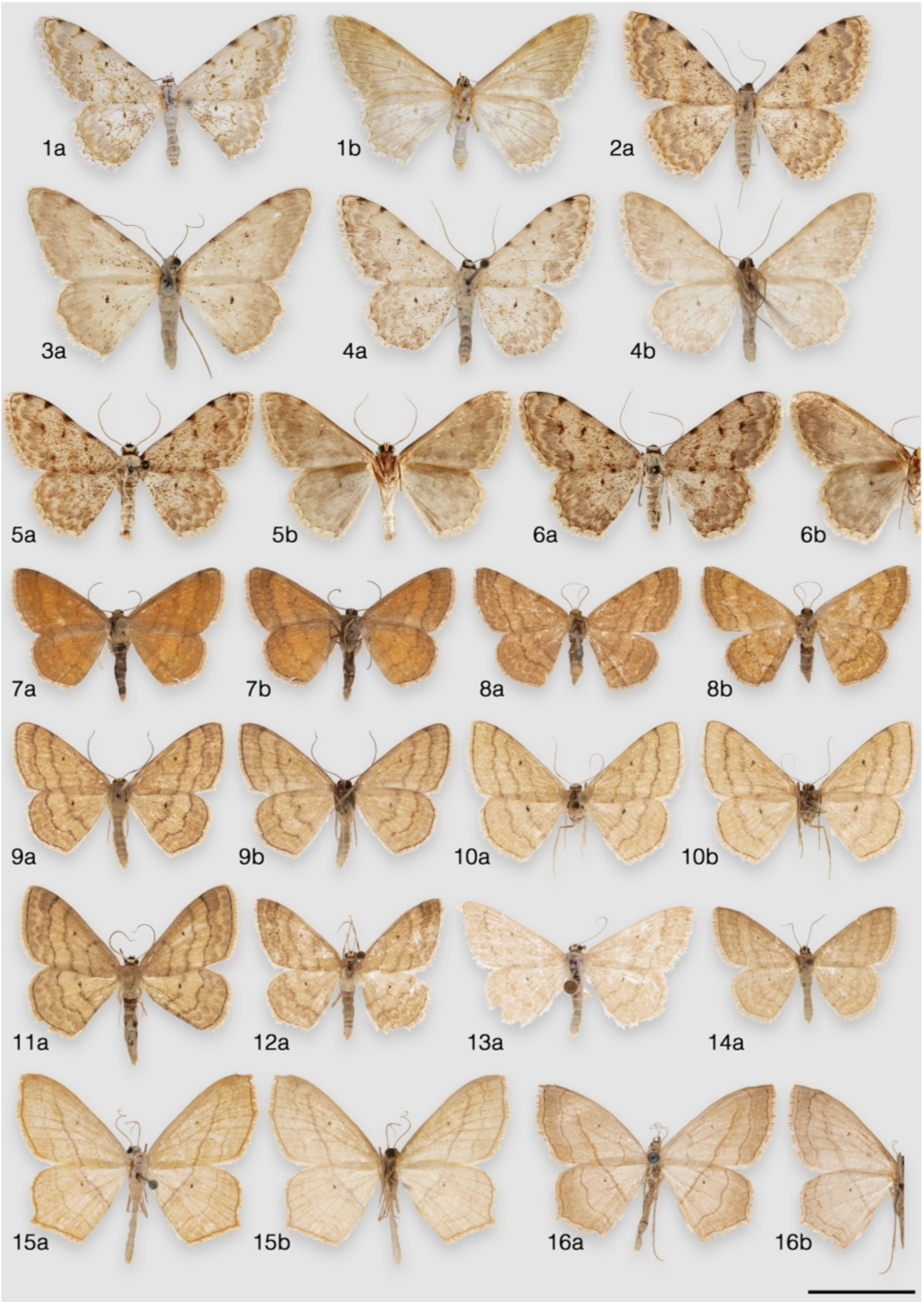
PLATE 5: Figures 1–15. Wing pattern of *Scopula* species. 1–2: *S. nigropunctata* (Turkey, Giresun, 1: g. prep. 1236/2021 D. Wanke, 2: g. prep. 1235/2021 D. Wanke); 3–7: *S. caesaria* (3: Syntype, Ceylon, NHMUK014173570; 4: Oman, Dhofar, NHMUK014173572; 5: N. Oman, Khasab, NHMUK014173571; 6: South Africa, Gauteng, Ezemvelo, g. prep. 1224/2021 D. Wanke; 7: South Yemen, Lahej Governorate, Al Dhala, g. prep. 1287/2022 D. Wanke); 8–9: *S. ornata enzela* (8: W-Iran, Kordestan, Straße Saghez-Baneh, g. prep. 0802/2020 D. Wanke; 9: N-Iran, Bandar Pahlavi, g. prep. 0796/2020 D. Wanke); 10–11: *S. orientalis* (10: Iran, Elburz, g. prep. 1192/2022 D. Wanke; 11: S Iran, Didegan, g. prep. 0801/2020 D. Wanke); 12–13: *S. decorata* (12: Iran, Masandaran, Damavand, g. prep. 0789/2020 D. Wanke; 13: Iran, Lorestan, E Borudjerd, g. prep. 0794/2020 D. Wanke); 14–15: *S. subtilata* (14: Russia, Sarepta [Volgograd], g. prep. 1272/2022 D. Wanke; 15: S. Russia, NHMUK014173553). a = upperside; b = underside. Scale-bar 1 cm.

PLATE 6: Figures 1–16. Wing pattern of *Scopula* species. 1–4: *S. transcaspica* (1: Paratype, [Turkmenistan], Ashkhabad, NHMUK010317468; 2: W-Iran, Kordestan, Straße Zandjan-Bijar, g. prep. 0811/2020 D. Wanke; 3: S-Iran, Bandar-Abbas, Kuhe Genou, g. prep. 0813/2020 D. Wanke; 4: S-Iran, Miyan Kotal, g. prep. 0809/2020 D. Wanke); 5–6: *S. transcaspica taftanica* **syn. nov.** of *S. transcaspica* (Baloutchistan, Kouh i Taftan, 5: Holotype, g. prep. 11021, 6: Paratype, g. prep. 11022); 7–8: *S. rubiginata* (7: Turkey, Aphrodisias, g. prep. 1291/2022 D. Wanke; 8: Amasia [Turkey], g. prep. 1290/2022 D. Wanke); 9–14: *S. turbulentaria steinbacheri* (9–11: Iran Mazandaran, Shirinabad, 9: g. prep. 0824/2020 D. Wanke, 10: g. prep. 0974/2020 D. Wanke, 11: 0973/2020 D. Wanke; 12: NW Iran, SE Maku, g. prep. 1172/2022 D. Wanke; 13: [Iran], [Tehran], Evin, g. prep. 1173/2022 D. Wanke; 14: N Iran, Tehran, Qolhak, g. prep. 0778/2020 D. Wanke); 15–16: *S. imitaria* ([Croatia], Krk, Fiumebucht, 15: g. prep. 0772/2020 D. Wanke, 16: g. prep. 0773/2020 D. Wanke). a = upperside; b = underside. Scale-bar 1 cm.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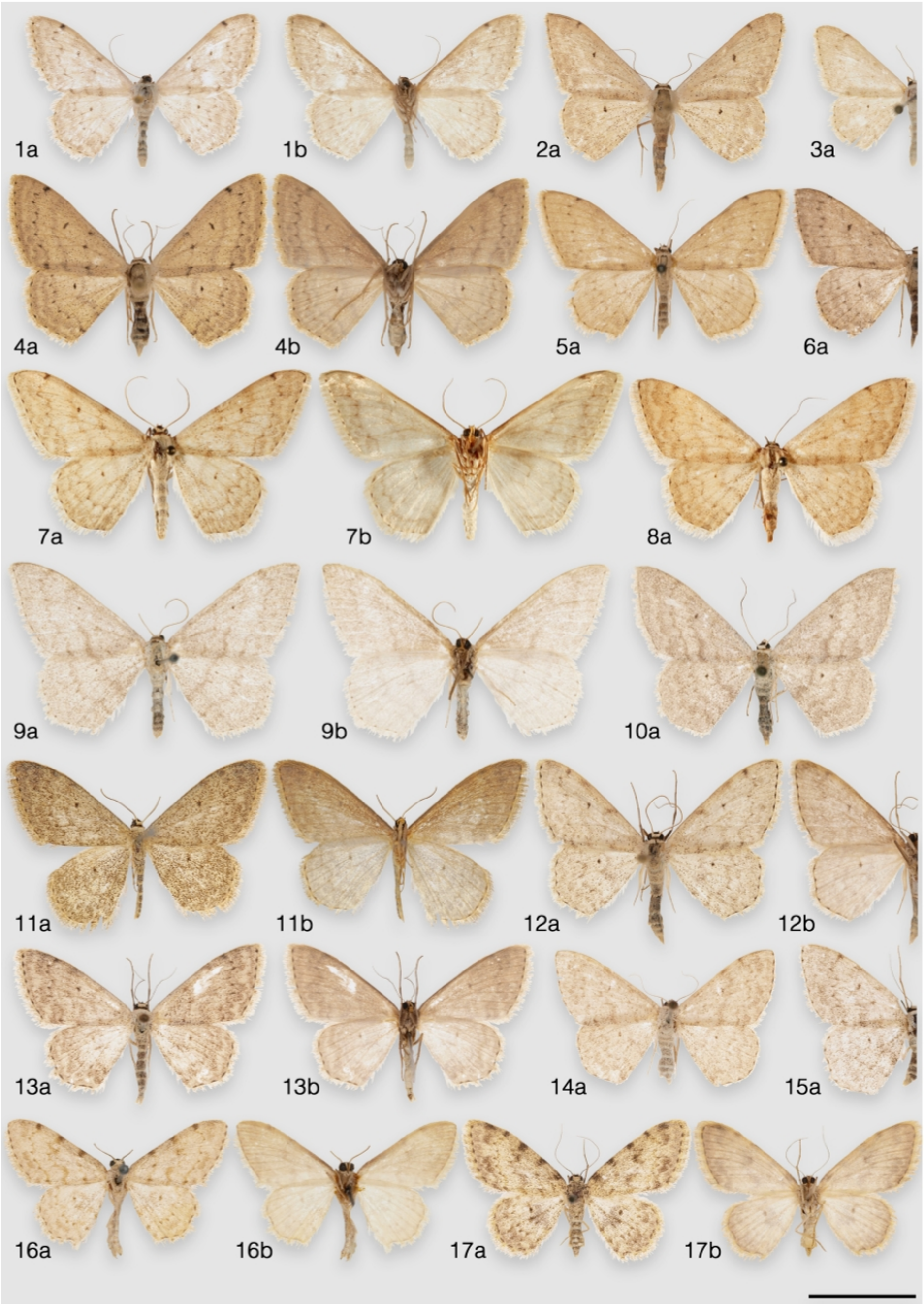
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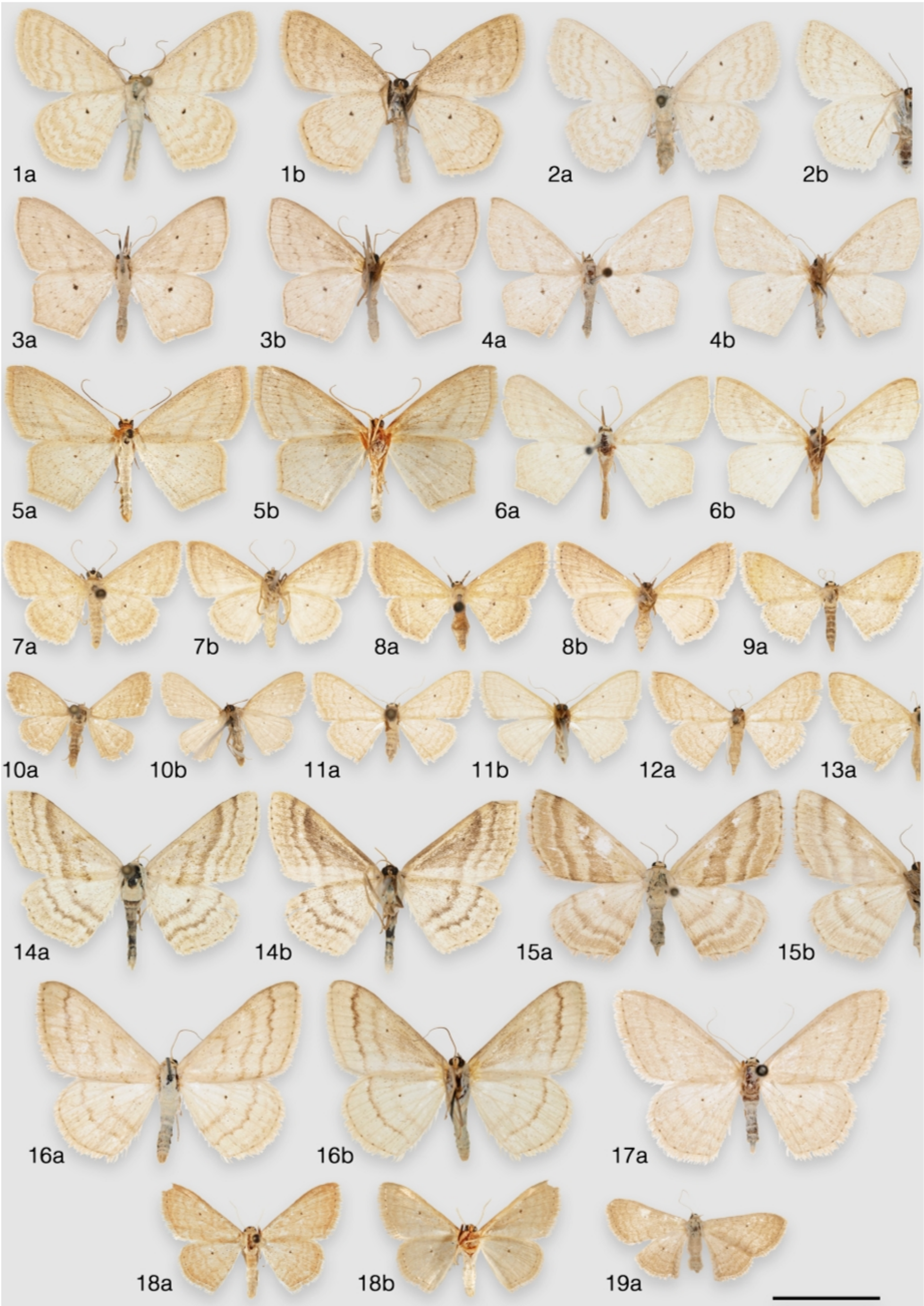
PLATE 7: Figures 1–17. Wing pattern of *Scopula* species. 1–6: *S. beckeraria* (1: Iran, Kerman, Hushin, g. prep. 1052/2022 D. Wanke; 2: Iran, Khorasan, Izmansufla, g. prep. 0839/2020 D. Wanke; 3: Iran, Esfahan, Kashan, g. prep. 0820/2020 D. Wanke; 4: Iran, Khorasan, Izmansufla, g. prep. 0905/2020 D. Wanke; 5: N-Iran, [Tehran], Varamin, g. prep. 0783/2020 D. Wanke; 6: NE Iran, Khorasan, Akbarabad, g. prep. 1002/2021 D. Wanke); 7–8: *S. hoerhammeri* (Iran, Fars, [Komehr], 7: Paratype, g. prep. 11019, 8: g. prep. 11020); 9–10: *S. incanata* ([Iran], Tacht i Suleiman, 9: g. prep. 1275/2022 D. Wanke, 10: g. prep. 1277/2022 D. Wanke); 11–15: *S. marginepunctata terrigena* (11: Type, [Iran], Mazanderan, [Sabat-Kuh], NHMUK014173548; 12: NE Iran, Khorasan, Izmansufla, g. prep. 0840/2020 D. Wanke; 13: N Iran, Amarlu, g. prep. 0875/2020 D. Wanke; 14: Iran, Mazandaran, Gonbad Qabus, g. prep. 0904/2020 D. Wanke; 15: NW Iran, Maku, g. prep. 1049/2021 D. Wanke); 16–17: *S. luridata* (16: Syria, Marasch, g. prep. 1295/2022 D. Wanke; 17: W Saudi Arabia, Al-Hada, g. prep. 1292/2022 D. Wanke);. a = upperside; b = underside. Scale-bar 1 cm.

PLATE 8: Figures 1–19. Wing pattern of *Scopula* species. 1–2: *S. immutata* ([Hungary], Bükkösd, 1: 1246/2021 D. Wanke, 2: 1247/2021 D. Wanke); 3–4: *S. flaccidaria* (3: N-Iran, Masandaran, Schasavar, g. prep. 1053/2021 D. Wanke; 4: N Iran, Bandar Pahlavi, g. prep. 1054/2021 D. Wanke); 5–6: *S. iranaria* **syn. nov.** of *S. flaccidaria* (Iran, Kerdej, 5: g. prep. 11060, 6: Cotype, g. prep. 2299/2020 H. Rajaei); 7–9: *S. minorata* (Spain, Gran Canaria, Las Palmas, 7: g. prep. 1248/2021 D. Wanke, 8: g. prep. 1249/2021 D. Wanke; 9: Yemen, Sana, Makaban, g. prep. 1304/2022 D. Wanke); 10–13: *S. adelpharia* (10: S Iran, Hormozgan, Sirki, g. prep. 1309/2022 D. Wanke; 11–13: Sudan, Ed Damer, Hudeiba, 11: g. prep. 1268/2022 D. Wanke, 12: g. prep. 1270/2022 D. Wanke, 13: g. prep. 1271/2022 D. Wanke); 14–15: *S. albiceraria* (14: Mongolia, Selenge aimag, near Ochron, g. prep. 1305/2022 D. Wanke; 15: SW Mongolia, Gobi-Altai aimak, SSW Zhargalan, g. prep. 1301/2022 D. Wanke); 16–17: *S. immistaria* (16: N Iran, Masandaran, Damavand, g. prep. 0830/2020 D. Wanke; 17: Iran, Esfahan, Fereydunshahr, g. prep. 0814/2020 D. Wanke); 18–19: *S. lactarioides* (18: Iran, Baloutchistan, Bender Tchahbahar, g. prep. 11057; 19: Iran, Makran, Chahbar Küste, g. prep. 0879/2020 D. Wanke). a = upperside; b = underside. Scale-bar 1 cm.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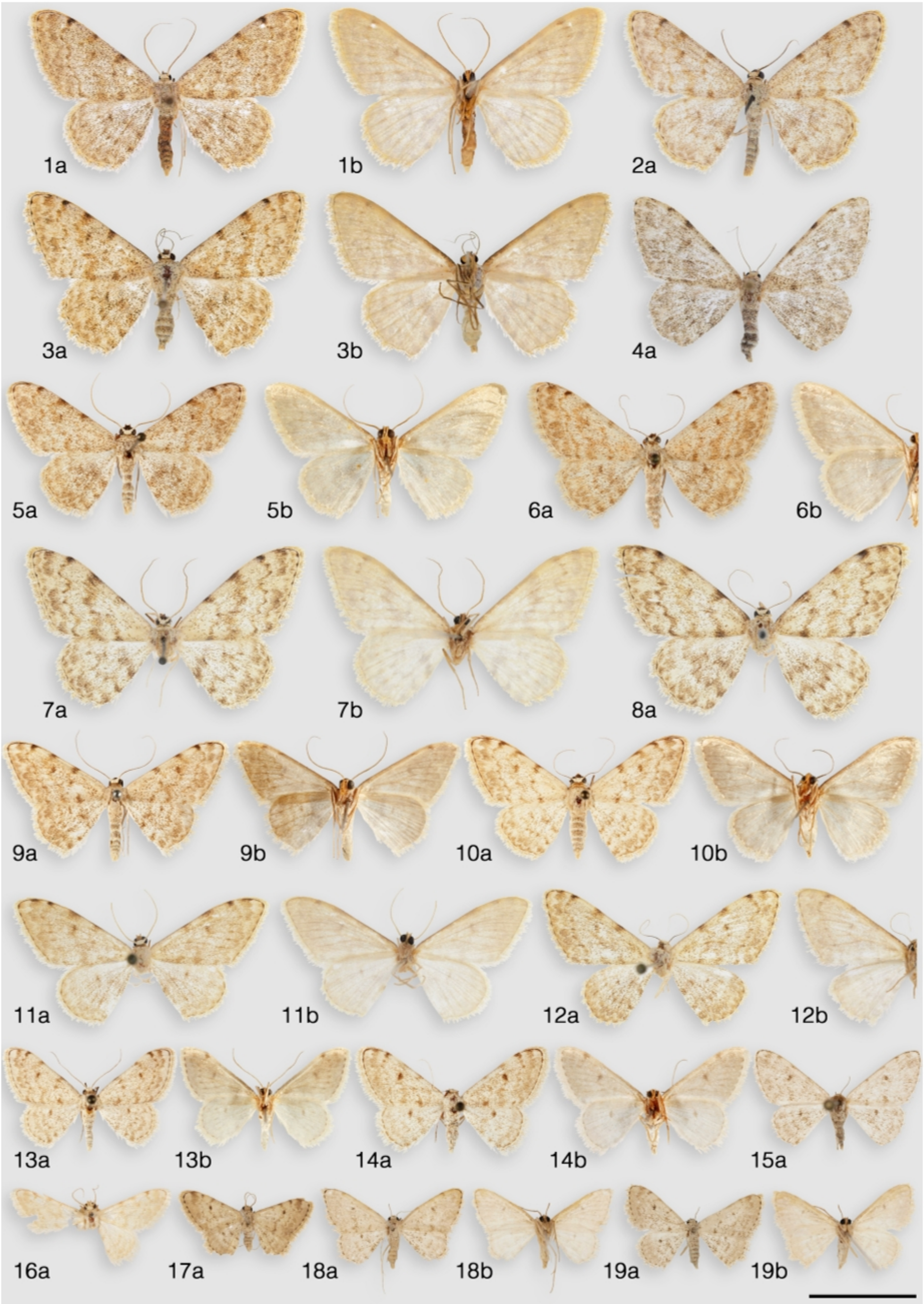
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PLATE 9: Figures 1–19. Wing pattern of *Scopula* species. 1–4: *S. diffinaria diffinaria* (1: Iran, Elbours, Polour, g. prep. 0533/2020 D. Wanke; 2: [Turkey], Akschehir, g. prep. 0574/2020 D. Wanke; 3: Iran, Kohkiluye va Boyerahmad, Yasuj, g. prep. 0713/2020 D. Wanke; 4: Iran, Mazandaran, Shah Kuh-Pain, g. prep. 0521/2020 D. Wanke); 5–6: *S. diffinaria asiatica* **syn. nov.** of *S. diffinaria diffinaria* (Paratypes, Iran, Fars, [Komehr], 5: g. prep. 10872, 6: g. prep. 10873); 7–8: *S. orbeorum* ([Iran], Tacht i Suleiman, 7: Holotype, g. prep. 1970 ZSM Hausmann, 8: Paratype g. prep. 4248 ZSM Hausmann); 9–10: *S. chalcographata* (Iran, Fars, Mian-Kotal, 9: g. prep. 10875; 10: Paratype g. prep. 10874); 11–12: *S. sacraria ariana* (Paratypes, Afghanistan, Sarobi, 11: g. prep. G40, 12: g. prep. G44); 13–15: *S. gracilis* (13-14: Iran Baloutchistan, Bender Tchahbahar, 13: g. prep. 10876, 14: g. prep. 10877; 15: Iran, Hormozgan, Sirik, g. prep. 1307/2022 D. Wanke); 16–19: *S. alfierii* (16: Paratype, Egypt, Wadi Digla, g. prep. 382 E.P. Wiltshire; 17: Yemen, Al Ain, g. prep. 1296/2022 D. Wanke; 18: Yemen, Al Mukalla, g. prep. 1297/2022 D. Wanke; 19: Yemen, Al Mukalla, g. prep. 1298/2022 D. Wanke). a = upperside; b = underside. Scale-bar 1 cm.

PLATE 10: Figures 1–7. Male genitalia of *Cinglis* and *Scopuloides* **stat. rev.** species. 1: *Cinglis humifusaria* (Iran, Zanjan, Ab-Dar, g. prep. 1253/2022 D. Wanke); 2: *Cinglis benigna benigna* **comb. nov.** (Iran, Baloutchistan, a, b, c1: g. prep. 11053; c2: g. prep. 0874/2020 D. Wanke; c3: g. prep. 0604/2020 D. Wanke); 3: *Cinglis benigna nigromaculata* **comb. nov.** (Iran, Kashan, g. prep. 0665/2020 D. Wanke); 4–5: *Cinglis benigna amseli* **syn. nov.** of *Cinglis benigna benigna* **comb. nov.** (4: Paratype, Afghanistan, Gulbahar, g. prep. WM. 131; 5a, b, c1: Paratype, Afghanistan, Gulbahar, g. prep. 2263/2020 H. Rajaei; 5c2: Afghanistan, Polichomri, g. prep. 2262/2020 H. Rajaei); 6: *Cinglis eurata* **comb. nov.** (Iran, Khorasan Razavi, g. prep. 1179/2021 D. Wanke); 7: *Scopuloides origalis* **stat. rev. (**Paratype, Iran, Laristan, Straße Bender-Abbas-Saidabad, g. prep. 10878). a = genitalia capsule; b = aedeagus; c = 8th sternite. Scale-bar 1 mm.

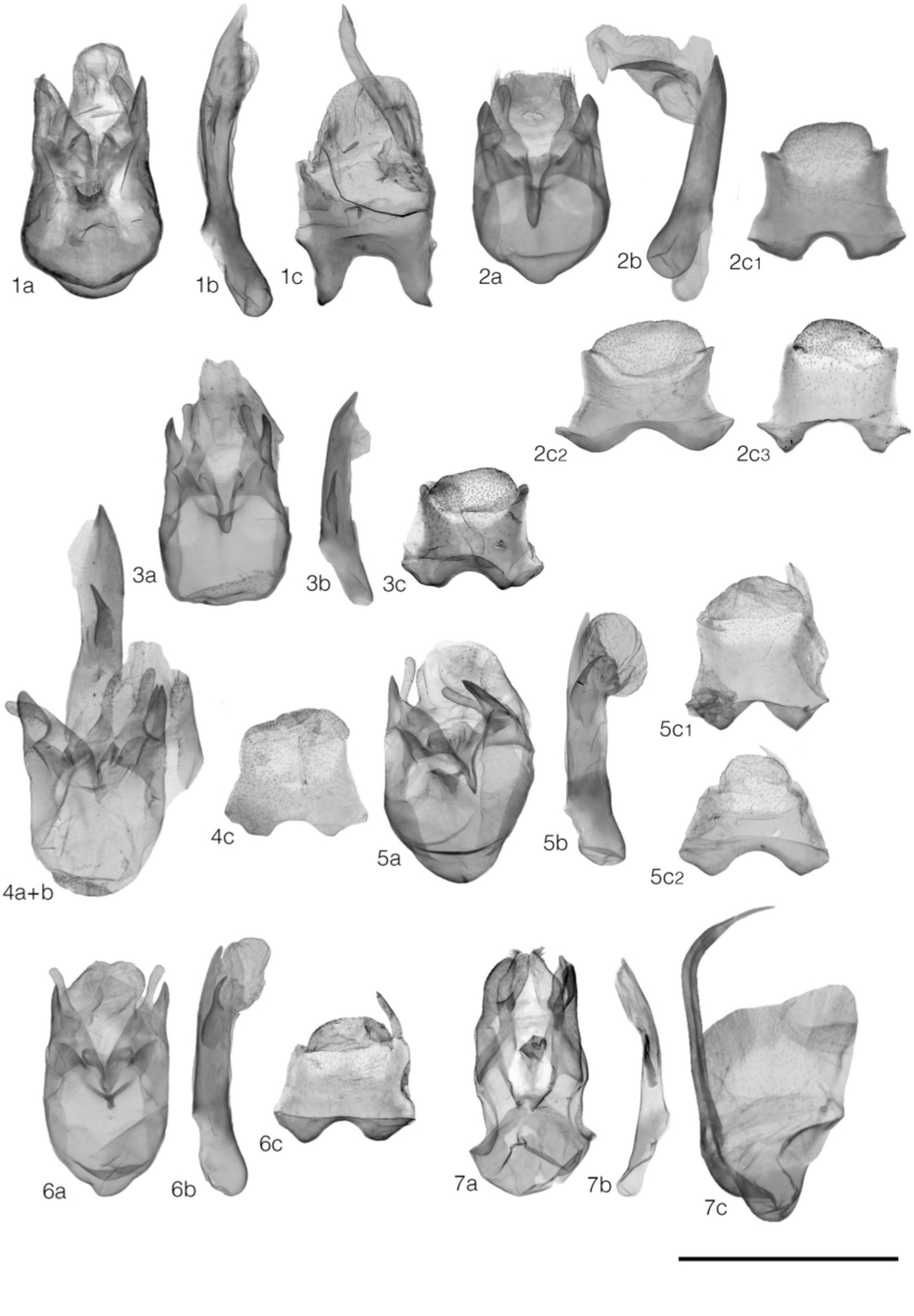
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PLATE 11: Figures 1–3. Male genitalia of *Scopula* species. 1–2: *Scopula conscensa* (India, NHMUK014314490, 1: in scale, 2: enlarged, out of scale); 3: *Scopula relictata* (Iran, Minab, g. prep. 0923/2021 D. Wanke). a = genitalia capsule; b = aedeagus; c = 8th sternite. Scale-bar 1 mm.

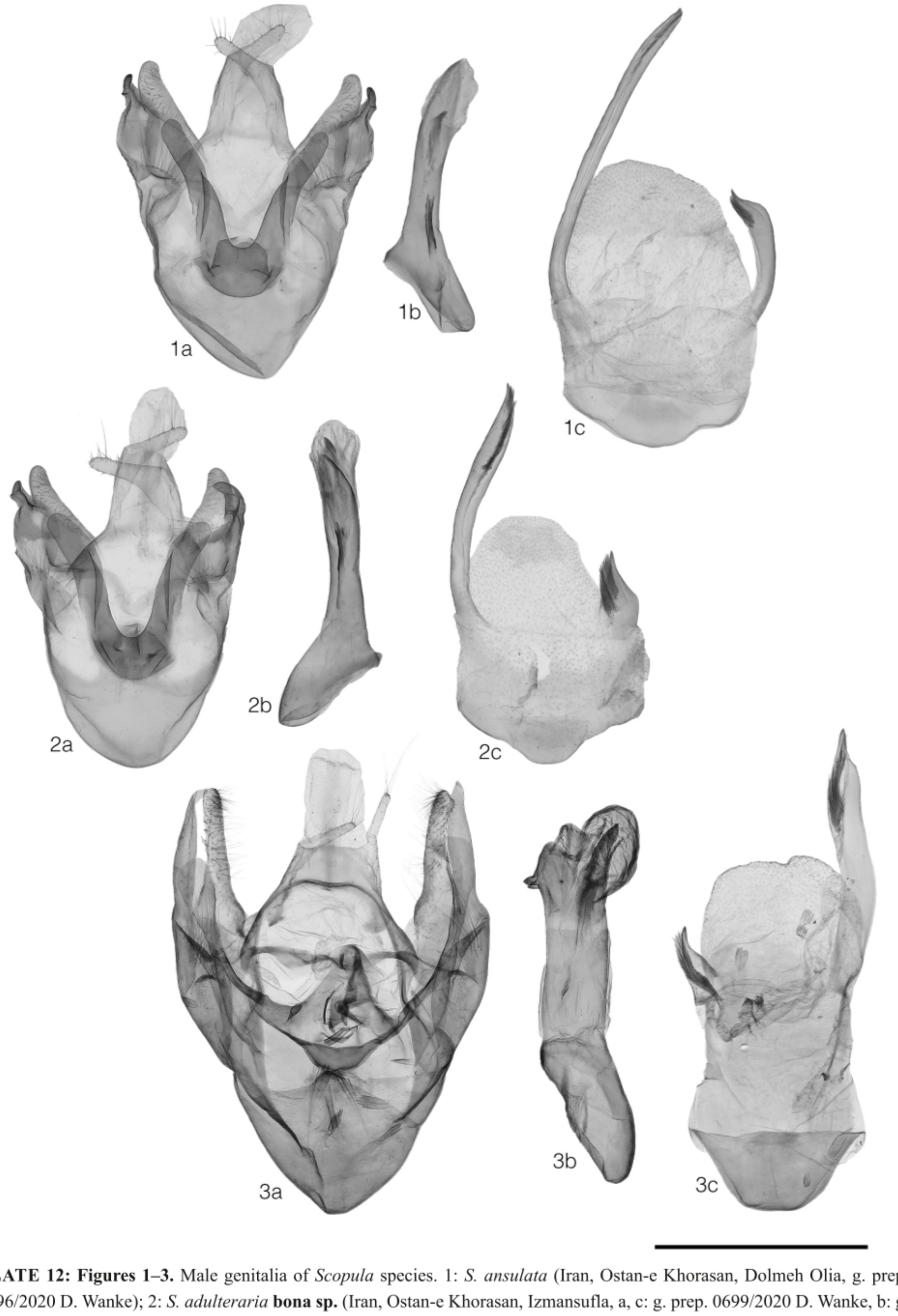

PLATE 12: Figures 1–3. Male genitalia of *Scopula* species. 1: *S. ansulata* (Iran, Ostan-e Khorasan, Dolmeh Olia, g. prep. 0696/2020 D. Wanke); 2: *S. adulteraria* **bona sp.** (Iran, Ostan-e Khorasan, Izmansufla, a, c: g. prep. 0699/2020 D. Wanke, b: g. prep. 0700/2020 D. Wanke); 3: *S. immorata* ([Iran], Särdab Tal-Vandarban, g. prep. 1286/2022 D. Wanke). a = genitalia capsule; b = aedeagus; c = 8th sternite. Scale-bar 1 mm.

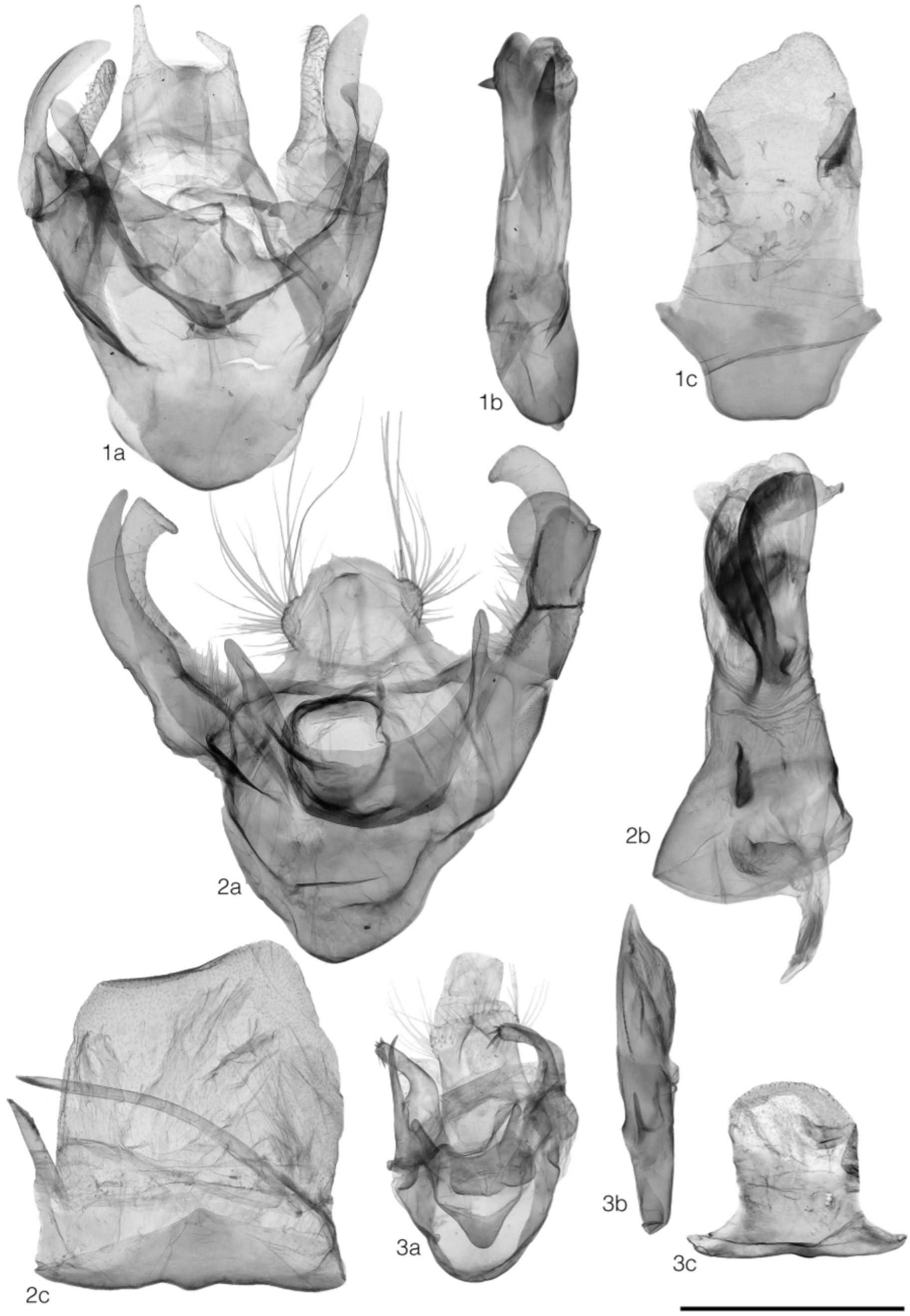

PLATE 13: Figures 1–3. Male genitalia of *Scopula* species. 1: *S. tessellaria* ([Iran], Tacht i Suleiman, g. prep. 1260/2022 D. Wanke); 2: *S. nigropunctata* (Turkey, Giresun, 1: g. prep. 1236/2021 D. Wanke); 3: *S. caesaria* (a, b: South Africa, Gauteng, Ezemvelo, g. prep. 1224/2021 D. Wanke; c: Oman, Dhofar, Wadi Sha'ath, g. prep. NHMUK 010317472). a = genitalia capsule; b = aedeagus; c = 8th sternite. Scale-bar 1 mm.

PLATE 14: Figures 1–3. Male genitalia of *Scopula* species. 1: *S. ornata enzela* (N-Iran, Bandar Pahlavi, g. prep. 0797/2020 D. Wanke); 2: *S. orientalis* (Iran, Elburz, g. prep. 1192/2022 D. Wanke); 3: *S. decorata* (W Iran, Kordestan, Straße Zandjan-Bijar, g. prep. 0792/2020 D. Wanke). a = genitalia capsule; b = aedeagus; c = 8th sternite. Scale-bar 1 mm.

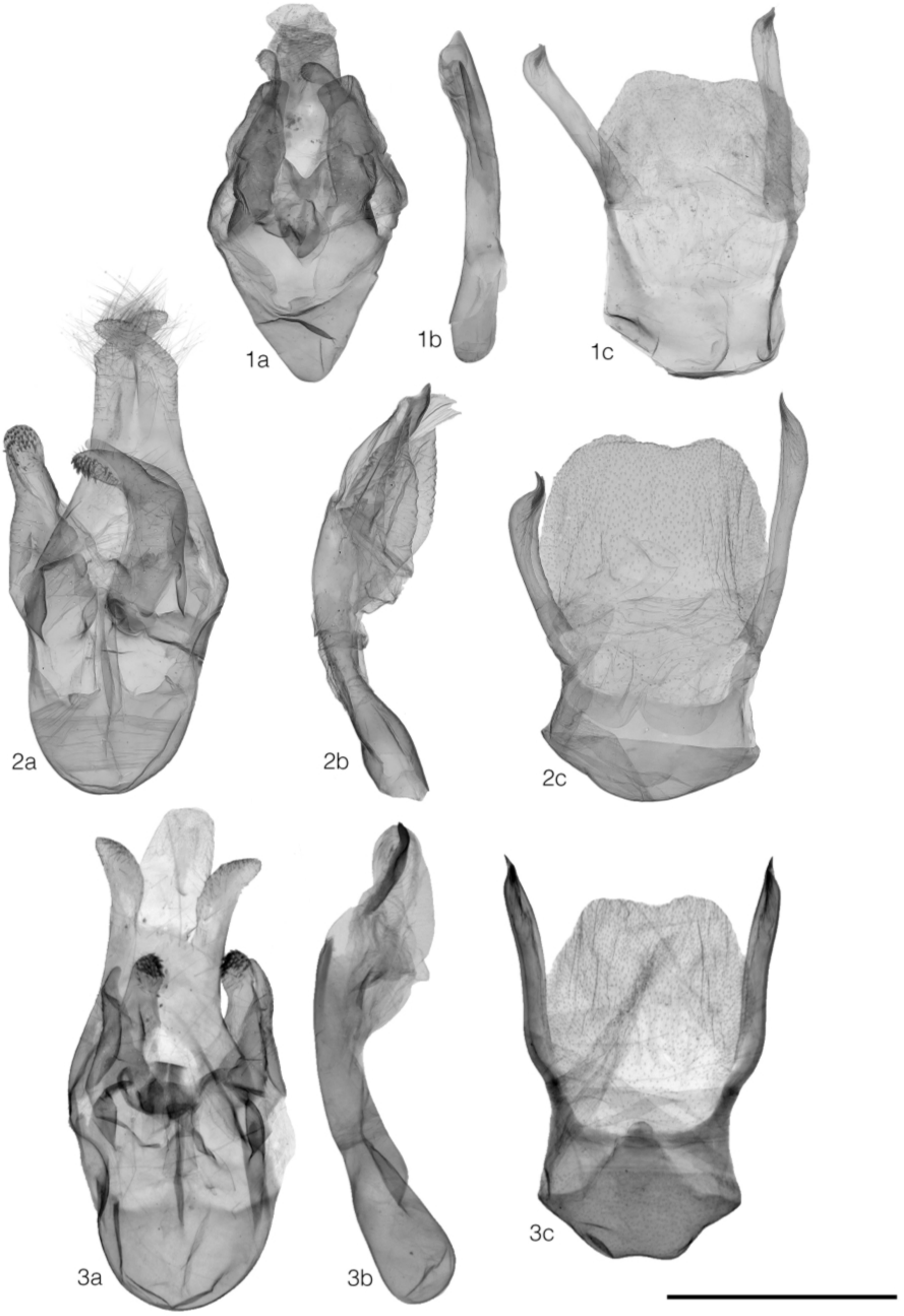

PLATE 15: Figures 1–3. Male genitalia of *Scopula* species. 1: *S. subtilata* (1: Russia, Sarepta [Volgograd], g. prep. 1272/2022 D. Wanke); 2: *S. transcaspica* (a, b, c: Iran, Ostan-e Khorasan, Izmansufla, a, c: g. prep. 0510/2020 D. Wanke, b: g. prep. 0518/2020 D. Wanke); 3: *S. transcaspica taftanica* **syn. nov.** of *S. transcaspica* (Holotype, Baloutchistan, Kouh i Taftan, g. prep. 11021). a = genitalia capsule; b = aedeagus; c = 8th sternite. Scale-bar 1 mm.

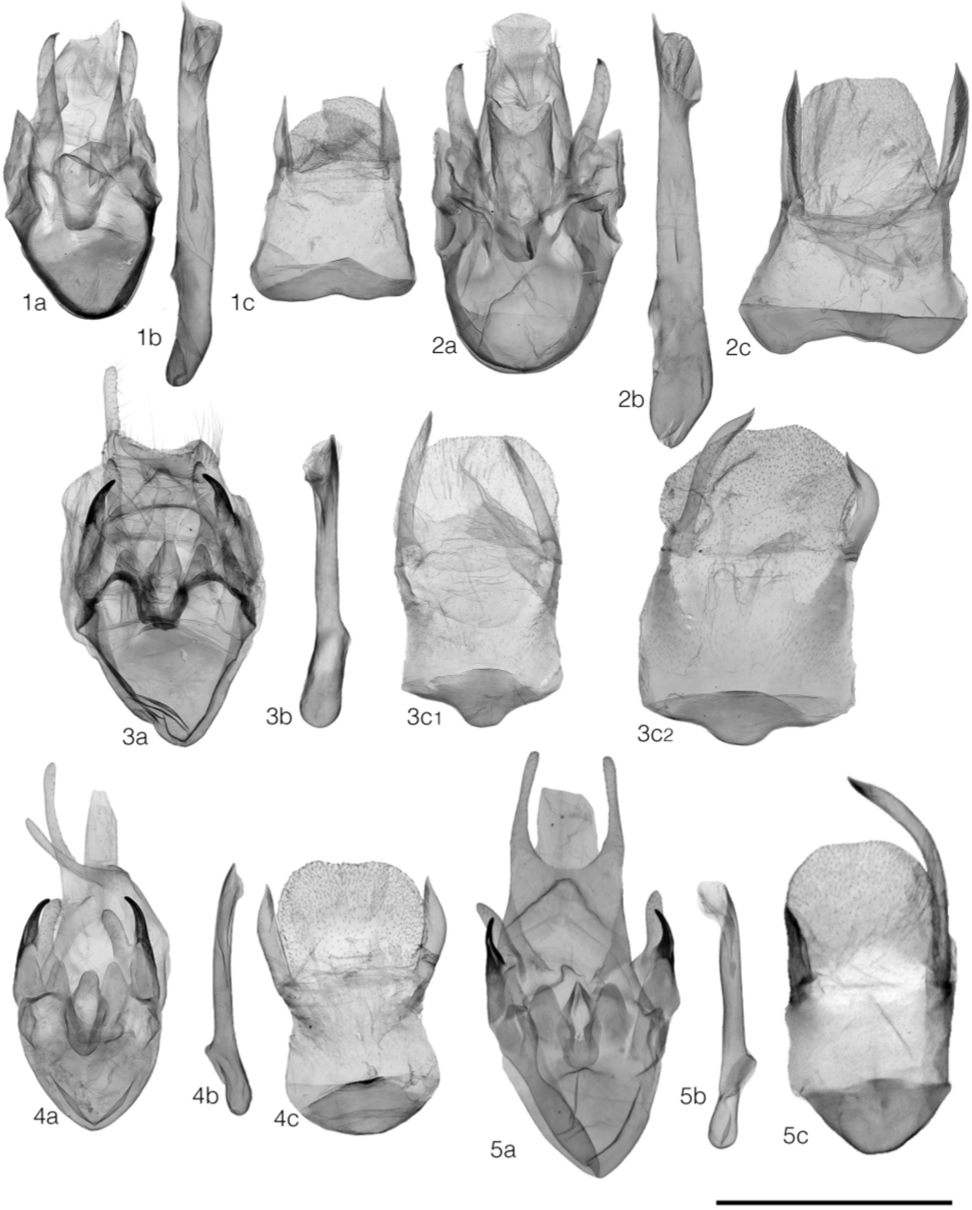

PLATE 16: Figures 1–5. Male genitalia of *Scopula* species. 1: *S. rubiginata* (Iran, Tehran, Qolhak, g. prep. 0778/2022 D. Wanke); 2: *S. turbulentaria steinbacheri* (Iran, Mazandaran, Shirinabad, 9: g. prep. 0825/2020 D. Wanke); 3: *S. imitaria* (a, b, c1: Cyprus, Paphos, g. prep. 1274/2022 D. Wanke, c2: [Croatia], Krk, Fiumebucht, g. prep. 0772/2020 D. Wanke); 4: *S. beckeraria* (a: Iran, Esfahan, Kashan, g. prep. 0820/2020 D. Wanke, b, c: N-Iran, [Tehran], Varamin, g. prep. 0782/2020 D. Wanke); 5: *S. hoerhammeri* (Paratype, Iran, Fars, [Komehr], g. prep. 11019). a = genitalia capsule; b = aedeagus; c = 8th sternite. Scale-bar 1 mm.

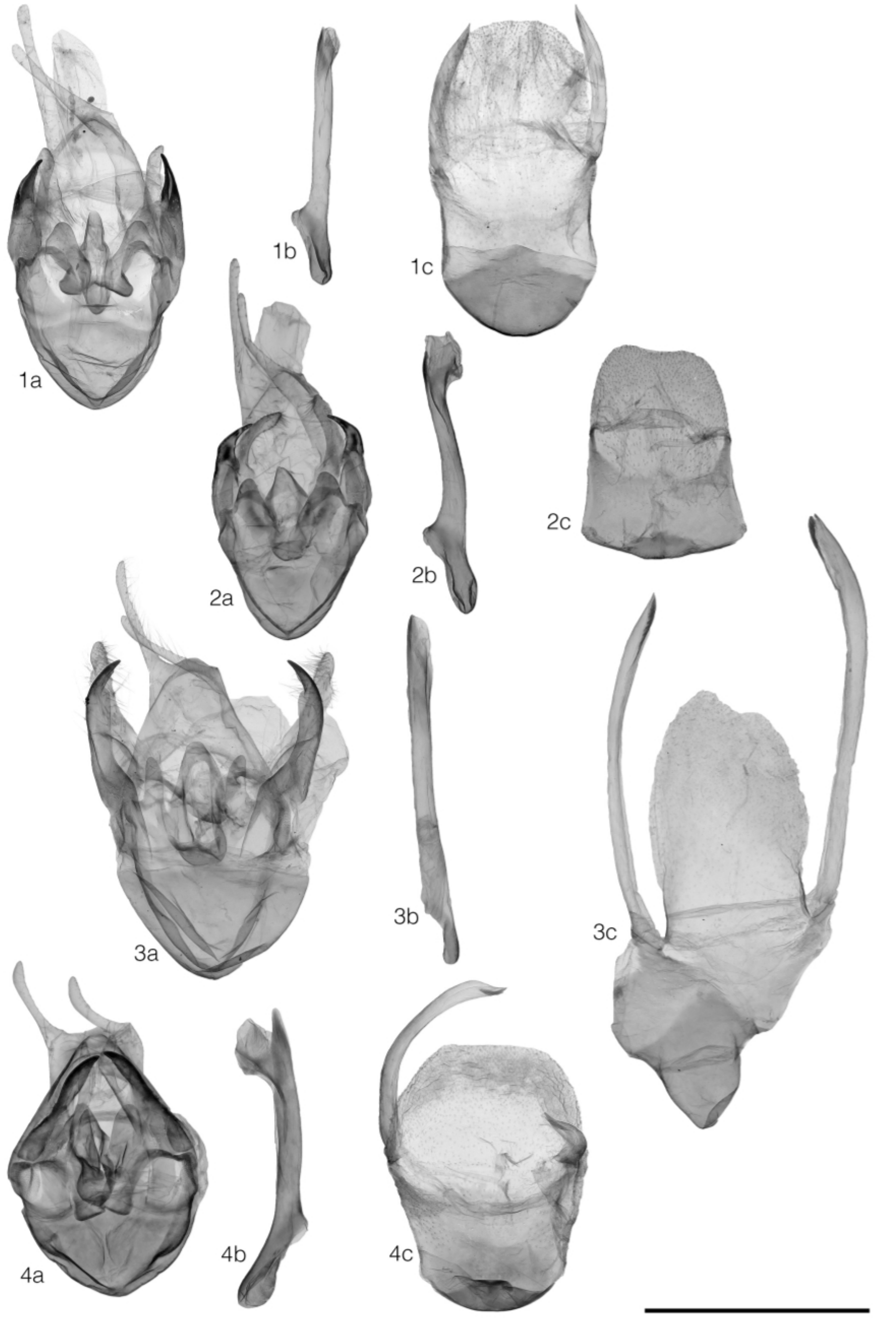

PLATE 17: Figures 1–4. Male genitalia of *Scopula* species. 1: *S. incanata* ([Iran], Tacht i Suleiman, g. prep. 1275/2022 D. Wanke); 2: *S. marginepunctata terrigena* (Iran, Mazandaran, Gonbad Qabus, g. prep. 0903/2020 D. Wanke); 3: *S. luridata* (Syria, Marasch, g. prep. 1295/2022 D. Wanke); 4: *S. immutata* ([Hungary], Bükkösd, 1246/2021 D. Wanke). a = genitalia capsule; b = aedeagus; c = 8th sternite. Scale-bar 1 mm.

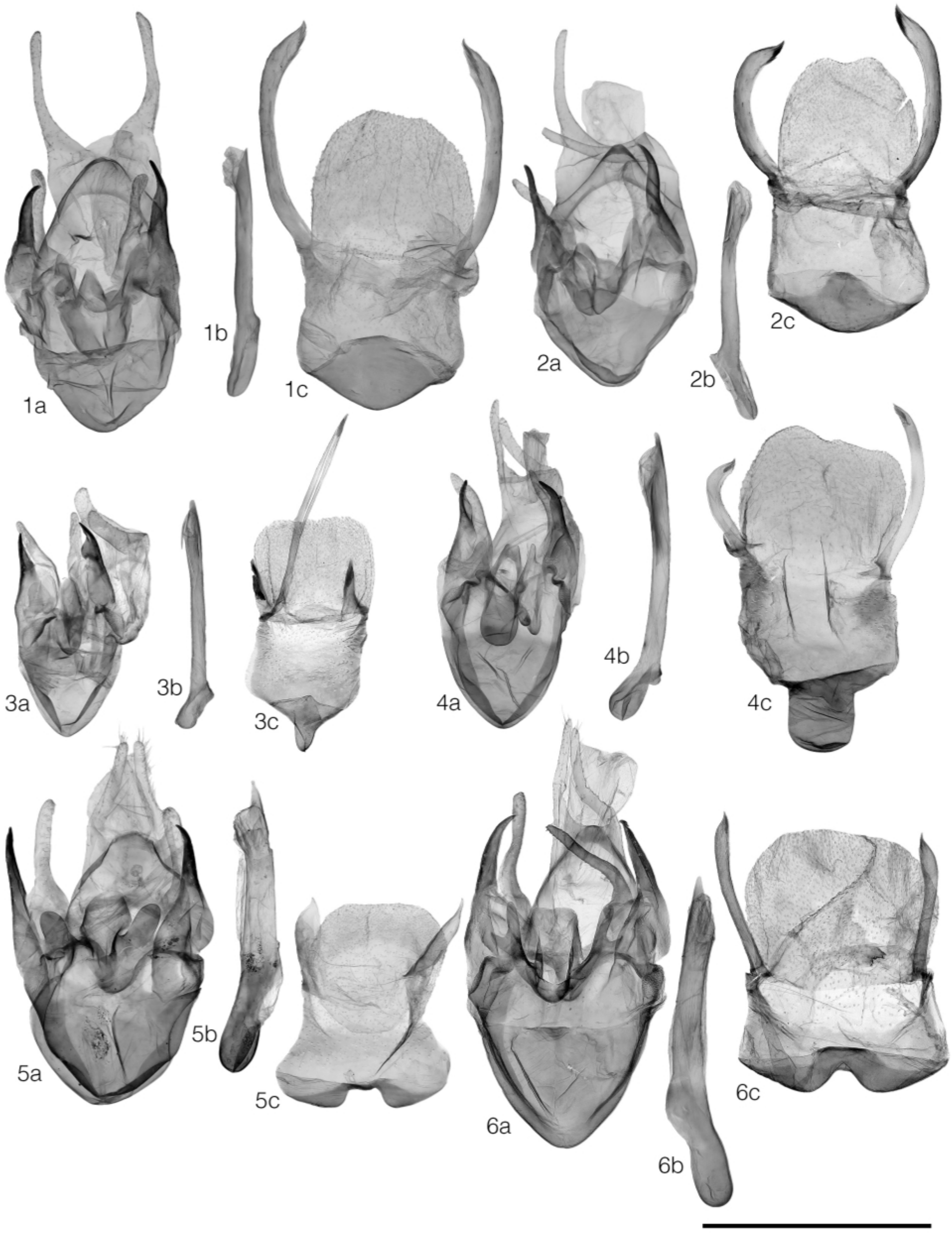

PLATE 18: Figures 1–6. Male genitalia of *Scopula* species. 1: *S. flaccidaria* (N-Iran, Masandaran, Schasavar, g. prep. 1053/2021 D. Wanke). 2: *S. iranaria* **syn. nov.** of *S. flaccidaria* (Cotype, Iran, Kerdej, g. prep. 2299/2020 H. Rajaei); 3: *S. minorata* (Spain, Gran Canaria, Las Palmas, g. prep. 1248/2021 D. Wanke); 4: *S. adelpharia* (S Iran, Hormozgan, Sirki, g. prep. 1309/2022 D. Wanke); 5: *S. albiceraria* (Mongolia, Selenge aimag, near Ochron, g. prep. 1305/2022 D. Wanke); 6: *S. immistaria* (N Iran, Masandaran, Damavand, g. prep. 0830/2020 D. Wanke); a = genitalia capsule; b = aedeagus; c = 8th sternite. Scale-bar 1 mm.

PLATE 19: Figures 1–4. Male genitalia of *Scopula* species. 1: *S. lactarioides* (Iran, Baloutchistan, Bender Tchahbahar, g. prep. 11057); 2: *S. diffinaria diffinaria* (a, b, c1: [Turkey], Akschehir, g. prep. 0574/2020 D. Wanke, c2: Iran, Elbours, Polour, g. prep. 0533/2020 D. Wanke; c3: Iran, Kordestan, NE Baneh, g. prep. 0653/2020 D. Wanke); 3: *S. diffinaria asiatica* **syn. nov.** of *S. diffinaria diffinaria* (a, b, c1: Paratype, Iran, Fars, [Komehr], g. prep. 10872, c2: S Iran, Fars, Tange Surkh, g. prep. 0592/2020 D. Wanke); 4: *S. orbeorum* (Holotype, [Iran], Tach i Suleiman, g. prep. 1970 ZSM Hausmann). a = genitalia capsule; b = aedeagus; c = 8th sternite. Scale-bar 1 mm.

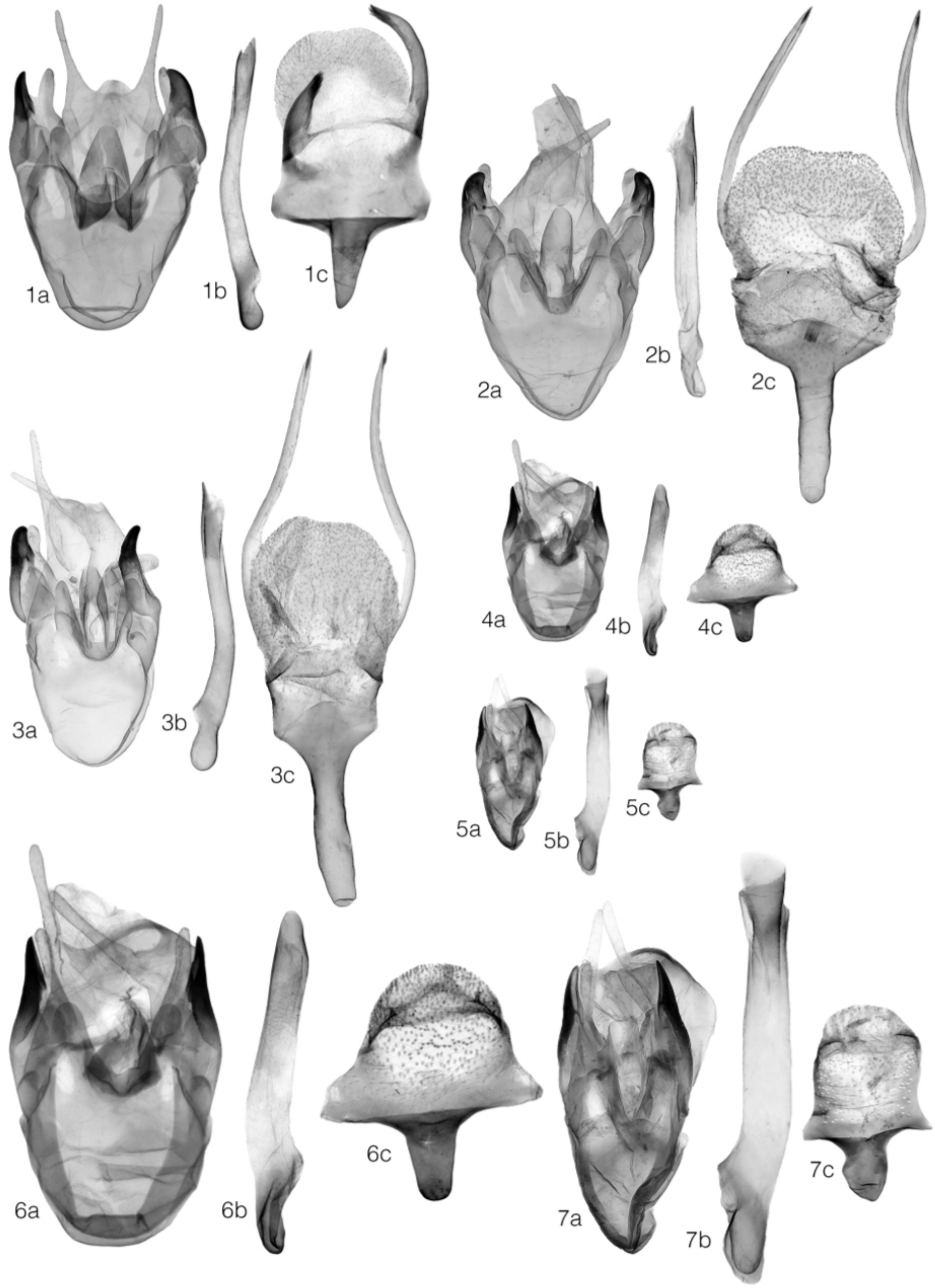

PLATE 20: Figures 1–7. Male genitalia of *Scopula* species. 1: *S. chalcographata* (Iran, Fars, Mian-Kotal, g. prep. 10875); 2–3: *S. sacraria ariana* (2: NO Afghanistan, Badakhshan, Baharak, g. prep. 0614/2020 D. Wanke; 3: Iran Boyerahamd-va-Kohgiluyeh, SE Yasuj, g. prep. 0557/2020 D. Wanke); 4+6: *S. gracilis* (Iran, Baloutchistan, Bender Tchahbahar, g. prep. 10876, 4: in scale, 6: enlarged, out of scale); 5+7: *S. alfierii* (Yemen, Al Ain, g. prep. 1296/2022 D. Wanke, 5: in scale, 7: enlarged, out of scale). a = genitalia capsule; b = aedeagus; c = 8th sternite. Scale-bar 1 mm.

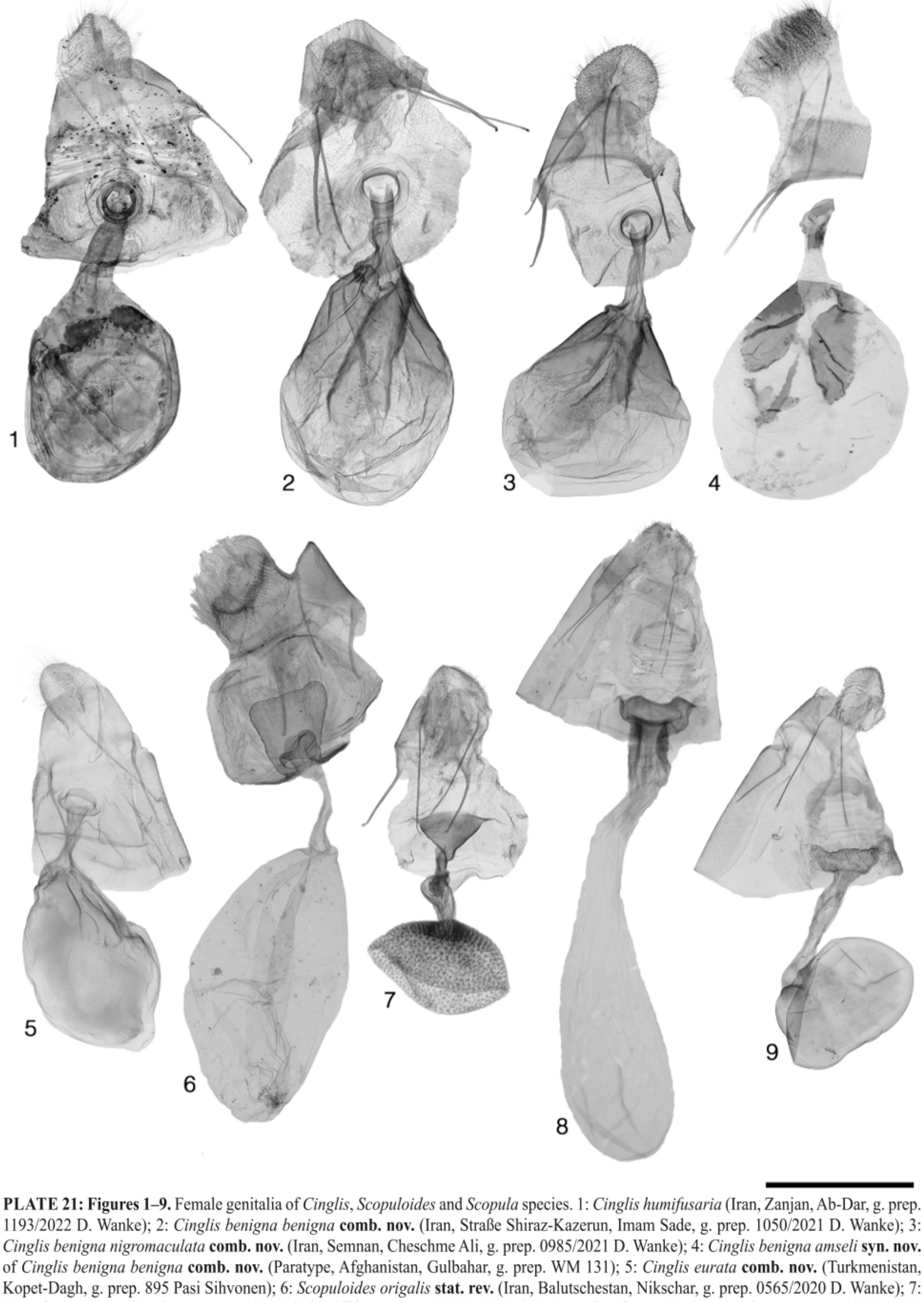

PLATE 21: Figures 1–9. Female genitalia of *Cinglis*, *Scopuloides* and *Scopula* species. 1: *Cinglis humifusaria* (Iran, Zanjan, Ab-Dar, g. prep. 1193/2022 D. Wanke); 2: *Cinglis benigna benigna* **comb. nov.** (Iran, Straße Shiraz-Kazerun, Imam Sade, g. prep. 1050/2021 D. Wanke); 3: *Cinglis benigna nigromaculata* **comb. nov.** (Iran, Semnan, Cheschme Ali, g. prep. 0985/2021 D. Wanke); 4: *Cinglis benigna amseli* **syn. nov.** of *Cinglis benigna benigna* **comb. nov.** (Paratype, Afghanistan, Gulbahar, g. prep. WM 131); 5: *Cinglis eurata* **comb. nov.** (Turkmenistan, Kopet-Dagh, g. prep. 895 Pasi Sihvonen); 6: *Scopuloides origalis* **stat. rev.** (Iran, Balutschestan, Nikschar, g. prep. 0565/2020 D. Wanke); 7: *Scopula conscensa* (Ceylon, NHMUK014173528, Slide NHMUK010317461); 8–9: *Scopula relictata* (8: Oman, Adam, NHMUK014173580, Slide NHMUK014314454; 9: [Kenya], Suna, S. Kavirondo, NHMUK014173536, Slide NHMUK014314489); Scale-bar 1 mm.

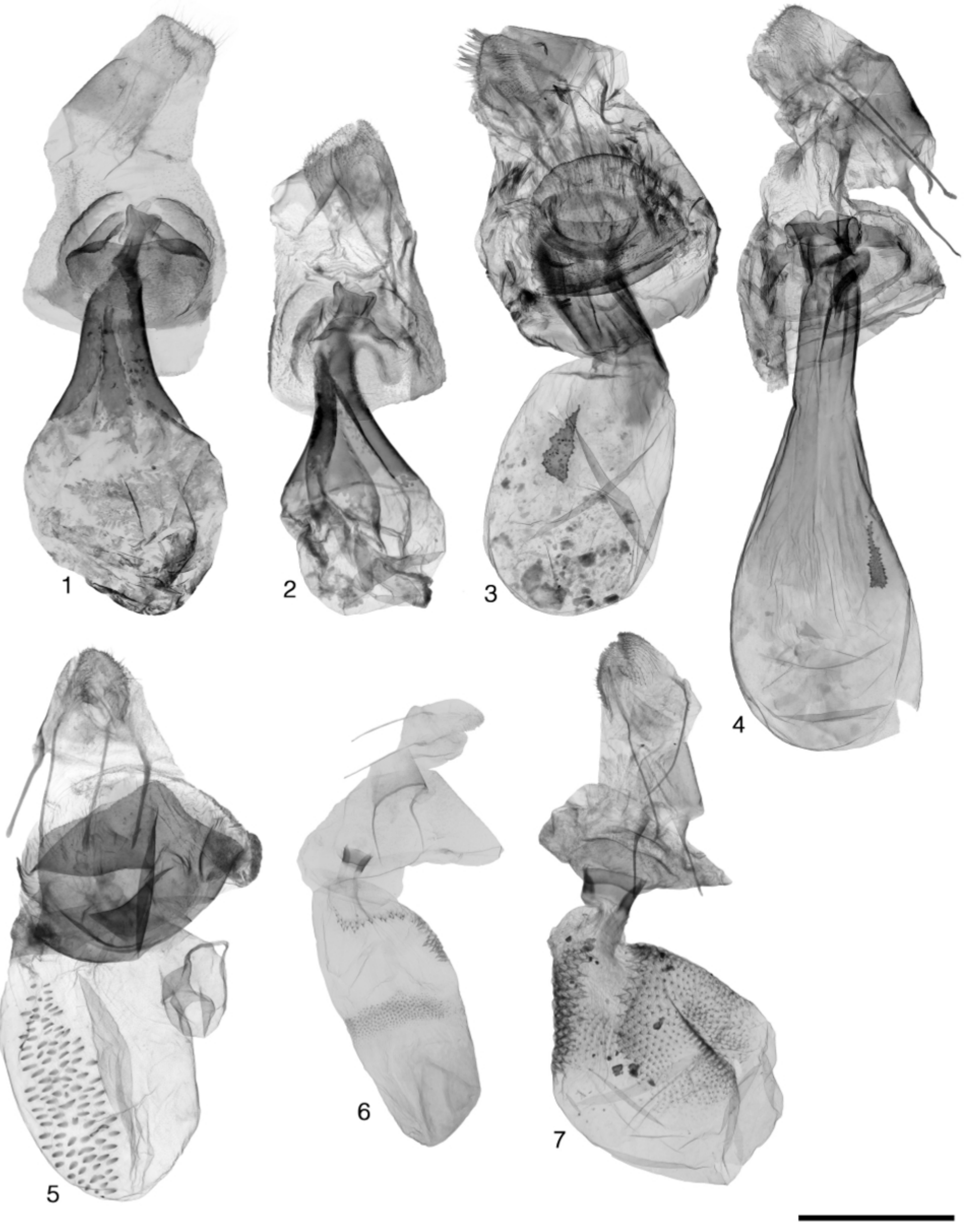

PLATE 22: Figures 1–7. Female genitalia of *Scopula* species. 1: *S. ansulata* (Iran, Ostan-e Khorasan, Haji Abad, g. prep. 0697/2020 D. Wanke); 2: *S. adulteraria* **bona sp.** (Iran, Ostan-e Khorasan, Izmansufla, g. prep. 1255/2022 D. Wanke); 3: *S. immorata* (Turkey, Erzurum, N-Askole, g. prep. 1226/2022 D. Wanke); 4: *S. tessellaria* (Kazakhstan, S Kirgyzsay, g. prep. 1242/2021 D. Wanke); 5: *S. nigropunctata* (Turkey, Giresun, 1: g. prep. 1235/2021 D. Wanke); 6–7: *S. caesaria* (6: Paratype, Ceylon, Slide NHMUK 012821272; 7: South Yemen, Lahej Governorate, Al Dhala, g. prep. 1287/2022 D. Wanke). Scale-bar 1 mm.

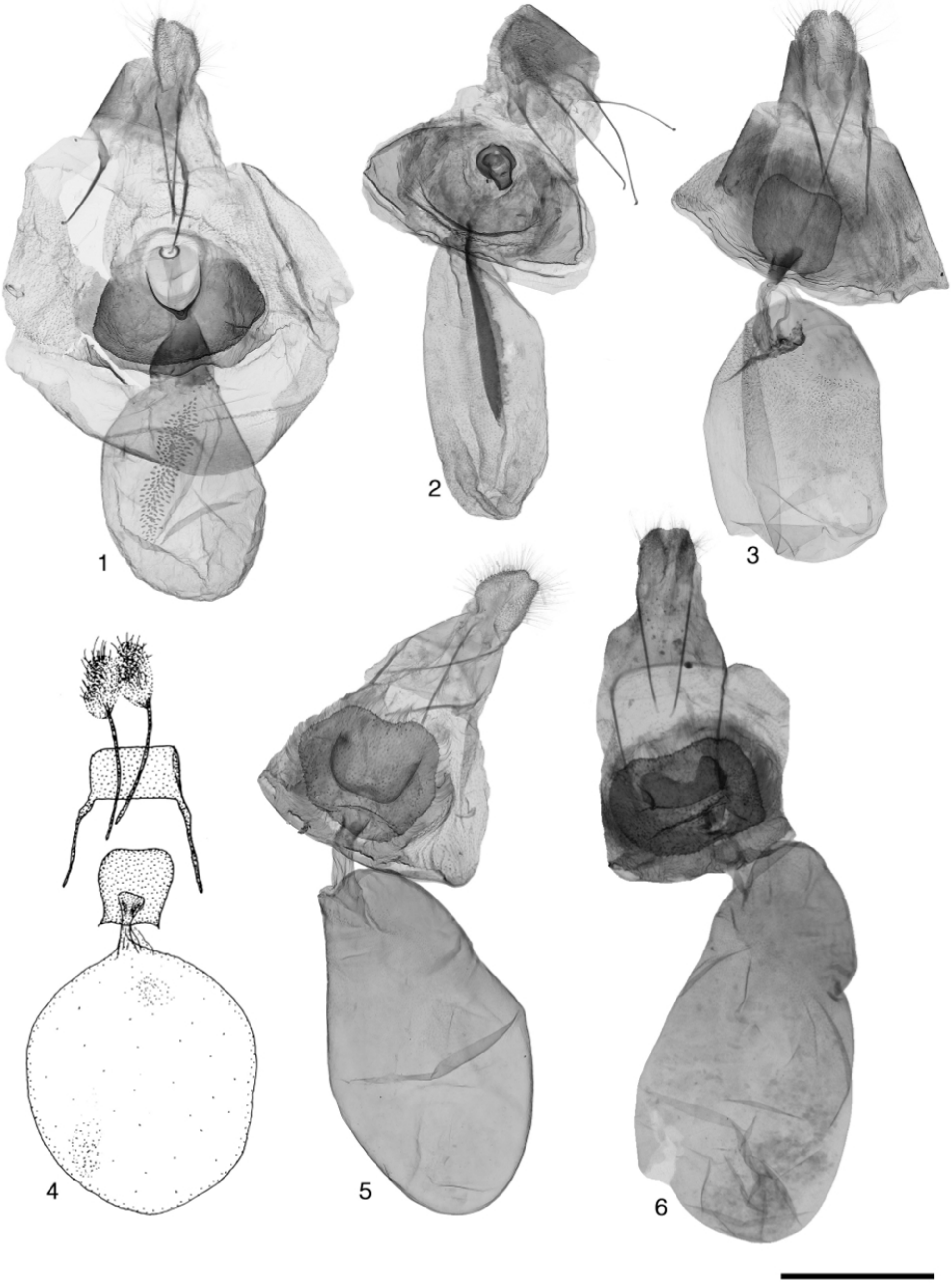

PLATE 23: Figures 1–6. Female genitalia of *Scopula* species. 1: *S. ornata enzela* (S-Iran, Miyan Kotal, g. prep. 0800/2020 D. Wanke); 2: *S. orientalis* (S-Iran, S Abadeh, N Didegan, g. prep. 0801/2020 D. Wanke); 3: *S. decorata* (N-Iran, Masandaran, Damavand, g. prep. 0790/2020 D. Wanke); 4: *S. subtilata* (altered Hausmann 2004); 5: *S. transcaspica* (S-Iran, Bandar Abbas, Kuhe Genou, g. prep. 0810/2020 D. Wanke); 6: *S. transcaspica taftanica* **syn. nov.** of *S. transcaspica* (Paratype, Baloutchistan, Kouh i Taftan, g. prep. 11022). Scale-bar 1 mm.

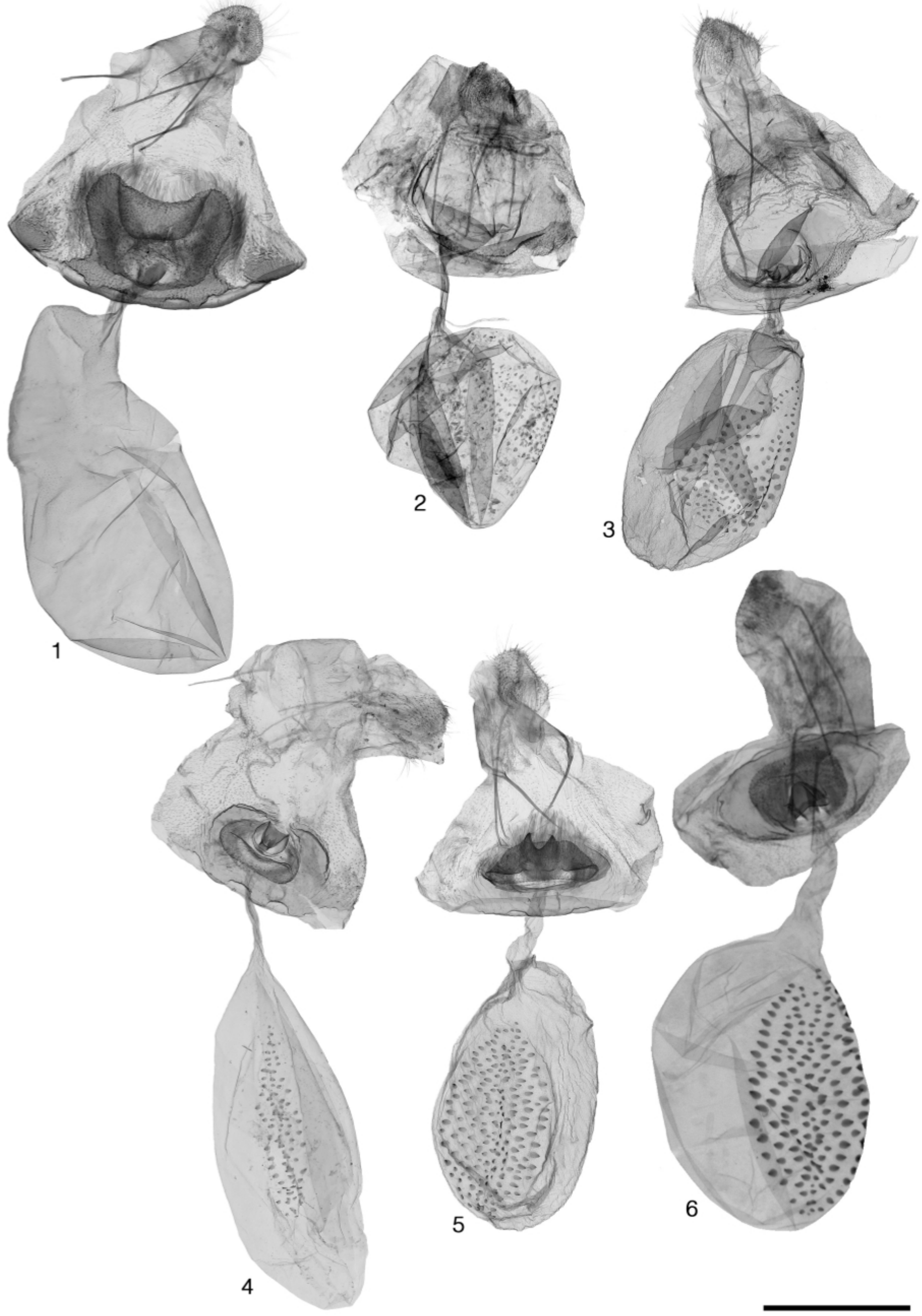

PLATE 24: Figures 1–6. Female genitalia of *Scopula* species. 1: *S. transcaspica* (Iran, Hamadan, S of Arak, g. prep. 0808/2020 D. Wanke); 2: *S. rubiginata* ([Turkey], Amasia, g. prep. 1290/2022 D. Wanke); 3: *S. turbulentaria steinbacheri* (Iran Mazandaran, Shirinabad, g. prep. 0974/2021 D. Wanke); 4: *S. imitaria* ([Croatia], Krk, Fiumebucht, g. prep. 0773/2020 D. Wanke); 5: *S. beckeraria* (Iran, Varamin, E Teheran, g. prep. 0783/2020 D. Wanke); 6: *S. hoerhammeri* (Iran, Fars, [Komehr], g. prep. 11020); Scale-bar 1 mm.

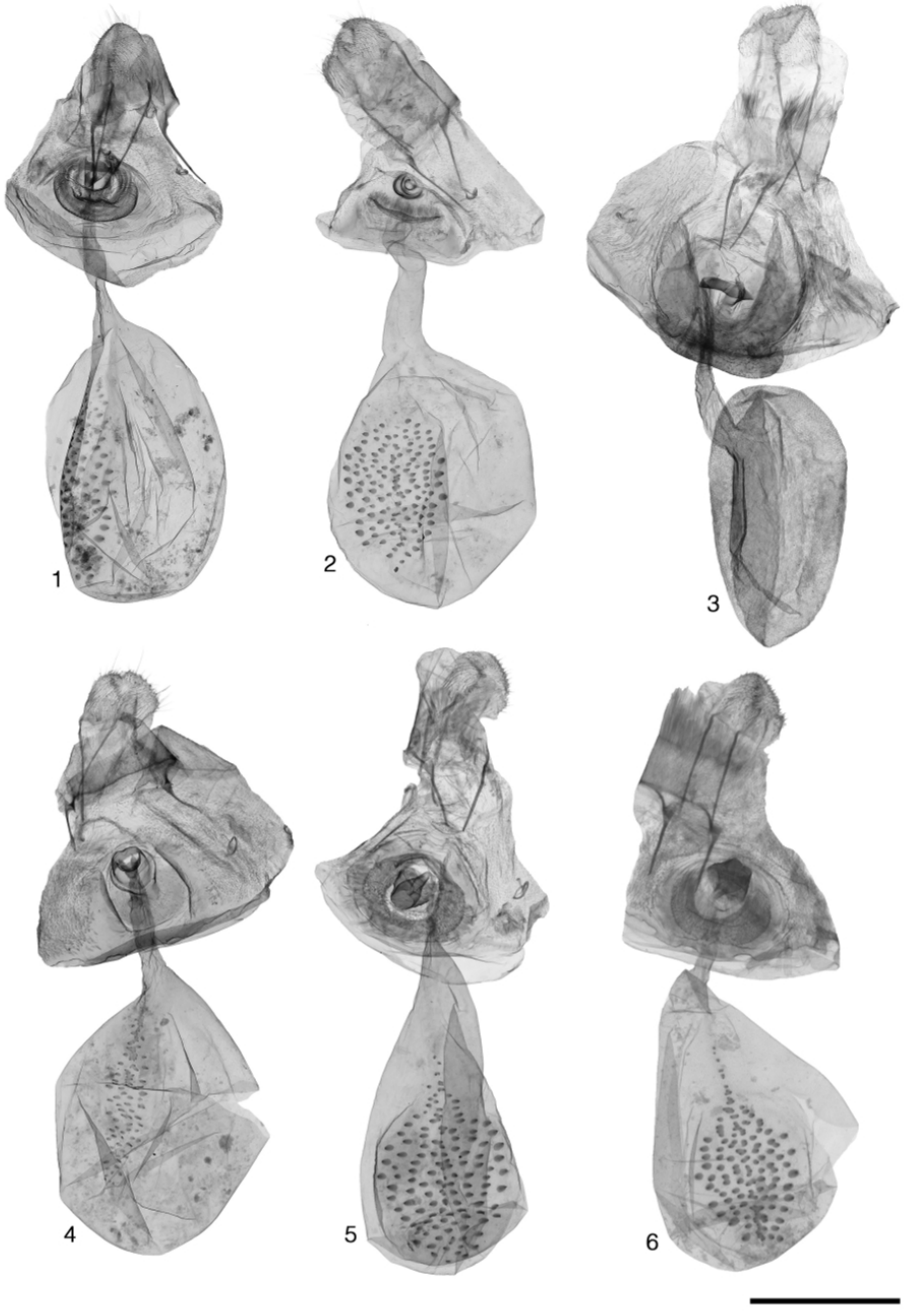

PLATE 25: Figures 1–5. Female genitalia of *Scopula* species. 1: *S. incanata* ([Iran], Tacht i Suleiman, g. prep. 1277/2022 D. Wanke); 2: *S. marginepunctata terrigena* (N-Iran, Amarlu, Rudbar, g. prep. 0875/2020 D. Wanke); 3: *S. luridata* ([Israel], Jaffa, g. prep. 1240/2021 D. Wanke); 4: *S. immutata* ([Hungary], Bükkösd, 1247/2021 D. Wanke); 5: *S. flaccidaria* (N-Iran, Bandar Pahlavi, g. prep. 1054/2021 D. Wanke); 6: *S. iranaria* **syn. nov.** of *S. flaccidaria* (Iran, Kerdej, g. prep. 11061). Scale-bar 1 mm.

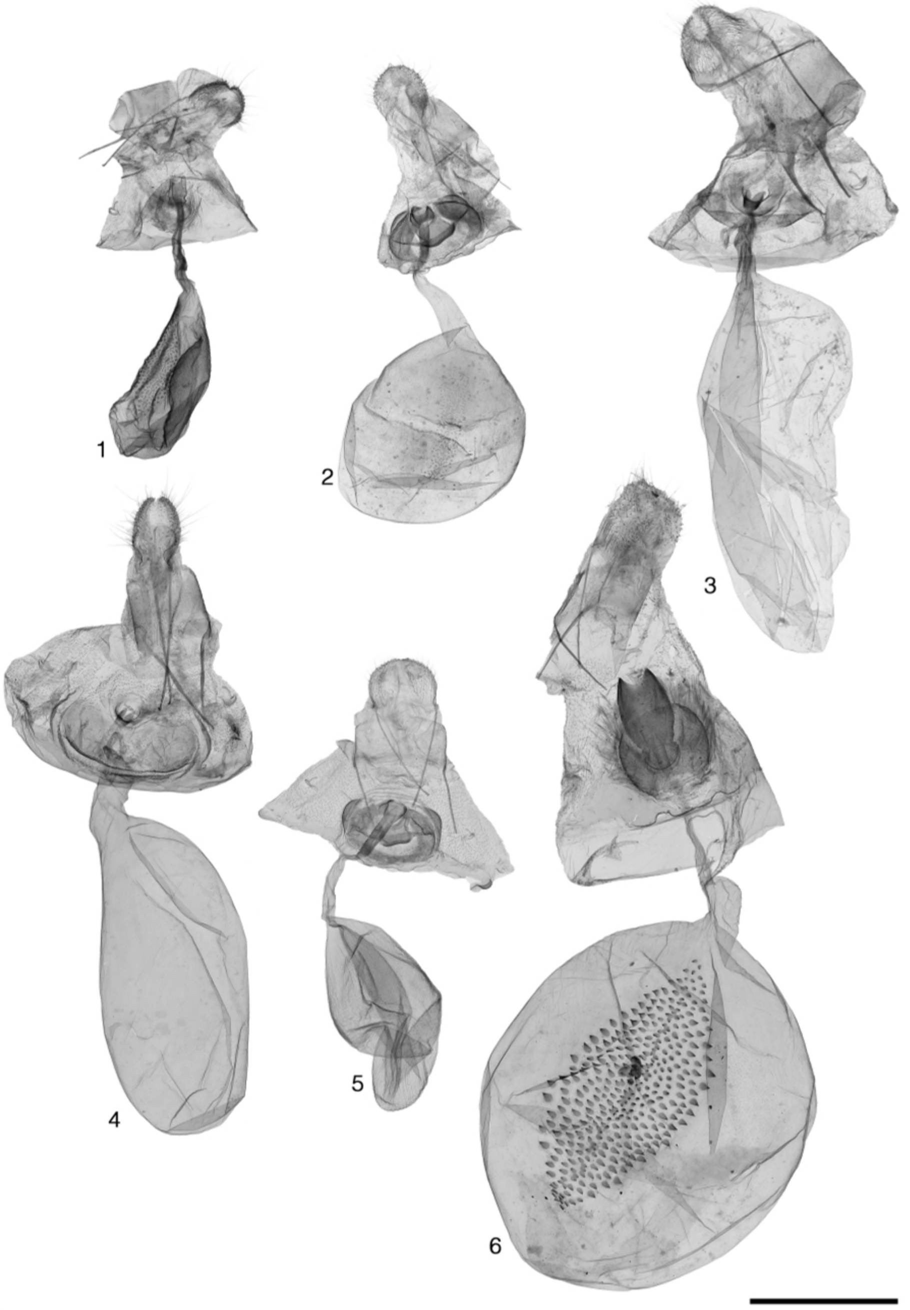

PLATE 26: Figures 1–7. Female genitalia of *Scopula* species. 1: *S. minorata* (Spain, Gran Canaria, Las Palmas, g. prep. 1249/2021 D. Wanke); 2: *S. adelpharia* (Sudan, Ed Damer, Hudeiba, g. prep. 1270/2022 D. Wanke); 3: *S. albiceraria* (SW-Mongolia, SSW Zhargalan, g. prep. 1301/2022 D. Wanke); 4: *S. immistaria* (Iran, Tehran, NNW Shemshak, g. prep. 0832/2020 D. Wanke); 5: *S. lactarioides* (Iran, Makran, Chahbar Küste, g. prep. 0879/2020 D. Wanke); 6: *S. diffinaria diffinaria* (Iran, Mazandaran, S Shah Kuh-e Pain, g. prep. 0521/2020 D. Wanke). Scale-bar 1 mm.

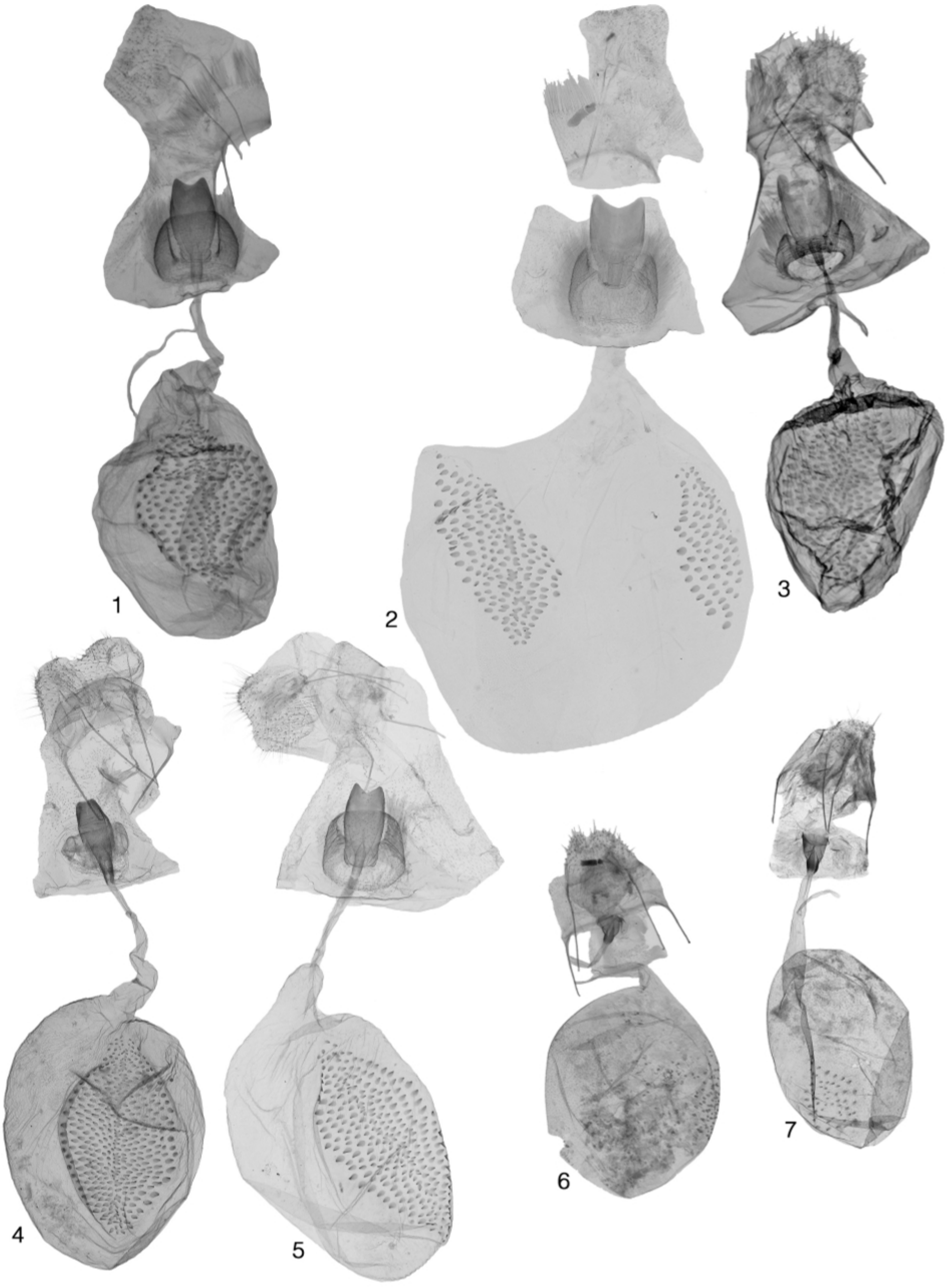

PLATE 27: Figures 1–7. Female genitalia of *Scopula* species. 1: *S. diffinaria asiatica* **syn. nov.** of *S. diffinaria diffinaria* (Paratype, Iran, Fars, [Komehr], g. prep. 10873); 2: *S. orbeorum* (Paratype, [Iran], Tacht i Suleiman, g. prep. 4248 ZSM Hausmann); 3: *S. chalcographata* (Paratype, Iran, Fars, Mian-Kotal, g. prep. 10874); 4–5: *S. sacraria ariana* (4: Iran, Fars, Sine-Sefid, g. prep. 0581/2020 D. Wanke; 5: N-Iran, Tehran-Evin, g. prep. 0684/2020 D. Wanke); 6: *S. gracilis* (Iran, Baloutchistan, Bender Tchahbahar, g. prep. 10877); 7: *S. alfierii* (Yemen, WSW Al Mukalla, g. prep. 1298/2022 D. Wanke). Scale-bar 1 mm.

Acknowledgements

We are very thankful to the curators of different collections for the loan of valuable specimens from their collections, namely Marianne Espeland (Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany), Robert Trusch and Michael Falkenberg (both Staatliches Museum für Naturkunde Karlsruhe, Germany), Geoff Martin (Natural History Museum, London, UK), Tobias Malm and Johannes Bergsten (both Naturhistoriska Riksmuseet, Stockholm, Sweden), Jörg-Uwe Meineke (Kippenheim, Germany), Théo Léger (Museum für Naturkunde der Humboldt-Universität, Berlin, Germany), Bernd Müller (Berlin, Germany) and Peder Skou (vester Skerninge, Denmark). We are grateful to Geoff Martin, David Lees and Alberto Zilli (Natural History Museum, London, UK) for their logistic support and scientific discussions during a collection visit of the first and last author (DW & HR) in NHMUK, London. Many thanks to Jessica Awad and Daniel Whitmore (both SMNS) for linguistic proof reading and valuable comments on the manuscript. We are grateful to the subject editor of *Zootaxa* Reza Zahiri, and two reviewers Malcom Scoble and Jaan Viidalepp for their critical review, constructive comments and valuable suggestions to this paper. The copyright of images from the NHMUK specimens belong to the Trustees of the Natural History Museum, London, and they are published here under a Creative Commons License 4.0 (https://creativecommons.org/ licenses/by/4.0/). This research received support from the SYNTHESYS+ Project (http://www.synthesys.info/), which is financed by European Community Research Infrastructure Action under the H2020 Integrating Activities Programme, Project number 823827.

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Appendix—Additional material examined

Cinglis humifusaria

4 ♂/♀, Iran, prov. Zanjan, Ab Bar, 1053 m, 17.v.2010, Leg. G. Petrányi, P. Hentschel, g. preps (♂) 1252, 1253/2022 D. Wanke (♀) 1193, 1194/2021 D. Wanke; **all in SMNS.**
3 ♂/♀, South East Kazakhstan, Almaty Province, 12 km SW of Akzhar vill. Ili River valley, 44°52'N, 75°53'E, 25.–26.v.2015, Leg. P. Gorbunov; 1 ♂/♀, West Kazakhstan, Irgiz river basin, 17 km NEN of Kurylys settl., saline semidesert, 49°47'N, 60°49'E, 13.v.2016, Leg. P. Gorbunov; **all in ZSM.**

Cinglis benigna benigna

1 ♂, Iran, Fars, Eqlid SSE, Kuh–e Bol, Darre Absad, 2700 – 3000 m, 23.vi.2005, leg. A. Hofmann, g. prep. 0519/2020 D. Wanke; 1 ♂, S–Iran, [prov. Fars], Miyan Kotal, östl. Kazerun, 4.–7.vi.1969, 1900 m, N 29°30', E 51°40', leg. G. Ebert, g. prep. 0867/2020 D. Wanke; 1 ♀, S–Iran, [prov. Fars], Straße Shiraz–Kazerun, Imam Sade, 1200 m, 3.vi.1969, leg. G. Ebert, g. prep. 1050/2021 D. Wanke; 1 ♂, S–Iran, [prov. Fars], 100 km s. Abadeh, n. Didegan, 2000 m, 9.vi.1969, leg. G. Ebert, g. prep. 1058/2021 D. Wanke; 3 ♂/♀, Iran, Balutschestan, Khasch, 3 km S Sangan, 1300 m, 13.v.1972, leg. Ebert & Falkner, g. prep. (♂) 0874/2020 D. Wanke; 2 ♂/♀, Iran, Baloutchistan, Straße Khach–Zahedan, Fort Sengan, 1800 m, 30.iv.1938, coll. Brandt, g. prep. 0604/2020 D. Wanke; 1 ♂, [Iran], Balutschestan, Khasch, Kousche, 2000 m, 21.v.1972, leg. Abai, Ebert, g. prep. 1163/2021 D. Wanke; **all in SMNK.**

Cinglis benigna nigromaculata

6 ♂/♀, Iran N, prov. Semnan, 30 km NW Damghan, Cheschme Ali, N 36°15'07'', E 54°04'20'', 1560 mNN, 23.v.05, leg. Trusch, Petschenka, Müller, g. preps (♂) 0983, 0984, (♀) 0985/2020 D. Wanke; 2 ♂/♀, Iran Z., Kashan, Karkas Berg, 22.v.1970, leg. M. Abai, g. prep. (♂) 0663/2020 D. Wanke; 4 ♂/♀, same locality as before, 2.vi.1970, leg. M. Abai, g. preps (♂) 0664, 0665/2020 D. Wanke; 1 ♂, N–Iran, Salzsee, 90 km s. Teheran, 800 m, 23.vi.1969, leg. H. G. Amsel, g. prep. 0868/2020 D. Wanke; 1 ♂/♀, N–Iran, Kamard, 40 km w. Teheran, ca. 1700 m, 9.ix.1970, leg. G. Ebert; **all in SMNK.**

Cinglis eurata

6 ♂/♀, Iran, Khorasan Razavi, 65 km Kalat road, Khor, 1431m, 36°38'15.1''N, 59°54'04''E, 16.vi.2016, leg. Sh. Feizpour, g. preps (♂) 0722/2020, 1179, 1180, 1181/2021 D. Wanke; 1 ♂/♀, Iran, Khorasan Razavi, 5 km W Chenaran, 3 km before Akhlamand, 1210 m, 36°38'21'' N, 58°57'04'' E, 16.vi.2010, leg. H. Rajaei; **all in SMNS.**
1 ♂, Turkmensitan, Kopet–Dagh Mts., 5 km S of Chull, 700–800 m, 58°01'E, 37°56'N, 5.viii.1992, No. L68, leg, M. Hreblay. Gy. László and G. Ronkay, g. prep. 894 Pasi Sihvonen, ZSM G 12558; 1 ♀, same data, but 55.viii.1992, No. L75, g. prep. 895 Pasi Sihvonen, ZSM G 12559; **all in ZSM.**

Scopuloides origalis

3 ♂, Iran–Centr., Prov. Yazd, N Yazd, Chak Chak, N 32°20' 07.8'', E 54°22'58.0'', 1.550 mNN, 10. – 11.iv.2007, leg. R. Trusch, SMNK E–Lep. 234, g. preps 0546, 0547/2020, 1182/2021 D. Wanke; 2 ♂, Iran, prov. Esfahan, Kuh–e–Karkas, 1600 m, 7 km NW of Natanz, 11.–12.vi.2005, leg. P. Gyulai & A. Garai, g. preps 0549, 0548/2020 D. Wanke; 1 ♂/♀, Iran, prov. Esfahan, Kuh–e–Karkas, 1700 m, 3 km SE of Natanz, 11.–12.vi.2005, leg. P. Gyulai & A. Garai; 1 ♂/♀, Iran, prov. Fars, S–Zagros, 40 km SW of Sivand, 09.–10.06. 2005, leg. P. Gyulai & A. Garai, 3 ♂/♀, Iran, Laristan, Straße Bender–Abbas–Saidabad, Sardze Umgebung, ca. 200 m, Mitte November 1937, coll. Brandt, g. preps (♂) 0586, 587/2020 D. Wanke; 9 ♂/♀, Iran, Balutschestan, Khasch, 11 km NE Karavandar, 1300 m, 13.v.1972, leg. Ebert & Falkner, g. preps (♂) 0627 (♀) 0617, 0626/2020 D. Wanke; 3 ♂/♀, Iran, Balutschestan, Nikschar, Tange–Sarheh, 1100m, 16.5.1972, leg. Ebert & Falkner, g. preps (♂) 0564, (♀) 0565/2020 D. Wanke; **all in SMNK.**

Scopula conscensa

1 ♂/♀ Ceylon, NHMUK014173528; 1 ♀ [India], Pusa, NHMUK 014173527; **all in NHMUK**

Scopula relictata

1 ♀, India, Dehra Dun, 2300 ft., 5.v.1936, Major J.A. Graham, at light, NHMUK 014173577, g. prep. NHMUK

010317475; 1 ♂, Bahrain, Jurdeh desert, 11.iii.[19]61, E.P. Wiltshire, NHMUK 014173578, g. prep. NHMUK 010317476; 1 ♂, Bahrain, Adari, 25.x.[19]59, E.P. Wiltshire, NHMUK 014173579, g. prep. E.P. Wiltshire 1027; 1 ♀, N. Oman, Adam, 22°22'N, 57°32'E, 17.vi.1990, MD. Gallagher, NHMUK 014173580, g. prep. E.P. Wiltshire 2690; **all in NHMUK.**

1 ♂, Iran, [prov. Hormozgan], Minab, 13.iii.1971, [leg.] Paz., Ayat, g. prep. 0923/2021 D. Wanke; **in SMNK.**

1 ♂/♀, Iran, Khuzestan, Shush, 19.–24.iii.1956, leg. Richter & Schäuffele; 1 ♂/♀, Iran, Khuzestan, Shadegan, 1.–10.iv.1956, leg. Richter & Schäuffele; **all in SMNS.**

Scopula ansulata

1 ♂/♀, Iran, Golestan, Sharud W, Kash, Kuh–e Shavar, 2900 m, 19.vii.2003, leg. A. Hofmann, J.–U. Meineke, G. Tremewan; **in PCJM.**

10 ♂/♀, NE–Iran, Prov. Ostan–e Khorasan, NE–Birjand, S Haji Abad, Gomenj vic., Kuh–e Mirza Arab, N 33°16'13.9", E 60°06'59.7", 1.v.2008, 2040 mNN, lux, leg. R. Trusch, M. Falkenberg & B. Müller, SMNK E–Lep. 247, g. prep. (♀) 0697/2020 D. Wanke; 11 ♂/♀, NE–Iran, Prov. Ostan–e Khorasan, Kopet Dagh, NW Mashad, N Tschenaran, N Radkan, Dolmeh Olia, N 36°55'56.6", E 59°02'18.6", 8.v.2008, 1560 mNN, lux, leg. R. Trusch, M. Falkenberg & B. Müller, SMNK E–Lep. 247, g. prep. (♂) 0695/2020 D. Wanke; 11 ♂/♀, same data, 9.v.2008, g. prep. (♂) 0696/2020 D. Wanke; 1 ♂/♀, NE–Iran, Prov. Ostan–e Khorasan, Kopet Dagh, ca. 50 km N Bojnurd, S Izmansufla, N 37°44'20", E 57°25'53", 10.v.2008, 1240mNN, lux, leg. R. Trusch, M. Falkenberg & B. Müller, SMNK E–Lep. 247; 2 ♂/♀, same data, 11.v.2008; 19 ♂/♀, Iran, prov. Semnan, 15 km W of Miyandasht, N 36°25', E 56°14', 1000 m, 16.iv.2010, leg. B. Benedek & T. Hácz; **all in SMNK.**

Scopula adulteraria

33 ♂/♀, NE–Iran, Prov. Ostan–e Khorasan, Kopet Dagh, ca. 50 km N Bojnurd, S Izmansufla, N 37°44'20", E 57°25'53", 10.v.2008, 1240 mNN, lux, leg. R. Trusch, M. Falkenberg & B. Müller, SMNK E–Lep. 247, g. preps (♀) 0698/2020, 1255/2022, (♂) 0700/2020 D. Wanke; 26 ♂/♀, same data, 11.v.2008, g. prep. (♂) 0699/2020 D. Wanke; 26 ♂/♀, same data, 17.v.2005, leg. R. Trusch, G. Petschenka & B. Müller, SMNK E. Lep. 215; 1 ♂/♀, N–Iran, E Alborz, Prov. Mazandaran, E Gorgan, S Aliabad, oberh. Shirinabad, N 36°47'21", E 55°01'25", 21.v.2005, 1100 mNN, leg. R. Trusch, G. Petschenka & B. Müller, SMNK E. Lep. 215; **all in SMNK.**

1 ♂/♀, Iran, Khorasan Shomali, Ismansufla, 18.v.2015, leg. Sh. Feizpour; **all in SMNS.**

Scopula immorata riloensis

1 ♀, Turkey, Erzurum, 20 km nördl. Askole, Kop Gec, 2300 m, 16.vii.1992, g. prep. 1226/2021 D. Wanke; 1 ♂, Persia sept., Elburs mts.c.s., Tacht i Suleiman, Hecarcal–Tal, 28–3200 m, 3.–7.vii.[19]37, E. Pfeiffer & W. Forster leg., München, g. prep. 1225/2021 D. Wanke; **all in SMNK.**

1 ♂, Turkey, Erzurum, Kopdagi gec., 2400 m, 10.–14.vii.1983, leg. W. Thomas, g. prep. 1230/2021 D. Wanke; 1 ♂, Kleinasien [Turkey], prov. Tokat–Sivas, Camlibel–Pass, 1700 m, 1.–10.vii.1978, leg. deFreina, g. prep. 1231/2021 D. Wanke; 1 ♂, Mongolia, Chentej aimak Tsenhernandel, Modoto Chentej Mts. 1600–1800 m, 47°48'N, 109°04'E, 9.–14.vii.1984, leg. Cerny, g. prep. 1232/2021 D. Wanke; **all in SMNS.**

1 ♂, [Iran] Persia sept., Elburs mts.c.s., Tacht i Suleiman, Hecarcal–Tal, 28–3200 m, 3.–7.vii.[19]37, E. Pfeiffer & W. Forster leg., München, g. prep. 1259/2022 D. Wanke; **in ZFMK.**

1 ♀, Persia sept. [Iran], Elburs mts.c.s., Tacht i Suleiman, Särdab–Tal (Tanakarud), 29–3200 m, 19.–23.vii.[19]37, leg. E. Pfeiffer & W. Forster, München, g. prep. 1284/2022 D. Wanke; 1 ♂, Persia sept. [Iran], Elburs mts.c.s., Särdab–Tal, 3000 m, 19.–23.vii.[19]37, leg. E. Pfeiffer & W. Forster, München, g. prep. 1285/2022 D. Wanke; 1 ♂, Persia sept. [Iran], Elburs mts.c.s., Särdab–Tal, Vandarban, 19–2200 m, 10.–14.vii.[19]37, leg. E. Pfeiffer & W. Forster, München, g. prep. 1286/2022 D. Wanke; **all in ZSM.**

Scopula tessellaria

6 ♂/♀, Kasachstan, Alma Ata, 1500 m, 12.vi.[19]69, g. preps (♂) 1227 (♀) 1228, 1229/2021 D. Wanke; **in SMNK.**

1 ♂, E Kazakhstan, S Tarbagatay Mts., 6 km, NE Kirovka (=Karatuma), 1100 m, 23.vi.2001, 47°10'N, 82°06'E, leg. D. Bartsch, g. prep. 1241/2021 D. Wanke; 1 ♀, SE Kazakhstan, N Ketmen Mts., S Kirgyzsay (=Podgornoe), 1600–1800 m, 3.vi.2001, 43°17'N, 79°31'E, leg. D. Bartsch, g. prep. 1242/2021 D. Wanke; **all in SMNS.** 1 ♂,

Persia sept., Elburs mts.c.s., Tacht i Suleiman, Vandarban–Tal, 19–2200 m, 1.–3.vii.[19]37, E. Pfeiffer & W. Forster leg., München, g. prep. 1260/2022 D. Wanke; **in ZFMK.**

Scopula nigropunctata

1 ♂, N–Iran, 12 km n. Amol, 250 m, 28.x.1970, leg. G. Ebert, g. prep. 0964/2021 D. Wanke; 1 ♀, [Iran], Shahsavar, 7.viii.1971, [leg.] Ghazioff, g. prep. 1069/2021 D. Wanke; **in SMNK.**

1 ♂, 1 ♀, Turkey, Giresun, 4 km W Tirebolu, 0 m, 21.–23.viii.[19]92, leg. P. Kautt & V. Weiss, g. preps (♂) 1235 (♀) 1236/2021 D. Wanke; **in SMNS.**

Scopula caesaria

1 ♀, N. Oman, Khasab, 9.iv.1983, leg. M.D. Gallagher, NHMUK014173571, g. prep. NHMUK 010317471; 1 ♂, Oman, Dhofar, Wadi Sha'ath, 5.x.1979, leg. T.B. Larsen, NHMUK014173572, g. prep. NHMUK 010317472; **all in NHMUK.**

1 ♂, Republic South Africa, Gauteng prov., Ezemvelo NR, 25°42'S, 29°00'E, 1350–1400 m, at light, 11.xii.2007, leg. D. Bartsch, g. prep. 1224/2021 D. Wanke; **in SMNS.**

1 ♀, South Yemen, P. D. R. Y, Lahej Governorate, Al Dhala, 1500 m, 7.vi.1987, leg. Bernd Müller, g. prep. 1287/2022 D. Wanke; **in ZSM.**

Scopula ornata enzela

3 ♂/♀, Iran, Kerman, Jiroft W, Shingera, 2800 m, 26./27.v.2004, leg. A. Hofmann, J.–U. Meineke, G. Tremewan; 1 ♂/♀, Iran, Esfahan, Yasuj E, Kuh–e–Dena, Nurabad N, 2450m, 08.vi.2005, leg. A. Hofmann, J.–U. Meineke; 3 ♂/♀, Iran, Khorasan–e Shomali, Kopet–Dagh, Izman–e Sufla vic., N 37°51'31.9", E 57°32'27.2", 1823 m, 2.vi.2013, leg. J.U. Meineke, H. Rajaei, B. Hafezi; 1 ♂/♀, Iran, Markazi, Tafresh via Dastgerd, 2300–2500m, 15./16.6.2005, leg. J.–U. Meineke; **all in PCJM.**

1 ♂, 1 ♀, N–Iran, Bandar Pahlavi, 28.ix.1970, 20 m, leg. Ebert, g. preps (♂) 0797, (♀) 0796/2020 D. Wanke; 1 ♂, 1 ♀, S–Iran, Miyan Kotal, östl. Kazerun, 4.–7.vi.1969, 1900 m, N 29°30', E 51°40', leg. G. Ebert, g. preps (♂) 0795, (♀) 0800/2020 D. Wanke; 2 ♂/♀, W–Iran, Kordestan, Straße Saghez–Baneh, 21 km NE Baneh, 30.–2.vii.1975, 1950 m, leg. Ebert & Falkner, g. prep. (♂) 0802/2020 D. Wanke; 1 ♂/♀, W–Iran, Kordestan, Straße Baneh–Marivan, 86 km SE Baneh, 5.vii.1975, 1950 m, leg. Ebert & Falkner; 1 ♀, N–Iran, Masandaran, Golestan–Wald, 60 km E Gonbad Qabus, 8.vii.1972, 510 m, leg. Ebert & Falkner, g. prep. 0798/2020 D. Wanke; 1 ♂/♀, Iran, Esfahan, W Fereydoun Shahr, vic. Sibac, 6./7.vi.2006, 2450 m, leg. W. ten Hagen; 1 ♂/♀, Iran, Esfahan, Esfahan–Daran, Ashan vic., 2.vii.2005, 2490 – 2500 m, leg. A. Hofmann; **all in SMNK.**

1 ♂/♀, Iran, prov. Chaharmahal–va–Bakhtiyari, Dehnau, 2248 m, 12.v.2010, leg. G. Petrányi, P. Hentschel; 2 ♂/♀, Iran, prov. Zanjan, Ab Bar, 1053 m, 17.v.2010, leg. G. Petrányi, P. Hentschel; **all in SMNS.**

1 ♂/♀, Nord–Iran, Schahkuh, West–abhg. Geröllzone, 1800–2000 m, Juni, Exp. Wernicke; **in ZFMK.**

Scopula orientalis

2 ♂/♀, S–Iran, 100 km s. Abadeh, n. Didegan, 9.vi.1969, 2000 km, leg. G. Ebert, g. prep. (♀) 0801/2020 D. Wanke; **in SMNK.**

1 ♀, Kleinasien, SW–Anatolien, Sultan Dagh, Um. Aksehir, 1000–1500 m, 16.vi.–01.vii.[19]76, leg. deFreina, g. prep. 1190/2021 D. Wanke; 1 ♀, Kleinasien, Prov. Hakkari, 15 km nordwest Yüksekova, vic. Suüstü, 1900 m, 20.vi.[19]81, leg. deFreina, g. prep. 1191/2021 D. Wanke;

1 ♂, Iran, Elburz, Dizin, 3200 m, vii.1975, leg. Czipka, g. prep. 1192/2021 D. Wanke; **all in SMNS.**

Scopula decorata

1 ♂/♀, Iran, Zagros, Esfahan Umg., Fereidun Shah, 2200 m, 9.vii.1999, leg. A. Hofmann, J. Meineke; 1 ♂/♀, Iran, prov. Azarbayjan–e–Gharbi, Takht–e Suleyman, 20 km E, Gharawol–Khaneh, 2300–2500 m, 29./30.vi.2009, leg. A. Hofmann, J. U.Meineke, H. Rajaei; 1 ♂/♀, Iran, prov. Azarbayjan–e–Sargi, Kaleybar 10 km E, 1900 m, 27./28.vii.2006, leg. A. Hofmann, J. Meineke; 1 ♂/♀, Iran, prov. Azarbayjan–e–Shargi, Kuh–e Bozghush, Sarab S, 2233 m, 28.vi.2013, N 37°45'49.4", E 47°21'30.8", leg. J. U. Meineke, H. Rajaei, B. Hafezi; 2 ♂/♀, Iran, prov. Azarbayjan–e–Shargi, Gharek Aghai, 2200 m, 4.vi.2013, N 36°50'16.5", E 46°58'07.5", leg. J. U. Meineke, H. Rajaei, B. Hafezi; 3 ♂/♀, Iran, Zanjan, Zanjan–Gilvan, Gargovol Dag, 2500m, 26./27.6.2001, leg. A. Hofmann,

J.–U. Meineke, W.G. Tremewan; 1 ♂/♀, Iran, Zanjan NE, Gard–ye Alamut N, 2000–2300 m, 1./2.vii.[20]09, leg. A. Hofmann, J. U. Meineke, A. Naderi, H. Rajaei; 1 ♂/♀, Iran, Mazandaran, Ramsar SE, Haris via Javaherdeh, Kaspiswald, 1350 m, 17.vii.2006, leg. J. U. Meineke, H. Rajaei; 1 ♂/♀, Iran, Golestan, Gorgan to Sharud, N 36°37'20.0", E 54°38'07.0", 2455 m, 23.vi.2013, leg. J. U. Meineke, H. Rajaei, B. Hafezi; 1 ♂/♀, Iran, Alborz, Demavand NE, via Taar See, 2400 m, 19.vii.2006, leg. J. U. Meineke, A. Hofmann, g. prep. 1254/2022 D. Wanke; **all in PCJM.**

45 ♂/♀, N–Iran, Elburs Mts., Masandaran, Polur, Damavand, 7.–10.vii.1972, 2500 m, leg. Ebert & Falkner, g. preps (♂) 0789, (♀) 0790/2020 D. Wanke; 3 ♂/♀, same data, 2200 m; 2 ♂/♀, N–Iran, Elburs Mts., Prov. Tehran, 15 km E Gatschsar, 5.viii.1972, 2600 m, leg. Ebert; 1 ♂/♀, N–Iran, Elburs Mts., N Teheran, Dizin Hotel, N 36°02'52.1", E 51°24'58.1", 2700 m, 20.vii.2006, leg. R. Trusch; 1 ♂/♀, N–Iran, Elburs Mts., N Teheran, ca. 30 km E Kendevan, Labaschm Pass, W Nesen, N 36°13'56.1", E 51°26'18.8", 3000 m, 19.vii.2006, leg. R. Trusch; 2 ♂/♀, NW–Iran, 17 km nw. Maku, 1400 m, 4.vi.1975, leg. H. G. Amsel, g. prep. (♀) 0791/2020 D. Wanke; 2 ♂/♀, W–Iran, Kordestan, Straße Zandjan–Bijar, 53 km S Zandjan, 28.–29.vi.1975, 1700m, leg. Ebert & Falkner, g. prep. (♂) 0792/2020 D. Wanke; 1 ♂/♀, Nordiran, Elbursgebirge östl. Shemshak, 50 km nördl. Teheran, 2100–2500 m, 8.–24.vi.1973, leg. G. Junge; 2 ♂/♀, Iran, prov. Azerbayejan, E–Sharqi, 10 km NW of Miyane, 14.–15.vi.2005, leg. P. Gyulai & A. Garai; 3 ♂/♀, N–Iran, Elburs Geb., Polour, 1600 m, 21.vi.1969, leg. H. G. Amsel; 9 ♂/♀, Iran, prov. Zanjan, W–Alborz range Tarom vic, 20 km NE of Zanjan, 13.–14.vi.2005, leg. P. Gyulai & A. Garai, g. prep. (♂) 0793/2020 D. Wanke; 1 ♀, W–Iran, Lorestan, 28 km E Borudjerd, 27.vii.1975, 2300 m, leg. Ebert & Falkner, g. prep. 0794/2020 D. Wanke; 1 ♂/♀, Iran, Ardabil, Talish, 3 km W Lake Noer, E Helabad, 23.vi.2006, 2600 m, leg. W. ten Hagen; **all in SMNK.**

3 ♂/♀, Iran, Zanjan prov., E Zanjan, road to Gilvan, Alt. 1889 m, N36°45'21.8", E48°49'20.7", 6.vii.2013, leg. H. Rajaei, J.–U. Meineke, B. Hafezi, g. prep. (♀) 1187/2021 D. Wanke; 3 ♂/♀, Iran, Azerbaijan–e Sharghi prov., S Ghareh Aghaj, after Argsnay–Sufla Alt. 2020 m, N 36°50'16.5", E 46°58'07.5", 4.vii.2013, leg. H. Rajaei, J.U. Meineke, B. Hafezi, g. prep. (♀) 1188/2021 D. Wanke; 1 ♂/♀, Iran, Azerbaijan–e Gharbi prov., Khoy to Ghotur road, Esteran vill., Alt. 1637 m, N 38°27' 03.1", E 44°44'33.6", 1.vii.2013, leg. H. Rajaei, J. U. Meineke, B. Hafezi; 2 ♂/♀, Iran, prov. Kordestan, Saghez–Baneh road, 10 km to Baneh Garnadeh–Khan, N 36°04'13", E 45°59'31", 1976 mNN, 26–27.vi2009, leg. H. Rajaei, J.U. Meineke & A. Hofmann, g. prep. (♀) 1185/2021 D. Wanke; 1 ♂/♀, Iran, Azerbaijan–e Sharghi prov., Kuh–e Bozghush, S Sarab, Warzeghan to Sarab sandy road, after Chichaklu vill., Alt. 2233 m, N 37°45'49.4", E 47°21'30.9", 28.vi.2013, leg. H. Rajaei, J.U. Meineke, B. Hafezi; 1 ♂/♀, Iran, Azerbaijan–e Gharbi prov., 15 km W Jolfa, Sint–Stepanus Church, Alt. 951 m, N 38°58' 43.2", E 45°28'24.0", 3.vii.2013, leg. H. Rajaei, J. U. Meineke, B. Hafezi; 1 ♂/♀, Iran, Ghazwin–Alamut road, after Gardane Alamut, sandy road to Khanjar Bolagh village N 36°24'11"; E50°12'52", 2024 m, 1.–2.vii.2009, H. Rajaei, J.–U. Meineke A. Hofmann, g. prep. (♀) 1186/2021 D. Wanke; 3 ♂/♀, Iran, prov. Zanjan, Ab Bar, 1053m, 17.v.2010, leg. G. Petrányi, P. Hentschel; 1 ♂/♀, Iran, Elburs, Shemshak, 2700 m, 10.–11.viii.1978, leg. W. Thomas; **all in SMNS.**

2 ♂/♀, NE Iran, Mazandaran, Sari, 100 m, viii.2002, leg. Müller; 1 ♂/♀, N Iran, Gilan prov., W. Alborz, Umg. Delir, ca 2600 m, 11.–20.vii.2001, leg. Müller; **all in ZSM.**

Scopula subtilata

1 ♂, S. Russia, NHMUK 014173553, g. prep. NHMUK 010317467; **in NHMUK.**

2 ♂/♀, Rossia m.or. Sarepta, g. preps (♂) 1272/2022 D. Wanke (♀) No. 9542 ZSM; **in ZSM**.

Scopula transcaspica

2 ♂/♀, Iran, Khorasan–e Shomali, Kopet–Dagh, Izman–e Sufla vic., N 37°51'31.9", E 57°32'27.2", 1823 m, 2.vi.2013, leg. J.U. Meineke, H. Rajaei, B. Hafezi; 4 ♂/♀, Iran, Markazi, Tafresh via Dastgerd, 2300–2500m, 15./16.6.2005, leg. J.–U. Meineke; 1 ♂/♀, Iran, Khorasan, Askaneh 20 km, 1800 m, 25.v.2008, leg. J.–U. Meineke, W. Kramer; 1 ♂/♀, Iran, Boyer Ahmad–Va–Kohgiluyeh, Gardaneh, Meymand, 2450–2800 m, 14./15.vi.2001, leg. A. Hofmann, J.–U. Meineke, G. Tremewan; 2 ♂/♀, Iran, prov. Azarbayjan–e–Shargi, Gharek Aghai, 2200 m, 4.vi.2013, N 36°50'16.5", E 46°58'07.5", leg. J.U. Meineke, H. Rajaei, B. Hafezi; 1 ♂/♀, Iran, prov. Hamadan, Hamadan NNE, Razan N, Gardaneh Avaj, 2100–2150 m, 19.vi.1998, leg. A. Hofmann, J.–U. Meineke; 2 ♂/♀, Iran, Tehran, Z–Elburs, Maighoon–Ort, 2200 m, 17.vii.2003, leg. A. Hofmann, J.–U. Meineke, G. Tremewan; 1 ♂/♀, Iran, Zagros, Boyer Ahmad–Va–Kohgiluyeh, Meymand Umg., 2500 m, 11./12.vii.1999, leg. A. Hofmann, J.–U. Meineke; 3 ♂/♀, Iran, Baluchestan, Kuh–e Taftan, Jain Chin, 2500m,16.– 18.v. 2004, leg. A. Hofmann, J.–U.

Meineke, G. Tremewan; 2 ♂/♀, Iran, Kerman, Rayen SW, Kuh–e Hesar, Abshar, 2700–3000 m, 24./25.v.2004, leg. A. Hofmann, J.–U. Meineke, G. Tremewan; 1 ♂/♀, Iran, Kerman, 55 km N Gardaneh–ye Khorasani, 2450–2600 m, 30./31.v.2001, leg. J.–U. Meineke, A. Hofmann, A. Kallies *et al.*; 9 ♂/♀, Iran, Kerman, Bam SW, Deh Bakri, 2000–2200 m, 18.–21.v.2004, leg. A. Hofmann, J.–U. Meineke, G. Tremewan; 1 ♂/♀, Iran, Kerman, Jiroft W, Shingera, 2800 m, 22./23.v.2004, leg. A. Hofmann, J.–U. Meineke, G. Tremewan; 1 ♂/♀, Same data, but 26./27. v.2004; **all in PCJM.**

22 ♂/♀, N–Iran, Elburs–Mts, Masandaran, Polur, Damavand, 2200 m, 11.vii.1972, leg. Ebert & Falkner, g. prep. (♂) 0534/2020 D. Wanke; 2 ♂/♀, N–Iran, Elburs–Mts, Masandaran, Polur, Damavand, 2500 m, 7.–10.vii.1972, leg. Ebert & Falkner; 1 ♂/♀, N–Iran, Elburs–Geb., Polour, 1600 m, 21.vi.1969, leg. H. G. Amsel; 7 ♂/♀, Iran, prov. Azerbayejan, E – Sharqi, 10km NW of Miyane, 14.–15.vi.2005, leg. P. Gyulai & A. Garai; 3 ♂/♀, Iran, prov. Azerbayejan, E – Sharqi, 10km NW of Miyane, 31.v.–01.vi.2005, leg. P. Gyulai & A. Garai; 3 ♂/♀, Iran, prov. Tehran, Elburz mts. 3km NNW Shemshak, N36°02' E051°28', 2860mNN, 24.vii.2003 (lux), leg. G. Ebert & R. Trusch; 2 ♂, NE–Iran, prov. Ostan–e Khorasan, Kopet Dagh, ca.50 km N Bojnurd, S Izmansufla, N 37°44'20'', E 57°25'53'', 10.v.2008, 1.240mNN, lux, leg. R. Trusch, M. Falkenberg & B. Müller, g. preps 0510, 0518/2020 D. Wanke; 2 ♂/♀, Iran, prov. Mazandaran, Elburs Mts., S Shah Kuh–e Bala, 2400 m, (lux), N 36°33', E 54°36', 19.vii.2003, leg. G. Ebert & R Trusch; 1 ♂/♀, N–Iran, 40 km östl. Teheran, 16.vi.1969, 1500 m, leg. H. G. Amsel; 2 ♂/♀, Iran, Elburs–Geb., 12 km v. Keredj, 1650 m, 12.vi.1969, leg. Ebert, g. prep. (♀) 1155/2021 D. Wanke; 1 ♂/♀, N–Iran, Elburs–Mts., prov. Tehran, Arangeh 25 km N Karadj, 1550 m, 1.–6.vi.1972, leg. Ebert & Falkner; 1 ♂/♀, Nordiran, Elbursgebirge östl. Shemshak, 50km nördl. Teheran, 2100 – 2500 m, 8–24.vi.1973, leg. G. Junge; 2 ♂/♀, N–Iran, Shemshak, ca. 70 km n. Teheran, 20.vi.1969, 1700 m, leg. H. G. Amsel; 1 ♀, Iran, prov. Hamadan, 8 km S of Arak, 02. – 03.vi.2005, leg. P. Gyulai & A. Garai, g. prep. 0808/2020 D. Wanke; 1 ♂/♀, Iran N, prov. Semnan, 30 km NW Damghan, Cheschme Ali, N 36°15'07'', E 54°04'20'', 1560 mNN, 23.v.[20]05, leg. Trusch, Petschenka, Müller; 2 ♂/♀, Iran NE, Kopet Dagh, prov. Khorasan, ca. 50 km N Bojnurd, S Izmansufla, N 37°44'20'', E 57°25'53'', 17.v.2005, 1240mNN, lux, leg. Trusch, Petschenka, Müller, g. prep. 0806/2020 D. Wanke; 2 ♂/♀, Iran, Esfahan, Esfahan – Daran, Ashan vic., 25.vi.2005, 2490 – 2500 m, leg. A. Hofmann; 2 ♂/♀, Iran, prov. Esfahan, N of Tarq, Kuh–e Karkas, 2600 m, N 33°24' E 051°48', 09.vii.2003, leg. G. Ebert & R. Trusch; 2 ♂/♀, Iran, prov. Esfahan Kuh–e–Karkas, 1600 m, 7 km NW of Natanz, 11.–12.vi.2005,

leg. P. Gyulai & A. Garai; 4 ♂/♀, W–Iran, Lorestan, 28 km E Borudjerd, 2300 m, 27.vii.1975, leg. Ebert & Falkner; 2 ♂/♀, W–Iran, Lorestan, Dorud, Darrya–che Gahar, 2400 m, 31.vii.1975, leg. Ebert & Falkner; 1 ♂/♀, W–Iran, Lorestan, Dorud, 4 km SE Saravand, "Nermyeh" 2400 m, 4.–6.viii.1975, leg. Ebert & Falkner; 3 ♂/♀, W–Iran, Kordestan, Straße Saghez–Baneh, 21 km NE Baneh, 1950 m, 30–2.vii.1975, leg. Ebert & Falkner; 1 ♂/♀, W–Iran, Kordestan, Straße Baneh–Marivan, 86 km SE Baneh, 1950 m, 5.vii.1975, leg. Ebert & Falkner; 1 ♂/♀, W–Iran, Kordestan, Ariz, 27 km W Sanandaj, 10.vii.1975, 2200 m, leg. Ebert & Falkner; 1 ♂/♀, NW–Iran, 15 km westl. Rezaiyeh, 1400 m, Artemisia–Steppe, 11.vi.[19]75, leg. H. G. Amsel; 1 ♂/♀, NW–Iran, 40 km westl. Marand, 1100 m, 6.vi.1975, leg. H. G. Amsel; 1 ♂/♀, W–Iran, 15 km nördl. Kermanshah, 1350 m, 16.vi.1975, leg. H. G. Amsel; 56 ♂/♀, W–Iran, Kordestan, Straße Zandjan–Bijar, 53 km S Zandjan, 28.–29.vi.1975, 1700 m, leg. Ebert & Falkner, g. preps (♀) 0811, 0812/2020 D. Wanke; 8 ♂/♀, Iran, prov. Boyerahmad–va–Kohgiluyeh, SE–Zagros, 35 km SE of Yasuj, 2600 m, 06.–07.vi.2005, leg. P. Gyulai & A. Garai, g. preps (♀) 0558, 0803/2020 D. Wanke; 1 ♂/♀, Iran, prov. Boyerahmad–va–Kohgiluyeh, SE–Zagros, 3000 m, 05.–06.vi.2005, Kuh–e–Dena, n. Bijan pass, 6 km N of Cisakht, leg. P. Gyulai & A. Garai; 1 ♂/♀, Iran, prov. Khuzestan, Yasudj, Sisakht, 50 km NW, 15.–18.vi.1975, leg. Ebert, Falkner; 4 ♂/♀, S–Iran, 100 km s. Abadeh, n. Didegan, 9.vi.1969, 2000 m, leg. G. Ebert; 1 ♂/♀, S–Iran, Straße Shiraz–Kazerun, Imam Sade, 1200 m, 3.vi.1969, leg. G. Ebert; 1 ♂/♀, S–Iran, Fars, Daschte Pirehsan, 18.vi.1972, 2000 m, leg. Ebert, Falkner; 5 ♂/♀, S–Iran, 4.–7.6.1969, Miyan Kotal, 1900m, östl. Kazerun, 51°40' öL./29°30' nB., leg. G. Ebert, g. preps (♂) 0563, 0809 (♀) 0560/2020 D. Wanke; 1 ♂/♀, S–Iran, Fars, Kaserun, Mian–Kotal, 1900 m, 11.vi.1972, leg. Ebert & Falkner; 2 ♂/♀, Iran, prov. Fars, S–Zagros, 40 km SW of Sivand, 09.–10.vi.2005, leg. P. Gyulai & A. Garai, g. prep. 0538/2020 D. Wanke; 7 ♂/♀, S–Iran, Bandar–Abbas, Kuhe Genou, S–exp. 550 m, 1.u.5.iii.1973, leg. G. Ebert, g. preps (♀) 0810, 0813/2020 D. Wanke; 1 ♂/♀, S–Iran, Bandar–Abbas, km 74 d. Strasse nach Sirdjan, 450 m 7.iii.1973, leg. G. Ebert; 1 ♀, Iran, Khorasan, Koppe Dag, 1200 m, Robat 25 km SW Izman so flea [Izman–e Sufla], 27.v.2008, leg. J.–U. Meineke, W. Kramer, g. prep. 1167/2021 D. Wanke; 1 ♂, [Iran], Baloutchestan, 18 km W Iranschar, Rig–Kaboud, 500 m, 15.v.1972, leg. Abai, Ebert, g. prep. 0804/2020 D. Wanke; 1 ♀, Iran, Balutschestan, Khasch, 3 km S Sangan, 1550 m, 19.v.1972, leg. Ebert & Falkner, g. prep. 1166/2021 D. Wanke; **all in SMNK.**

3 ♂/♀, Iran, Azerbaijan–e Gharbi prov., Khoy to Ghotur road, Esteran vill., Alt. 1637 m, N 38°27' 03.1", E 44°44'33.6", 1.vii.2013, leg. H. Rajaei, J. U. Meineke, B. Hafezi, g. preps (♂) 0729 (♀) 0726/2020, 1189/2021 D. Wanke; 1 ♂/♀, Iran, Azerbaijan–e Sharghi prov., S Ghareh Aghaj, after Argsnay–Sufla Alt. 2020 m, N 36°50'16.5", E 46°58'07.5", 4.vii.2013, leg. H. Rajaei, J.U. Meineke, B. Hafezi; 1 ♂/♀, Iran, prov. Lorestan, Noorabad–Nahawand road, 25km to Nahawand, Gardane–Garrin, N34°02'48" E 48°20'31", Alt. 2135m, 25.vi.2009, leg. H. Rajaei, J.U. Meineke & A. Hofmann; 2 ♂/♀, Iran, Zanjan prov., E Zanjan, road to Gilvan, Alt. 1889 m, N36°45'21.8", E48°49'20.7", 6.vii.2013, leg. H. Rajaei, J.–U. Meineke, B. Hafezi; 1 ♂/♀, Iran, prov. Azarbayjan–e–Shargi, S Sahand Mt., 2431 m, 30.vi.2013, N 37°35'41", E 46°27'18.4", leg. J.U. Meineke, H. Rajaei, B. Hafezi; 1 ♂/♀, Iran, Ghazwin–Alamut road, after Gardane Alamut, sandy road to Khanjar Bolagh village N 36°24'11"; E50°12'52", 2024 m, 1.–2.vii.2009, H. Rajaei, J.–U. Meineke A. Hofmann; 2 ♂/♀, Iran, Lorestan, Dorud, Gahar lake, 2309 m, 33°18'40.8"N, 49°16'43"E, 28.vii.2016, leg. Sh. Feizpour; 2 ♂/♀, Iran, Kohkiluye va Boyerahmad, Yasuj, Sisakht, Dena, 2799 m, 30°57'23.6"N, 51°23'28.9", 30.vii.2016, leg. Sh. Feizpour; 5 ♂/♀, Iran, Isfahan prov. Abade–Semirom road, 30 km before Hanna protected area, 2435 m, N 31°12'22", E 51°51'37" 09.vi.2010 leg. H. Rajaei, g. preps (♀) 0701, 0702/2020 D. Wanke; 1 ♀, Iran, Isfahan prov. Kashan, 7 km after Ghamsar to Ghohroud, 1705 m, N 33°44' 49", E 51'29'10", 08.vi.2010, leg. H.Rajaei, g. prep. 0703/2020 D. Wanke; 1 ♂, Iran, Hormozgan, Bandar Abbas, Genu, 2128 m, 27°25'02"N, 56°10'160", 01.v.2016, leg. Sh. Feizpour, g. prep. 0710/2020 D. Wanke; 1 ♂/♀, Iran, prov. Chaharmahal–va–Bakhtiyari, Dehnau, 2248m, 12.v.2010, Leg. G. Petrányi, P. Hentschel; 2 ♂/♀, Iran, prov. Esfahan, near Qamsar, 1781m, 06.v.2010, Leg. G. Petrányi, P. Hentschel; 3 ♂/♀, Iran, prov. Hamedan, Nehavand, 1855m, 13.v.2010, Leg. G. Petrányi, P. Hentschel; 3 ♂/♀, Iran, prov. Zanjan, Ab Bar, 1053m, 17.v.2010, Leg. G. Petrányi, P. Hentschel; 4 ♂/♀, NW–Iran, Kaleibar, 1700m, 3.viii.1977, leg. W. Thomas; 2 ♂/♀, Nordpersien, Umg. Shahabad Nationalpark, 1300 m, 21.–22.viii.1977, leg. deFreina; **all in SMNS.**

1 ♂/♀, Nordost–Iran, Kuh i Mirabi, Waldzone, 1600–1900m, Juli, Exp. Wernicke; 1 ♂/♀, Persia sept. [Iran], Elburs mts.c.s., Särdab Tal–Vandarban, 19–2200 m, 1.–3.vii.[19]37, E. Pfeiffer & W. Forster München leg.; 1 ♂/♀, Persia sept. [Iran], Elburs mts.c.s., Ort Demavend, Tar Tal, 22–2500 m, 13.–17.vii.[19]36, Pfeiffer München leg.; **all in ZFMK.**

2 ♂/♀, Iran, Sharqui, prov. Kivi, 2200 m, viii.2002, leg. Müller; 1 ♂, Iran, Lorestan, 22 km E Dorud, vic. Saravand, 2300–2500 m, 33°23'N, 49°11'E, 9.–10.vi.1997, leg. A. Hofmann & P. Kautt, coll N. Pöll, g. prep. ZSM G 10719; 1 ♂/♀, S. Iran, Hormozgan, Beshagerd Mts., Davari vill., 26°27'N, 57°38'E, 5.–11.vi.2000, leg. V. Siniaev & A. Plutenko; 1 ♀, Iran, Kerman, 5 km S Deh Bakri, 2300–2400 m, leg. A. Hofmann & P. Kautt, 28°59'N, 57°55'E, 31.v.–1.vi.1997, coll N. Pöll, g. prep. ZSM G 10718; **all in ZSM.**

Scopula rubiginata

1 ♀, Asia min. [Turkey], Paphlagonia, Songuldak, 30.viii.[19]35, coll. Osthelder, g. prep. 1288/2022 D. Wanke; 1 ♂, same data but 15.–30.viii.[19]35, coll. Osthelder, g. prep. 1289/2022 D. Wanke; 1 ♀, Amasia [Turkey], 1888, Korb, g. prep. 1290/2022 D. Wanke; 1 ♂, Turkey, Aphrodisias, 10 km E Karakasu, LF, 09.v.1988, leg. J. Lenz, g. prep. 1291/2022 D. Wanke; 1 ♂/♀, NO–Turkey, Umg. Ankara, Güvern, 06.vi.1991, leg. Geck; **all in ZSM.**

Scopula turbulentaria steinbacheri

7 ♂/♀, Iran N, E Alborz, prov. Mazandaran, E Gorgan, S Aliabad, oberh. Shirinabad, N 36°47'21", E 55°01'25", 21.v.2005, 1100 mNN, leg. Trusch, Petschenka, Müller, SMNK E–Lep. 215, g. preps 0824, 0825/2020 D. Wanke; 2 ♂, Iran N, E Alborz, prov. Mazandaran, E Gorgan, S Aliabad, oberh. Shirinabad, N 36°47'21", E 55°01'25", 22.v.2005, 1100 mNN, leg. Trusch, Petschenka, Müller, SMNK E–Lep. 215; 1 ♂/♀, N–Iran, Masandaran, Golestan–Wald, 60 km E Gonbad Qabus, 8.vii.1972, 510 m, leg. Ebert & Falkner; 1 ♂/♀, N–Iran, Elburs–Mts. S–Rand, Tehran–Evin, 1600 m, 27.v.1972, leg. G. Ebert; 1 ♂, [Iran], Polour, 22.ix.1970, [leg.] Abai, g. prep. 1071/2021 D. Wanke; 1 ♂/♀, [Iran], Evin, 15.v.[19]70; 1 ♂/♀, Iran, Amarlu östl., Rudbar, 1000 m, 27.ix.1970, leg. G. Ebert; 1 ♂/♀, S–Iran, 1600m, 2.vi.1969, Persepolis, leg. G. Ebert; 1♀, S–Iran, prov. Khuzestan, Yasudj, Sisakht, 50 km NW, 15.–18.vi.1975, leg. Ebert & Falkner, g. prep. 0880/2020 D. Wanke; 1 ♂, Iran, Khuzistan, Shadegan, 1.–8.iii.1956, leg. Richter; 1 ♂/♀, Iran, prov. Khuzestan, Yasudj, Sisakht, 50 km NW, 15.–18.vi.1975, leg. Ebert, Falkner; 1 ♂, NW–Iran, 15 km sö. Maku, 1050 m, 3.vi.1975, leg. H. G. Amsel, g. prep. 1172/2021 D. Wanke; 1 ♂, [Iran], Evin, 22.v.1970, [leg.] L.T., g. prep. 1173/2021 D. Wanke; 1 ♂, [Iran], Gorgan, 8.viii.1970, g. prep. 1174/2021 D. Wanke; 1♀, [Iran], Varamin, 5.viii.1949, Eghl., g. prep. 0998/2021 D. Wanke; 1 ♂, Iran, Tehran, Qollhak, 1400 m, 14.x.1961, leg. J. Klapperich, g. prep. 0778/2020 D. Wanke; 1 ♀, Iran, 10.vii.1961, leg. J. Klapperich, g. prep. 1136/2021 D.

Wanke; 1 ♂, [Iran], Evin, 15.v.[19]70, [leg.] L.T., g. prep. 1171/2021 D. Wanke; 1 ♀, N–Iran, Teheran/Evin, ca. 1400 m, 4. – 10.x.1970, leg. G. Ebert, g. prep. 0975/2020 D. Wanke; 1 ♀, W–Iran, Kordestan, 95 km N Kermanschah, Straße nach Sanandaj, 11.vii.1975, 1350 m, leg. Ebert & Falkner, g. prep. 1123/2021 D. Wanke; **all in SMNK.**
1 ♂/♀, Iran, Kohkiluye va Boyerahmad, Yasuj, Sisakht, Dena, 2799 m, 30°57'23.6"N, 51°23'28.9"E, 30.vii.2016, leg. Sh. Feizpour; **all in SMNS.**

Scopula imitaria
1 ♂, Croatia, Krk (Fiumebucht), 26.v.1928, Licht, Günther Barth, g. prep. 0772/2020 D. Wanke; 1 ♀, same data but 8.vi.1930, g. prep. 0773/2020 D. Wanke; **all in SMNS.**
1 ♀, Asiamin. [Turkey], Gebze, 17.ix.1963, e.o. 27.v.1969, leg. Friedel, g. prep. 1273/2022 D. Wanke; 1 ♂, Zypern, Paphos Umg., 13.–19.iii.[19]94, leg. J. Wimmer, g. prep. 1274/2022 D. Wanke; **all in ZSM.**

Scopula beckeraria
4 ♂/♀, Iran, Chamarmahal–va–Bakhtiyari, Zarde–Kuh, Samsami vic., Gardaneh–ye Cheri, 2800–3000 m, 8./9. vii.2003, leg. A. Hofmann, J.–U. Meineke, G. Tremewan; 2 ♂/♀, Iran, Esfahan, Miyandasht NW, Afous. Chebleh–Kuh, Sar Chesmeh vic., 2700–2900 m, 12./13.vii.2003, leg. A. Hofmann, J.–U. Meineke, G. Tremewan; 2 ♂/♀, Iran, Esfahan, Fereidun Shahr S, Gardaneh–ye Kameran, 2900–3200 m, 16./17.vi.2002, leg. J.–U. Meineke, A. Hofmann, A. Kallies *et al.*; 2 ♂/♀, Iran, Markazi, Tafresh via Dastgerd, 2300–2500m, 15./16.6.2005, leg. J.–U. Meineke; 6 ♂/♀, Iran, Alborz, Theran, Firuzkuh W, Abzweig, Namrud, 2050 m, 21.vii.2006, leg. A. Hofmann, J.–U. Meineke; 5 ♂/♀, Iran, Esfahan, Kashan S, Quarud SW, 2600 m, 24.vi.2001, leg. A. Hofmann, J.–U. Meineke, W. G. Tremewan; 2 ♂/♀, Iran, Zanjan, Zanjan E to Gill van, N36°45'21.8", E 48°49'20.7", 1900 m, 6.vii.2013, leg. J.U. Meineke, H. Rajaei, B. Hafezi; 1 ♂/♀, Iran, Zanjan, Zanjan–Gilvan, Gargovol Dag, 2500m, 26./27.6.2001, leg. A. Hofmann, J.–U. Meineke, W.G. Tremewan; 1 ♂/♀, Iran, prov. Hamadan, Hamadan NNE, Razan N, Mahanye 2 km N, 2100–2150 m, 19.vi.1998, leg. A. Hofmann & J.–U. Meineke; 1 ♂/♀, Iran, prov. Hamadan, Hamadan NNE, Razan N, Gardaneh Avaj, 2300–2500 m, 25.vi.2001, leg. A. Hofmann, J.–U. Meineke, W. G. Tremewan; 2 ♂/♀, Iran, Theran, Firuzkuh 20 km E, 2200 m, 05.vi.2008, leg. J.–U. Meineke, W. Kramer; 5 ♂/♀, Iran, Boyer Ahmad–Va–Kohgiluyeh, Gardaneh, Meymand, 2450–2800m, 14./15.vi.2001, leg. A. Hofmann, J.–U. Meineke, G. Tremewan; 9 ♂/♀, Iran, Khorasan, Koppe Dag, 1200 m, Robat 20 km SW Izman Olia, 25./26.v.2008, leg. J.–U. Meineke, W. Kramer; 5 ♂/♀, Iran, Khorasan, Askaneh 20 km, 1800 m, 25.v.2008, leg. J.–U. Meineke, W. Kramer; 1 ♂/♀, Iran, Fars, Shiraz E, Dash–e–Arzhan E, 1900–2200 m, 6./7.vi.2002, leg. J.–U. Meineke, A. Hofmann, A. Kallies *et al.*;
1 ♂/♀, Iran, Fars, Eqid via Gardaneh, Timur Gun, 2400 m, 6./7.vi.2005, leg. J.–U. Meineke, A. Hofmann; 1 ♂/♀, Iran, Khorasan–e Razavi, Nishabour to Quochan, Bar vic., 1718 m, 17.vi.2013, N36°30'27.9", E 58°44'30.8", leg. J.U. Meineke, H. Rajaei, B. Hafezi; 1 ♂/♀, Iran, Khorasan–e Shomali, Allah–o Akbar Mt., 1763 m, 18.vi.2013, N37°19'27.2", E 58°43'26.1", leg. J.U. Meineke, H. Rajaei, B. Hafezi; 1 ♂/♀, Iran, Kerman, Baft E, Darb–e–Beshnesht S, Kuh–e Bochrasman, Khaf Kuh, 2900–3100 m, 4.vi.2002, leg. J.–U. Meineke, A. Hofmann, A. Kallies *et al.*; 2 ♂/♀, Iran, Kerman, Jiroft W, Shingera, 2800 m, 26./27.v.2004, leg. A. Hofmann, J.–U. Meineke, G. Tremewan; 1 ♂/♀, Iran, Kerman, Rayen SW, Kuh–e Hesar, Abshar, 2700–3000 m, 24./25.v.2004, leg. A. Hofmann, J.–U. Meineke, G. Tremewan; 1 ♂/♀, Iran, Kerman, Baft 20 km W, Gard Timur Gun, 2300 m, 27.v.2004, leg. A. Hofmann, J.–U. Meineke, G. Tremewan; **all in PCJM.**
11 ♂/♀, NW–Iran, 12 km westl. Rezaiyeh, 1350 m, 3.v.1975, leg. Amsel, g. prep. (♀)1045/2021 D. Wanke; 7 ♂/♀, NW–Iran, 17 km nw. Maku, 1400 m, 4.vi.1975, leg. H. G. Amsel, g. prep. (♀) 0791/2020 D. Wanke; 2 ♀, NE–Iran, Prov. Ostan–e Khorasan W Torbat de Heidarye, Kuh–e Sorkh, N Rivash, Akbarabad vic., N 35°34'16", E 58°35'53.3", 30.iv.2008, 2100 mNN, leg. R. Trusch, M. Falkenberg, B. Müller, g. preps 1001, 1002/2021 D. Wanke; 1 ♂/♀, NE–Iran, Prov. Ostan–e Khorasan E Torbat de Heidarye S Fariman, Zharf vic. N 35°24'25.1", E 59°56'08.2" 5.v.2008, 2160 m, leg. R. Trusch, M. Falkenberg, B. Müller, SMNK E–Lep. 247; 2 ♂/♀, NE–Iran, Prov. Ostan–e Khorasan, Kopet Dagh, ca. 50 km N Bojnurd, S Izmansufla, N 37°44'20", E 57°25'53", 11.v.2008, 1240 mNN, lux, leg. R. Trusch, M. Falkenberg & B. Müller, SMNK E–Lep. 247, g. prep. (♂) 1000/2021 D. Wanke; 1 ♀, NE–Iran, Prov. Ostan–e Khorasan, NE–Birjand, S Haji Abad, Gomenj vic., Kuh–e Mirza Arab, N 33°16'13.9", E 60°06'59.7", 1.v.2008, 2040 mNN, lux, leg. R. Trusch, M. Falkenberg & B. Müller, SMNK E–Lep. 247, g. prep. 1003/2021 D. Wanke; 1 ♂/♀, NE–Iran, Prov. Ostan–e Khorasan, Kopet Dagh, NW Mashad, N Tschenaran, N Radkan, Dolmeh Olia, N 36°55'56.6", E 59°02'18.6", 9.v.2008, 1560 mNN, lux, leg. R. Trusch, M. Falkenberg & B. Müller, SMNK

E–Lep. 247; 4 ♂/♀, W–Iran, Kordestan, Straße Zandjan–Bijar, 53 km S Zandjan, 28.–29.vi.1975, 1700m, leg. Ebert & Falkner, g. preps (♂) 0993 (♀) 1048/2021 D. Wanke; 2 ♂/♀, Iran, prov. Chahar Mahal, Zagros mts. NW Samsami, 2800 mNN, N 32°09', E050°11', 13.vii.2003 (lux), leg. G. Ebert & R. Trusch; 3 ♂/♀, Iran NE, Kopet Dagh, prov. Khorasan, ca. 50 km N Bojnurd, S Izmansufla, N 37°44'20", E 57°25'53", 1.240 mNN, 17.v.2005, leg. Trusch, Petschenka, Müller, g. preps (♂) 0839, (♀) 0905/2020 D. Wanke; 1 ♂/♀, Jran mer. occ., Kasrun, 900 m, Ende iv.[19]38; 1 ♂, 1♀, Iran–N, Varamin, E. Tehran, 1000 m, 14.vi.1961, leg. J. Klapperich, g. preps (♂) 0782, (♀) 0783/2020 D. Wanke; 6 ♂/♀, N–Iran, Kamard, 40 km w. Teheran, ca. 1700 m, 9.ix.1970, leg. G. Ebert; 4 ♂/♀, N–Iran, Masandaran, Golestan–Wald, 60 km E Gonbad Qabus, 8.vii.1972, 510 m, leg. Ebert & Falkner; 1 ♂/♀, N–Iran, Elburs Mts., Masandaran, Polur, Damavand, 7.–10.vii.1972, 2500 m, leg. Ebert & Falkner; 1 ♂/♀, N–Iran, Teheran/ Evin, ca. 1600 m, 4.–10.x.1970, leg. G. Ebert; 3 ♂/♀, N–Iran, Elburs–Mts., S–Rand, Tehran–Evin, 30.vi.–5.vii.1972, 1600 m, leg. G. Ebert; 1 ♂, same data, 24.ix.1972, 1600 m, leg. G. Ebert, g. prep. 1140/2021 D. Wanke; 1 ♂/♀, same data, 17.viii.1963, 1600 m, leg. Dr. Leuchs; 2 ♂/♀, N–Iran, Elburs–Mts., prov. Tehran, Arangeh, 25 km N Karadi, 4.vii.1972, 1550 m, leg. Ebert & Falkner, g. prep. (♂) 1135/2021 D. Wanke; 1 ♂/♀, Iran, Amarlu östl., Rudbar, 1000 m, 27.ix.1970, leg. G. Ebert; 1 ♂/♀, N–Iran, Salzsee, 90 km s. Teheran, 800 m, 18/23.vi.1969, leg. H. G. Amsel; 1 ♂/♀, N–Iran, Elburs–Geb., Sheshmak, 1700 m, 20.vi.1969, leg. H. G. Amsel; 1 ♂/♀, N–Iran, 70 km s. Teheran, 1300 m, 29.v.1969; 1 ♂, Iran, Elburs–Geb., 12 km v. Keredj, 1650 m, 27.v.1969, leg. Ebert, g. prep. 1159/2021 D. Wanke; 1 ♂, W–Iran, Kordestan, Straße Saghez–Baneh, 23 km NE Baneh, 2.vii.1975, 1800 m, leg. Ebert & Falkner, g. prep. 1162/2021 D. Wanke; 1 ♂/♀, N–Iran, Elburs Mts., Prov. Tehran, 15 km E Gatschsar, 17.viii.1972, 2800 m, leg. Ebert; 5 ♂/♀, [Iran], Kurdistan, Wan [Van] Umgeb., 1800 – 2000 m, 1.–5.ix.[19]35, g. preps. (♀) 0779, 0780/2020 D. Wanke; 5 ♂/♀, Iran, prov. Boyerahmad–va–Kohgiluyeh, SE–Zagros, 35 km SE of Yasuj, 06.–07.vi.2005, 2600 m, leg. P. Gyulai & A. Garai; 2 ♂, Iran, prov. Zanjan, W–Alborz range Tarom vic, 20 km NE of Zanjan, 13.–14.vi.2005, leg. P. Gyulai & A. Garai, g. prep. 0838, 0999/2020 D. Wanke; 1 ♂, Iran, prov. Esfahan, 1 km N of road between Abuzeidabad and Kashan, N 33°59'17", E 51°35'71", 925 m, 01.vi.2005, leg. M. Fibiger & R. Zahiri, g. prep. 0820/2020 D. Wanke; 1 ♂, Iran N, prov. Semnan, 90 km S Damghan, N 35°21'83", E 54°27'63", 1750 m, 30.v.2005, leg. M. Fibiger & R. Zahiri, g. prep. 0821/2020 D. Wanke; 1 ♂/♀, S–Iran, prov. Khuzestan, Yasudj, Sisakht, 50 km NW, 15.–18.vi.1975, leg. Ebert & Falkner; 1 ♂/♀, W–Iran, Kermanshahan, Ghalladje Pass, 40 km S Schahabad, 1880 m, 13.vii.1975, leg. Ebert & Falkner; 1 ♂/♀, W–Iran, 51 km westl. Kermanshah, 1500 m, Quercetum, 17.vi.1975, leg. H. G. Amsel; 1 ♂, Iran c., Prov. Esfahan, Kashan–Meymeh, Qorud, N 33°39'04", E 51°23'53", 2450 mNN, 12.v.2005, leg. Trusch, Petschenka, Müller, SMNK E–Lep. 215, g. prep. 1046/2021 D. Wanke; 1 ♀, W–Iran, Lorestan, 28 km E Borudjerd, 27.vii.1975, 2300 m, leg. Ebert & Falkner, g. prep. 1047/2021 D. Wanke; 1 ♂, S–Iran, Khusestan, 15 km SE Yassudj, 2250 m, 13./14.vi.1972, leg. Ebert & Falkner, g. prep. 1144/2021 D. Wanke; 21 ♂/♀, S–Iran, Straße Shiraz–Kazerun, Imam Sade, 1200 m, 3.vi.1969, leg. G. Ebert; 34 ♂/♀, S–Iran, Miyan Kotal, östl. Kazerun, 4.–7.vi.1969, 1900 m, N 29°30', E 51°40', leg. G. Ebert; 20 ♂/♀, S–Iran, prov. Fars, Tange Surkh, 50 km NW Ardekan, 2250 m, 12.–15.vi.1975, leg. Ebert/Falkner; 1 ♂/♀, Iran, prov. Fars, S–Zagros, 40 km SW of Sivand, 09.–10.vi.2005, leg. P. Gyulai & A. Garai; 1 ♂/♀, Iran, prov. Fars, S–Zagros, 5km NE of Saidatshahr, 09.–10.vi.2005, leg. P. Gyulai & A. Garai; 1 ♂/♀, Iran, Fars, Eqlid SSE, Kuh–e Bol, Darre Absad, 2700 – 3000 m, 23.vi.2005, leg. A. Hofmann; 1 ♂, Iran, prov. Fars, ca. 20 km S Jahron, Sistan, Garden Ahmad Najafzadeh, N 28°21', E 53°22', 29.iii.2006, 870 mNN, leg. Hossein Rajaei, g. prep. 0822/2020 D. Wanke; 2 ♂/♀, Iran, Hushin, 5.v.2005, leg. A. Hofmann; 1 ♂, Iran, Kerman, Ostor E, Hushin vic., LF, 2250 m, 12.v.2005, leg. A. Hofmann, g. prep. 1052/2021 D. Wanke; 5 ♂/♀, S–Iran, Tangetchogan, 930 m, 30 km n. Kazerun, 23.iii.[19]73, leg. H. G. Amsel; 2♂/♀, S–Iran, Fars, Kaserun, Mian–Kotal, 1900 m, 11.vi.1972, leg. Ebert & Falkner; 2 ♂/♀, S–Iran, Fars, Daschte Ardjan, Kotal–Pirehsan, 20.vi.1972, 2000 m, leg. Ebert & Falkner; 1 ♂/♀, same data, leg. Ebert & Pazouki; 1 ♂/♀, S–Iran, Bandar–Abbas–Sirjan, km 24, 250 m, 2.iv.1973, leg. H. G. Amsel; 1 ♂/♀, S–Iran, Bandar–Abbas, km 107 d. Strasse nach Sirdjan, 850 m, 7.iii.1973, leg. G. Ebert; 1 ♂, S–Iran, Straße Shiraz–Kazerun, Imam Sade, 1200 m, 3.vi.1969, leg. G. Ebert, g. prep. 1161/2021 D. Wanke; 1 ♂/♀, Iran, prov. Esfahan, Zagros mts., Feridun Shar, Kamaran, val., 2770 m, N 32°45', E 49°59', 11.vii.2003, lux, leg. G. Ebert & R. Trusch; 3 ♂/♀, same data as before, 12.vii.2003, g. prep. (♂) 1099/2020 D. Wanke; 40 ♂/♀, Iran, prov. Chahar Mahal, Zagros mts. NW Samsami, 2800 mNN, N 32°09', E050°11', 13.vii.2003 (lux), leg. G. Ebert & R. Trusch, g. preps (♂) 0846, 0848/2020, 1097, 1106/2021, (♀) 1107, 1108/2021 D. Wanke; 1 ♂, Iran, prov. Esfahan, N of Tarq, Kuh–e Karkas, 2600 m, N 33°24' E 051°48', 07.vii.2003, leg. G. Ebert & R. Trusch, g. prep. 0846/2020 D. Wanke; 11 ♂/♀, W–Iran, Kordestan, Straße Baneh–Marivan, 25 km E Baneh, 4.vii.1975, 1950 m, leg. Ebert & Falkner; 4 ♂/♀, W–Iran, Kordestan, Straße Saghez–Baneh, 23 km NE Baneh, 2.vii.1975, 1800 m, leg. Ebert & Falkner; 7 ♂/♀, W–Iran, Kordestan, 36 km, NE Marivan, Straße nach Baneh, 1550m, 8.–9.7.1975, leg. Ebert & Falkner; 33 ♂/♀, W–Iran, Kordestan, Straße Saghez–Baneh, 21 km NE Baneh, 1950 m, 30.[vi.]–2.vii.1975, leg. Ebert & Falkner, g. preps (♂) 1112, 1115/2021; 11 ♂/♀, W–Iran, Kordestan, Straße Zandjan–Bijar, 53 km S Zandjan, 28.–29.vi.1975, 1700m, leg. Ebert & Falkner; 8 ♂/♀, W–Iran, Lorestan, Dorud, Darrya–che Gahar, 2400 m, 1.–3.viii.1975, leg. Ebert & Falkner; 1 ♂/♀, same data, 31.vii.1975; 3 ♂/♀, W–Iran, Lorestan, 14 km E Dorud, 6.viii.1975, 1990 m, leg. Ebert & Falkner; 2 ♂/♀, W–Iran, Kordestan, Straße Baneh–Marivan, 86 km SE Baneh, 5.vii.1975, 1950 m, leg. Ebert & Falkner; 4 ♂/♀, W–Iran, Lorestan, Dorud, 4 km SE Saravand, "Nermyeh", 4.–6.viii.1975, 2400 m, leg. Ebert & Falkner; 2 ♂/♀, W–Iran, Lorestan, Dorud, 5 km SE Saravand, "Kohyeh", 29–30.vii.1975, 2300 m, leg. Ebert & Falkner; 7 ♂/♀, W–Iran, Lorestan, 28 km E Borudjerd, 27.vii.1975, 2300 m, leg. Ebert & Falkner; 4 ♂/♀, W–Iran, W–Azarbaijan, 2 km W Sardasht, 1650 m, 3.vii.1975, leg. Ebert & Falkner; 2 ♂/♀, W–Iran, Kordestan, 95 km N Kermanschah, Straße nach Sanandaj, 11.vii.1975, 1350 m, leg. Ebert & Falkner; 3 ♂/♀, W–Iran, Kordestan Paß, 10 km W Bijar, Straße nach Saghez, 29.–30.vi.1975, 2180 m, leg. Ebert & Falkner; 1 ♂/♀, W–Iran, Kordestan, Ariz, 27 km W Sanandaj, 10.vii.1975, 2200 m, leg. Ebert & Falkner; 5 ♂/♀, W–Iran, Kermanshahan, Ghalladje Pass, 40 km S Schahabad, 1880 m, 13.vii.1975, leg. Ebert & Falkner; 1 ♂/♀, W–Iran, Kermanshahan, Surkhe Dizeh, 56 km NW Schahabad, 1320 m, 14.vii.1975, leg. Ebert & Falkner; 1 ♂/♀, NW–Iran, 17 km nw. Maku, 1400 m, 4.vi.1975, leg. H. G. Amsel; 1 ♂/♀, NW–Iran, 12 km westl. Rezaiyeh, 1350 m, 30.v.1975, leg. Amsel; 1 ♂/♀, NW–Iran, 8 km westl. Rezaiyeh, 1400 m, 2.vi.1975, leg. Amsel; **all in SMNK.**

21 ♂/♀, Iran, Azerbaijan–e Gharbi prov., Khoy to Ghotur road, Esteran vill., Alt. 1637 m, N 38°27' 03.1", E 44°44'33.6", 1.vii.2013, leg. H. Rajaei, J. U. Meineke, B. Hafezi; 2 ♂/♀, Iran, prov. Azarbayjan–e–Shargi, S Sahand Mt., 2431 m, 30.vi.2013, N 37°35'41", E 46°27'18.4", leg. J.U. Meineke, H. Rajaei, B. Hafezi; 3 ♂/♀, Iran, Ghazwin–Alamut road, after Gardane Alamut, sandy road to Khanjar Bolagh village N 36°24'11"; E50°12'52", 2024 m, 1.–2.vii.2009, H. Rajaei, J.–U. Meineke A. Hofmann; 12 ♂/♀, Iran, Lorestan, Dorud, Gahar road, 2281 m, 33°22'32.1"N, 49°11'34.8"E, 27.vii.2016, leg. Sh. Feizpour; 5 ♂/♀, Iran, Lorestan, Dorud, Gahar lake, 2309 m, 33°18'40.8"N, 49°16'43"E, 28.vii.2016, leg. Sh. Feizpour; 5 ♂/♀, Iran, Lorestan, Dorud, Astaneh door, 1801 m, 33°24'48.1"N, 49°08'42.5"E, 25.vii.2016, leg. Sh. Feizpour; 4 ♂/♀, Iran, Khorasan Razavi, 5 km W Chenaran, 3 km before Akhlamand, 1210 m, 36°38'21" N, 58°57'04" E, 16.vi.2010, leg. H. Rajaei; 2 ♂/♀, Iran, Khorasan Razavi, 65 km Kalat road, Khor, 1431m, 36°38'15.1"N, 59°54'04"E, 16.vi.2016, leg. Sh. Feizpour; 1 ♂/♀, Iran, Khorasan Shomali, Babaaman, near Bojnurd, 26.vi.2016, leg. Sh. Feizpour; 2 ♂/♀, Iran, Khorasan Razavi, Mashad, Binaloud, 1553m, 36°15'17.5"N, 59°21'41.2"E, 13.vi.2016, leg. Sh. Feizpour; 1 ♂/♀, Iran, prov. Azarbayjan–e–Shargi, S Sahand Mt., S Batmanghelich vill., 2358 m, 29.vi.2013, N 37°34'29.8", E 46°27'03.4", leg. J.U. Meineke, H. Rajaei, B. Hafezi; 1 ♂/♀, Iran, Isfahan prov. Kashan, 7 km after Ghamsar to Ghohroud, 1705 m, N 33°44' 49", E 51'29'10", 08.vi.2010, leg. H. Rajaei; 1 ♂/♀, Iran, Prov. Golestan, Shahrud–Golestan road, Shahkuh, 2585 m, 36°38'36"N, 54°31'31"E, 28.v.2015, leg. Sh. Feizpour; 1 ♂/♀, Iran, Zanjan prov., E Zanjan, road to Gilvan, Alt. 1889 m, 36°45' 21.8"N,48°49'20.7"E, 6.vii.2013, leg. H. Rajaei, J.U. Meineke, B. Hafezi; 3 ♂/♀, Iran, Kohkiluye va Boyerahmad, yasuj, Sisakht, Dena, 2799 m, 30°57'23.6"N, 51°23'28.9"E, 30.vii.2016, leg. Sh. Feizpour; 1 ♂/♀, Iran, Prov. Fars, ca. 20 km S Jahron, Sistan, Garden Ahmad Najafzadeh, N28°21' E53°22', 30.iii.2011, 870 mNN, leg. Hossein Rajaei; 1 ♂/♀, Iran, Fars prov., Shiraz–Kazeroun Road, Dasht Arjan, 2090 m, N 29°38'38, E 052°00'59, 12.vi.2010, H. Rajaei; 1 ♂/♀, Iran, prov. Hamedan, Nehavand, 1855m, 13.v.2010, Leg. G. Petrányi, P. Hentschel; 5 ♂/♀, Iran, prov. Zanjan, Ab Bar, 1053m, 17.v.2010, Leg. G. Petrányi, P. Hentschel; 1 ♂/♀, Iran, Elburs, vic. Kendevan, 7.–9.viii.1977, 2500–3000 m, leg. W. Thomas; 1 ♂/♀, Iran, Ostan Boyr Amadi, yasuj, Abshar, 2000 m, 16.–18.iv. 1978, leg. W. L. Blom; 1 ♂/♀, Iran, Tabris, Azar Shahr, südl. Tabris, vii.1976, leg. Czipka; **all in SMNS.**

1 ♂/♀, Nordost–Iran, Kuh I Mirabi, Waldzone, 1600–1900m, Juli, Exp. Wernicke; **in ZFMK.**

1 ♂/♀, NW Iran, Kordestan, Bijar, 2500 m, viii.2002, leg. Müller; 1 ♂/♀, N Iran, 20 km NO Teheran, Steppe (Tagfang), 21.–31.vii.1996, leg. Müller; 1 ♂/♀, NW Iran, Azarbaijan prov., Marand, 2000 m, viii.2002, leg. Müller; 3 ♂/♀, Iran, Fars, Dast–E–Arzan, 1950 m, 29°35'N, 51°56'E, leg. A. Hofmann & P. Kautt, 5.–6.vi.1997, coll N. Pöll; 1 ♂, Iran, Kerman, 5 km S Deh Bakri, 2300–2400 m, leg. A. Hofmann & P. Kautt, 28°59'N, 57°55'E, 31.v.–1.vi.1997, coll N. Pöll, g. prep. ZSM G 10723; **all in ZSM.**

Scopula incanata

1 ♂/♀, Iran, Mazandaran, Sari, Darabkola Forest, N 36°31'57", E 53°16'35', alt. 391 m, 23.v.2015, Forest type: *Pinus brutia* mix, leg. Goodarz, Hajizadeh; 4 ♂/♀, Iran, Mazandaran, Sari, Darabkola Forest, N 36°30'42", E

53°18'17', alt. 550 m, 6.vi.2015, Forest type: *Parrotia persica*, *Carpinus betulus*, leg. Goodarz, Hajizadeh; 2 ♂/♀, Iran, Mazandaran, Sari, Darabkola Forest, N 36°30'42'', E 53°18'17', alt. 550 m, 17.vi.2015, Forest type: *Parrotia persica*, *Carpinus betulus*, leg. Goodarz, Hajizadeh; 2 ♂/♀, Iran, Mazandaran, Sari, Darabkola Forest, N 36°30'38'', E 53°18'19', alt. 555 m, 18.viii.2015, Forest type: *Parrotia persica*, *Carpinus betulus*, leg. Goodarz, Hajizadeh; **all in SMNS.**

1 ♂, 1 ♀, Persia sept. [Iran], Elburs mts.c.s., Tacht i Suleiman, Särdab–Tal (Vanderban), 25–2700cm, 14.–18.vii.[19]37, E. Pfeiffer & W. Forster leg., München, g. preps (♂) 1275, (♀) 1276/2022 D. Wanke;

1 ♀, same data but 19–2200 m, 10.–14.vii.[19]37, g. prep. 1277/2022 D. Wanke; **all in ZSM.**

Scopula marginepunctata terrigena

9 ♂/♀, Iran, Zagros, Esfahan Umg., Fereidun Shah, 2200 m, 9.vii.1999, leg. A. Hofmann, J. Meineke; 2 ♂/♀, Iran, Zanjan, Takht–e Suleiman, Barbar Naza, 2462 m, 5.vii.2013, N36°33'49.0'', E 47°17'57.7', leg. J.U. Meineke, H. Rajaei, B. Hafezi; 1 ♂/♀, Iran, Ardabil, Kuhha–ye Tales, Khal Khal W, Meragin vic., 2400 m, 1.viii.2006, leg. A. Hofmann, J. Meineke; 1 ♂/♀, Iran, prov. Hamadan, Hamadan NNE, Razan N, Gardaneh Avaj, 2100–2150 m, 19.vi.1998, leg. A. Hofmann, J.–U. Meineke; 2 ♂/♀, Iran, prov. Azarbayjan–e–Gharbi, Takht–e Suleyman, 20 km E, Gharawol–Khaneh, 2300–2500 m, 29./30.vi.2009, leg. A. Hofmann, J.U.Meineke, H. Rajaei; 1 ♂/♀, Iran, prov. Azarbayjan–e–Shargi, Kuh–e Bozghush, Sarab S, 2233 m, 28.vi.2013, N 37°45'49.4'', E 47°21'30.8'', leg. J.U. Meineke, H. Rajaei, B. Hafezi; 2 ♂/♀, Iran, prov. Azarbayjan–e–Shargi, Gharek Aghai, 2200 m, 4.vi.2013, N 36°50'16.5'', E 46°58'07.5'', leg. J.U. Meineke, H. Rajaei, B. Hafezi; 2 ♂/♀, Iran, prov. Azarbayjan–e–Shargi, Sahand Mt., S Batmanghelich S, 2358 m, 29.vi.2013, N 37°34'29.8'', E 46°27'03.4'', leg. J.U. Meineke, H. Rajaei, B. Hafezi; 2 ♂/♀, Iran, Zanjan NE, Gard–ye Alamut N, 2000–2300 m, 1./2.vii.[20]09, leg. A. Hofmann, J.U. Meineke, A. Naderi, H. Rajaei; 2 ♂/♀, Iran, Zanjan, Zanjan E to Gill van, N 36°45'21.8'', E 48°49'20.7'', 1900 m, 6.vii.2013, leg. J.U. Meineke, H. Rajaei, B. Hafezi; 8 ♂/♀, Iran, Golestan, Shahkuh 20 km W, Paband, 2000 m, 31.v.2008, leg. J.–U. Meineke, W. Kramer; 1 ♂/♀, Iran, Golestan, Tange Gol, N 37°22'13.2'', E 55°56'10.2'', 700 m, 21.vi.2013, leg. J.U. Meineke, H. Rajaei, B. Hafezi; 7 ♂/♀, Iran, Khorasan, Koppe Dag, 1200 m, Robat 20 km SW Izman Olia, 25./26.v.2008, leg. J.–U. Meineke, W. Kramer; 6 ♂/♀, Iran, Khorasan–e Shomali, Kopet–Dagh, Izman–e Sufla vic., N 37°51'31.9'', E 57°32'27.2'', 1823 m, 2.vi.2013, leg. J.U. Meineke, H. Rajaei, B. Hafezi; 2 ♂/♀, Iran, Khorasan–e Shomali, Allah–o Akbar Mt., 1763 m, 18.vi.2013, N37°19'27.2'', E 58°43'26.1', leg. J.U. Meineke, H. Rajaei, B. Hafezi; 2 ♂/♀, Iran, Khorasan–e Shomali, Kopet–Dagh, Darreh Hersh, 2038 m, 19.vi.2013, N37°40'23.2'', E 58°09'22.6', leg. J.U. Meineke, H. Rajaei, B. Hafezi; 1 ♂/♀, Iran, prov. Khorasan, Kuh–e Sorb, Kadkan S, 2200–2400 m, leg. A. Hofmann, J.U. Meineke; 2 ♂/♀, Iran, Esfahan, Semirom W, Pashmeh Kuh, Hochtal, 2800 m, 31.v.–2.vi.2004, leg. A. Hofmann, J.–U. Meineke, W.G. Tremewan; 1 ♂/♀, Iran, Khorasan–e Razavi, Nishabour to Quochan, Bar vic., 1718 m, 17.vi.2013, N36°30'27.9'', E 58°44'30.8', leg. J.U. Meineke, H. Rajaei, B. Hafezi; **all in PCJM.**

9 ♂/♀, N–Iran, Amarlu östl., Rudbar, 1000 m, 27.ix.1970, leg. G. Ebert, g. preps (♀) 0875, 0876/2020 D. Wanke; 1 ♂/♀, N–Iran, Teheran/Evin, ca. 1400 m, 4. – 10.x.1970, leg. G. Ebert; 1 ♂/♀, N–Iran, Talysch, Asalem, 1300 m, 29.ix.1970, leg. G. Ebert; 10 ♂/♀, N–Iran, Elburs–Mts, Masandaran, Polur, Damavand, 11.vii.1972, 2200 m, leg. Ebert & Falkner; 8 ♂/♀, N–Iran, Elburs Mts., Masandaran, Polur, Damavand, 7.–10.vii.1972, 2500 m, leg. Ebert & Falkner, (♂) g. prep. 1133/2021 D. Wanke; 56 ♂/♀, N–Iran, Masandaran, Golestan–Wald, 60 km E Gonbad Qabus, 8.vii.1972, 510 m, leg. Ebert & Falkner, g. preps (♂) 0903/2020, 1132/2021 (♀) 0904/2020 D. Wanke; 26 ♂/♀, N–Iran, E Alborz, Prov. Mazandaran, E Gorgan, S Aliabad, oberh. Shirinabad, N 36°47'21'', E 55°01'25'', 21.v.2005, 1100 mNN, leg. R. Trusch, G. Petschenka & B. Müller, SMNK E. Lep. 215; 3 ♂/♀, N–Iran, 10 km s. Chalus, 130 m, 26.v.1969, leg. G. Ebert; 3 ♂/♀, N–Iran, Masandaran, Lar–Tal, NW Polur, 2200 – 2500 m, 20.vii.1975, leg. Müller; 1 ♂/♀, Iran, prov. Mazandaran, Elburs Mts., S Shah Kuh–e Bala, 2400 m, N 36°33', E 54°36', 20.vii.2003, leg. G. Ebert & R Trusch (lux); 8 ♂/♀, Persia sept., Elburs mts.c.s., Tacht i Suleiman, Särdab–Tal (Vanderban), 25–2700m, 14.–18.7. [19]37, leg. E. Pfeiffer & W. Forster, München, g. preps (♂) 0787, (♀) 0786/2020 D. Wanke; 2 ♂/♀, Persia [Iran], Särdabtal, 1500 m, 19.–22.vii.[19]37; 2 ♂/♀, Iran, prov. Esfahan, C–Zagros, 2600 m, 2 km NE of Semirom, 03.–04.vi.2005, leg. P. Gyulai & A. Garai, g. prep. (♂) 0781/2020 D. Wanke; 3 ♂/♀, Iran, prov. Hamadan, 5 km SW of Aradj Pass to Razan, 2500 m, 1. – 02.vi.2005, leg. P. Gyulai & A. Garai; 2 ♂/♀, Iran, prov. Tehran, Elburz mts. 3 km NNW Shemshak, N36°02', E051°28', 24.vii.2003, 2860 mNN, lux, leg. G. Ebert & R. Trusch; 1 ♂/♀, Nordiran, Elbursgebirge östl. Shemshak, 50 km nördl. Teheran, 2100 – 2500 m, 8.–24.vi.1973, leg. G. Junge; 3 ♂/♀, NW–Iran, 17 km nw. Maku, 1400 m, 4.vi.1975, leg. H. G. Amsel, g. prep. (♀) 1049/2021 D. Wanke; 1 ♂/♀,

N–Iran, Elburs Geb., Polour, 1600 m, 21.vi.1969, leg. H. G. Amsel; 1 ♂/♀ N–Iran, Elburs–Mts., Prov. Tehran, Arangeh 25 km N Karadj, 1550 m, 1.–6.vi.1972, leg. Ebert & Falkner; 1 ♂/♀, N–Iran, Elburs Mts., Prov. Tehran, 15 km E Gatschsar, 17.viii.1972, 2800 m, leg. Ebert; 2 ♂/♀, N–Iran, 12 km n. Amarlu, 250 m, 28.x.1970, leg. G. Ebert; 1 ♀, Iran, Tehran, Qollhak, 1400 m, 19.vi.1961, leg. J. Klapperich, g. prep. 0784/2020 D. Wanke; 1 ♀, same data, 04.vii.1961, g. prep. 0785/2020 D. Wanke; 1 ♂/♀, Iran, 15.viii.1961, leg. J. Klapperich; 1 ♂/♀, Iran, 10.vii.1961, leg. J. Klapperich; 1 ♂/♀, Iran, 14.vii.1961, leg. J. Klapperich; 3 ♂/♀, Iran, prov. Boyerahmad–va–Kohgiluyeh, SE–Zagros, 3000 m, 05.–06.vi.2005, Kuh–e–Dena, n. Bijan pass, 6 km N of Cisakht, leg. P. Gyulai & A. Garai; 2 ♂/♀, Iran, prov. Azerbayejan, E – Sharqi, 10 km NW of Miyane, 14.–15.vi.2005, leg. P. Gyulai & A. Garai; 1 ♂/♀, Iran, prov. Azerbayejan, E – Garbi, 8 km S of Shoet, 15.–16.vi.2005, 1350 m, leg. P. Gyulai & A. Garai; 49 ♂/♀, Iran NE, Kopet Dagh, prov. Khorasan, ca. 50 km N Bojnurd, S Izmansufla, N 37°44'20", E 57°25'53", 1.240 mNN, 17.v.2005, leg. Trusch, Petschenka, Müller, g. prep. (♂) 0840, 0906/2020 D. Wanke; 1 ♂/♀, same data, 18.v.2005; 17 ♂/♀, same data, 11.v.2005; 30 ♂/♀, same data, 10.v.2005; 24 ♂/♀, NE–Iran, Prov. Ostan–e Khorasan E Torbat de Heidarye S Fariman, Zharf vic. N 35°24'25.1", E 59°56'08.2" 5.v.2008, 2160 m, leg. R. Trusch, M. Falkenberg, B. Müller; 31 ♂/♀, same data, 6.v.2008, g. prep. (♀) 0841/2020 D. Wanke; 17 ♂/♀, NE–Iran, Prov. Ostan–e Khorasan, Kopet Dagh, NW Mashad, N Tschenaran, N Radkan, Dolmeh Olia, N 36°55'56.6", E 59°02'18.6", 8.v.2008, 1560 mNN, lux, leg. R. Trusch, M. Falkenberg & B. Müller, SMNK E–Lep. 247; 19 ♂/♀, same data, 9.v.2008; 1 ♂/♀, N–Iran, Elburs Mts., N Teheran, Dizin Hotel, N 36°02'52.1", E 51°24'58.1", 2700 m, 20.vii.2006, leg. R. Trusch; 1 ♂/♀, Iran–Centr., Prov. Yazd, N Yazd, Chak Chak, N 32°20' 07.8", E 54°22'58.0", 1.550 mNN, 10. – 11.iv.2007, leg. R. Trusch, SMNK E–Lep. 234; 1 ♂, Iran, prov. Zanjan, Takhte Suleyman–Dandi road, 15 km E Takhte Suleyman, N36°36'23", E47°21'02", 2420 m, 29.vi.2009 leg. H. Rajaei, J.U. Meineke A. Hofmann, g. prep. 0828/2020 D. Wanke; 8 ♂/♀, Iran, prov. Zanjan, 2350 m, W–Alborz range Tarom vic. 20 km NE of Zanjan, 13.–14.vi.2005, leg. P. Gyulai & A. Garai E–Lep 221, g. prep. (♂) 0837/2020, 1146/2021 D. Wanke; 3 ♂/♀, NW–Iran, 12 km westl. Rezaiyeh, 1350 m, 3.v.1975, leg. Amsel; 1 ♂, N–Iran, Elburs Mts., Prov. Tehran, 15 km E Gatschsar, 17.viii.1972, 2800 m, leg. Ebert, g. prep. 1145/2021 D. Wanke; 1 ♂/♀, same data, 5.viii.1972, 2600 m; 1 ♂, N–Iran, Elburs–Mts., S–Rand, Tehran–Evin, 24.vii.1972, 1600 m, leg. G. Ebert, g. prep. 1139/2021 D. Wanke; 1 ♂/♀, N–Iran, Shemshak, ca. 70 km n. Teheran, 20.vi.1969, 1700 m, leg. H. G. Amsel; **all in SMNK.**

6 ♂/♀, Iran, Azerbaijan–e Gharbi prov., Khoy to Ghotur road, Esteran vill., Alt. 1637 m, N 38°27' 03.1", E 44°44'33.6", 1.vii.2013, leg. H. Rajaei, J. U. Meineke, B. Hafezi, g. preps (♀) 0727, 0730/2020 D. Wanke; 2 ♂/♀, Iran, Azerbaijan–e Gharbi prov., Urmia to Seru road, after Eshke–Su, Alt. 1915 m, N 37°45' 50.1", E 44°48'46.4", 30.vi.2013, leg. H. Rajaei, J. U. Meineke, B. Hafezi; 1 ♂/♀, Iran, prov. Azarbayjan–e–Shargi, S Sahand Mt., 2431 m, 30.vi.2013, N 37°35'41", E 46°27'18.4", leg. J.U. Meineke, H. Rajaei, B. Hafezi; 2 ♂/♀, Iran, Zanjan prov., E Zanjan, road to Gilvan, Alt. 1889 m, N36°45'21.8", E48°49'20.7", 6.vii.2013, leg. H. Rajaei, J.–U. Meineke, B. Hafezi; 2 ♂/♀, Iran, Ghazwin–Alamut road, after Gardane Alamut, sandy road to Khanjar Bolagh village N 36°24'11"; E50°12'52", 2024 m, 1.–2.vii.2009, H. Rajaei, J.–U. Meineke A. Hofmann; 2 ♂/♀, Iran, Khorasan Shomali, Babaaman, near Bojnurd, 26.vi.2016, leg. Sh. Feizpour; 1 ♂/♀, Iran, Azerbaijan–e Gharbi prov., 15 km W Jolfa, Sint–Stepanus Church, Alt. 951 m, N 38°58' 43.2", E 45°28'24.0", 3.vii.2013, leg. H. Rajaei, J. U. Meineke, B. Hafezi; 4 ♂/♀, Iran, Azerbaijan–e Sharghi prov., S Ghareh Aghaj, after Argsnay–Sufla Alt. 2020 m, N 36°50'16.5", E 46°58'07.5", 4.vii.2013, leg. H. Rajaei, J.U. Meineke, B. Hafezi; 1 ♂, Iran, Lorestan, Dorud, Astaneh door, 1801 m, 33°24'48.1"N, 49°08'42.5"E, 25.vii.2016, leg. Sh. Feizpour, g. prep. 0706/2020 D. Wanke; 1 ♂/♀, Iran, Khorasan Razavi, 65 km Kalat road, Khor, 1431m, 36°38'15.1"N, 59°54'04"E, 16.vi.2016, leg. Sh. Feizpour; 1 ♂/♀, Iran, Prov. Golestan, Shahrud–Golestan road, Shahkuh, 2585 m, 36°38'36"N, 54°31'31"E, 16.vii.2015, leg. Sh. Feizpour; 1 ♂, Iran, Mazandaran prov., Noor, Sisangan Foresty Park, 35 m, N 36°32'09.3", E 052° 04'55.8", 24.vi.2013, leg. H. Rajaei, J.U. Meineke, B. Hafezi, g. prep. 0725/2020 D. Wanke; 8 ♂/♀, Iran, prov. Chaharmahal–va–Bakhtiyari, Dehnau, 2248m, 12.v.2010, Leg. G. Petrányi, P. Hentschel; 2 ♂/♀, Iran, prov. Fars, Ardakan (Sepidan), 2400–2500m, 08–11.v.2010, Leg. G. Petrányi, P. Hentschel; 2 ♂/♀, Iran, prov. Yazd, Sir Kuh, near Sanij, 2634m, 07.v.2010, Leg. G. Petrányi, P. Hentschel; 8 ♂/♀, Iran, prov. Hamedan, Nehavand, 1855m, 13.v.2010, Leg. G. Petrányi, P. Hentschel; 12 ♂/♀, Iran, prov. Golestan, Azad Sahr, 483m, 18.v.2010, Leg. G. Petrányi, P. Hentschel; 24 ♂/♀, Iran, prov. Zanjan, Ab Bar, 1053m, 17.v.2010, Leg. G. Petrányi, P. Hentschel; 9 ♂/♀, Iran, prov. Kordestan, Askaran, 1374m, 14–16.v.2010, Leg. G. Petrányi, P. Hentschel; 5 ♂/♀, NW–Iran, Kaleibar, 1700m, 3.viii.1977, leg. W. Thomas; **all in SMNS.**

1 ♂/♀, Nord–Iran, Schahkuh, West–abhg. Geröllzone, 1800–2000 m, Juni, Exp. Wernicke; 1 ♂/♀, Nordost–Iran, Kuh i Mirabi, Waldzone, 1600–1900m, Juli, Exp. Wernicke; 2 ♂/♀, Persia sept. [Iran], Elburs mts.c.s., Särdab

Tal–Vandarban, 19–2200 m, 1.–3.vii.[19]37, E. Pfeiffer & W. Forster München leg.; **all in ZFMK.**
1 ♂/♀, Iran, Lorestan prov., Z. Zagros, W. Nar Abad, ca. 1900 m, 11.–20.v.2001, leg. G. Müller; 1 ♂/♀, Iran, Golestan, Jahan Nama, 1800 m, 20.–21.x.2003, 36'40.36,6/54'18.34,6, leg. Ch Wieser; 1 ♂, Iran, Esfahan, 57 km S Borujen, 3 km S Dorahan, 31°36'N, 51°12'E, 8.vi.1997, 1950 m, leg. A. Hofmann & P. Kautt, coll N. Pöll; **all in ZSM.**

Scopula luridata distracta
1 ♂, 1 ♀, [Israel], Jaffa, 3.x., g. preps (♂) 1239 (♀) 1240/2021 D. Wanke; **in SMNS.**
1 ♀, W–Saudi Arabia, env. Taif, Al–Hada, 1950 m, 19–26.xi.1992, g. prep. 1292/2022 D. Wanke; 1 ♀, South Yemen, P. D. R. Y, Lahej Governorate, 7km N.W. Al Dhala, Jihafi Mountaine, As Sareer, 2200 m, 12.vi.1987, leg. Bernd Müller, g. prep. 1293/2022 D. Wanke; 1 ♂/♀, South Yemen, P. D. R. Y, Lahej Governorate, Labos, 2100 m, 26.vi.1987, leg. Bernd Müller; 1 ♂/♀, Republik of Yemen, prov. San'a, 15°35N, 43°47'E, mountains WSW Amran, Masaani–Gummama, 30.x.1996, 3000 m, Li[cht], leg. Bischof, Hacker, Schreier; 1 ♂, 1 ♀, Syria sept., Taurus, Marasch, 1928, E. Pfeiffer München, g. preps (♂) 1295 (♀) 1294/2022 D. Wanke; **all in ZSM.**

Scopula immutata
1 ♂, 1 ♀, Hungary, Bükkösd, 15 km WNW Pécs, 8.vi.1992, LF, leg. K.–R. Beck, g. preps (♂) 1246 (♀) 1247/2021 D. Wanke; **in SMNS.**

Scopula flaccidaria
6 ♂/♀, Iran, Gilan, Siakhal via Deilaman, Kaspiswald, 500 m, 16.vii.2006, leg. J.U. Meineke, H. Rajaei; 2 ♂/♀, Iran, Mazandaran, Chalmardi, Kaspiswald, 220 m, 2.vi.2008, leg. J.U. Meineke, H. Rajaei; **all in PCJM.**
1 ♀, Iran, Teheran, 40 km E Parchin, 26.v.2005, 1300 m, leg. M. Fibiger & R. Zahiri, g. prep. 0818/2020 D. Wanke;
1 ♀, N–Iran, Bandar Pahlavi, 28.ix.1970, 20 m, leg. Ebert, g. prep. 1054/2021 D. Wanke;
1 ♂, N–Iran, Masandaran, Schasavar envir., 0 m Zone, 21.v.1973, leg. Ebert, g. prep. 1053/2021 D. Wanke; 2 ♂/♀, same data as before, 27.v.1973; 1 ♂/♀, S–Iran, Bandar Abbas, km 107 der Strasse nach Sirdjan, 850 m, 7.iii.1973, leg. G. Ebert; **all in SMNK.**

Scopula minorata
1 ♂, 1 ♀, Gran Canaria, Las Palmas, x.[19]57, leg. Pinker, g. preps. (♂) 1248, (♀) 1249/2021 D. Wanke; **in SMNS.**
1 ♀, Iran, Golestan, Ala Gol, 17 m, 37'22.465/54'34.581, 16.–17.v.2001, leg. Ch Wieser, g. prep. ZSM G 12911; 1 ♀, Republik of Yemen, prov. San'a, 15°04'N, 43°39'E, 60 km SW San'a, Makaban, Naqil Manakhah (Westside), 2.xi.1996, 1900 m, Li[cht], leg. Bischof, Hacker, Schreier, g. prep. 1304/2022 D. Wanke; 1 ♂/♀, Republik of Yemen, prov. Hadramaut, 15°24'N, 48°21'E, Wadi Daw'an, Khar Sowdan, 10 km S Al Huraydah, 13.xi.1996, 900 m, TF/Li[cht], leg. Bischof, Hacker, Schreier, g. prep. ZSM G 12462; 1 ♀, UAE, 5 km S Huwaylat, 250 m, 11.xi.2007, 24°52'59''N, 56°8'20''E, leg. C. & FK. Gielis, g. prep. 1306/2022 D. Wanke; **all in ZSM.**

Scopula adelpharia
2 ♀, Sudan, Ed Damer, Hudeiba, 5.ii.1962, leg. R. Remane, g. preps 1268, 1269/2022 D. Wanke; 1 ♀, same data but 11.iii.1962, g. prep. 1270/2022 D. Wanke; 1 ♀, same data but 15.iii.1962, g. prep. 1271/2022 D. Wanke; 1 ♂, Iran, prov. Hormozgan. Sirik, 50 m, 11.–20.iii.2001, leg. G. Müller, g. prep. 1309/2022 D. Wanke; 1 ♂, Iran, prov. Baluchestan. Konarak, 50 m, 1.–10.iii.2001, leg. G. Müller; **all in ZSM.**

Scopula albiceraria
1 ♂, Mongolia, Selenge aimag, near Orchon, 774 m, 20–21.viii.2010, leg. B. Benedek & K. Székely, g. prep. 1305/2022 D. Wanke; 1 ♀, SW Mongolia, Gobi–Altai aimak, Mongolian Altai Mts., Khasgt–Khaikhan Mts., 17 km SSW Zhargalan, 46°48'N, 95°49'E, 2500–2900 m, 19.–21.vii.2010, leg. R. Yakovlev, Guskova, g. prep. 1301/2022 D. Wanke; **all in ZSM.**

Scopula immistaria
3 ♂/♀, Iran, Chaharmahal–va–Bakhtiyari, Shar–e Kord vic., Sibak, 2600–2900 m, 19./20.vi.2009, leg. A. Hofmann,

J.–U. Meineke, H. Rajaei; 1 ♂/♀, Iran, Alborz, Theran NW, Azadbar vic., 2900 m, 22.vii.2006, leg. A. Hofmann, J.–U. Meineke; 1 ♂/♀, Iran, Golestan, Sharud W, Kash, Kuh–e Shavar, 2900 m, 19.vii.2003, leg. A. Hofmann, J.–U. Meineke, G. Tremewan; 1 ♂/♀, Iran, Esfahan, Chonsar vic., Kuh–e–Derrebid, 2700 m, 15.vi.2002, leg. J.–U. Meineke, A. Hofmann, A. Kallies *et al.*; 1 ♂/♀, Iran, Esfahan, Fereidun Shar vic., Kuh–e Sibak, 2500 m, 17./18. vi.2002, leg. J.–U. Meineke, A. Hofmann, A. Kallies *et al.*; 1 ♂/♀, Iran, Esfahan, Kuh–e–Derre Bid, 2700–2900 m, 26.vi.2001, leg. A. Hofmann, J.–U. Meineke, W.G. Tremewan; 1 ♂/♀, Iran, Theran, Firuzkuh 20 km E, 2200 m, 05.vi.2008, leg. J.–U. Meineke, W. Kramer; 1 ♂/♀, Iran, Lorestan, Dorud, Kuh–e Osturan, 2400 m, 22.–24.vi.2009, leg. A. Hofmann, J.–U. Meineke, H. Rajaei; 2 ♂/♀, Iran, Zagros, Esfahan Umg., Fereidun Shah, 2200 m, 9.vii.1999, leg. A. Hofmann, J. Meineke; 2 ♂/♀, Iran, Boyer Ahmad–Va–Kohgiluyeh, Gardaneh, Meymand, 2450–2800 m, 14./15.vi.2001, leg. A. Hofmann, J.–U. Meineke, G. Tremewan; 1 ♂/♀, Iran, prov. Hamadan, Hamadan NNE, Razan N, Gardaneh Avaj, 2100–2150 m, 19.vi.1998, leg. A. Hofmann, J.–U. Meineke; 1 ♂/♀, Iran, Zanjan, Zanjan–Gilvan, Gargovol Dag, 2500m, 26./27.6.2001, leg. A. Hofmann, J.–U. Meineke, W.G. Tremewan; 1 ♂/♀, Iran, Zanjan, Zanjan–Gilvan, Gargovol Dag, 2500m, 9.vi.2001, leg. A. Hofmann, J.–U. Meineke, W.G. Tremewan; 1 ♂/♀, Iran, Zanjan, Takht–e Suleiman, Barbar Naza, 2462 m, 5.vii.2013, N36°33'49.0'', E 47°17'57.7', leg. J.U. Meineke, H. Rajaei, B. Hafezi; 1 ♂/♀, Iran, Elburs, Zanjan, Zanjan Umg., Gargovoldag, 2500m, 3./4.vi.2001, leg. A. Hofmann, J.–U. Meineke, W.G. Tremewan; 5 ♂/♀, Iran, Kerman, Jiroft W, Shingera, 2800 m, 26./27.v.2004, leg. A. Hofmann, J.–U. Meineke, G. Tremewan; 2 ♂/♀, Iran, Kerman, Jiroft NW, Gardaneh, Sarbishan, Shingara vic., 2700–2900m, 3./4.vi.2002, leg. J.–U. Meineke, A. Hofmann, A. Kallies *et al.*; **all in PCJM.**

4 ♂/♀, Iran, prov. Mazandaran, Elburs mts., S Shah Kuh–e Bala, 19.vii.2003, lux, 2400 mNN, N 36°33', E 54°36', leg. G. Ebert & R. Trusch; 2 ♂/♀, N–Iran, Masandaran, Lar–Tal, NW Polur, 2200–2500 m, 20.vii.1975, leg. Müller; 6 ♂/♀, W–Iran, Lorestan, Dorud, 4 km SE Saravand, "Nermyeh'', 4.–6.viii.1975, 2400 m, leg. Ebert & Falkner, g. preps (♂) 0829, (♀) 0836/2020 D. Wanke; 4 ♂/♀, W–Iran, Lorestan, Dorud, 28 km E Borudjerd, 27.vii.1975, 2300 m, leg. Ebert & Falkner; 2 ♂/♀, W–Iran, Kordestan, Straße Baneh–Marivan, 86 km SE Baneh, 5.vii.1975, 1950 m, leg. Ebert & Falkner; 3 ♂/♀, W–Iran, Kordestan, Straße Saghez–Baneh, 23 km NE Baneh, 2.vii.1975, 1800 m, leg. Ebert & Falkner;

2 ♂/♀, W–Iran, Kordestan, Straße Saghez–Baneh, 21 km NE Baneh, 1950 m, 30.[vi.]–2.vii.1975, leg. Ebert & Falkner; 3 ♂/♀, N–Iran, Elburs mts., prov. Tehran, 15 km E Gatschsar, 5.viii.1972, 2600 m, leg. Ebert; 4 ♂/♀, same data, 2800m, 7.viii.1972, g. prep. (♀) 0831/2020 D. Wanke; 5 ♂/♀, Iran, prov. Tehran, Elburz mts. 3 km NNW Shemshak, N36°02' E051°28', 24.vii.2003, 2860 mNN, lux, leg. G. Ebert & R. Trusch, E–Lep 213, g. preps (♀) 0832, 0833/2020 D. Wanke; 1 ♀, [Iran], Fars, Kazeroun, Mian–Kotal, 11.vi.1972, 1900 m, leg. Ebert & Pazouki, g. prep. 0835/2020 D. Wanke; 1 ♂/♀, Iran, Boyerahmad–va–Kohgiluyeh, Shahr–e Kord N, Ben W, 24.vi.2005, 2490 – 2550 m, leg. A. Hofmann;

1 ♂/♀, Iran, Boyerahmad–va–Kohgiluyeh, Yasuj E, Abnar Region, Kakari – Baba Hasan, 24.vi.2005, 2550 – 2800 m, leg. A. Hofmann; 1 ♂/♀, Iran, prov. Boyerahmad–va–Kohgiluyeh, SE–Zagros, Kuh–e–Dena, 5 km SW of Sisakht, 04.–05.vi.2005, 2450 m, leg. P. Gyulai & A. Garai; 1 ♂/♀, Iran, prov. Esfahan S Fereydunshahr, Fereydun–shahr–Sibak, 2 km to Sibak, N 32°54'07'', E 50°04'48'', 19.–20.vi.2009, 2622 m, leg. H. Rajaei, J.–U. Meineke A. Hofman SMNK, E–Lep 259; 1 ♂/♀, Nordiran, Elbursgebirge östl. Shemshak, 50km nördl. Teheran, 2100 – 2500 m, 8–24. vi.1973, leg. G. Junge; 1 ♂/♀, Iran, Qazvin, 30 km N Qazvin, Sutehkesh (Paßhöhe), 3.vi.2005, 2200 m, leg. W. ten Hagen; 1 ♂, N–Iran, Elburs–Mts, Masandaran, Polur, Damavand, 2500m, 7.–10.vii.1972, leg. Ebert & Falkner, g. prep. (♂) 0830/2020 D. Wanke; 1 ♂/♀, same data, 29.vii.1972; 1 ♂, N–Iran, Masandaran, Golestan–Wald, 60 km E Gonbad Qabus, 8.vii.1972, 510 m, leg. Ebert & Falkner; 1 ♂/♀, S–Iran, Fars, Kaserun, Mian–Kotal, 1900 m, 11.vi.1972, leg. Ebert & Falkner; 1 ♀, N–Iran, Elburs–Mts., prov. Tehran, Arangeh, 25 km N Karadi, 4.vii.1972, 1550 m, leg. Ebert & Falkner, g. prep. (♀) 0834/2020 D. Wanke; 1 ♂/♀, N–Iran, Elburs–Mts., S–Rand, Tehran–Evin, 24.vii.1972, 1600 m, leg. G. Ebert; 1 ♂/♀, same data, 27.viii.1972; 1 ♂/♀, S–Iran, Khusestan, 15 km SE Yassudj, 2250 m, 13./14.vi.1972, leg. Ebert & Falkner; 1 ♂/♀, N–Iran, Elburs Mts., Prov. Tehran, 15 km E Gatschsar, 17.viii.1972, 2800 m, leg. Ebert;

1 ♂/♀, Pers.[ia] [Iran], Elbursgeb[irge], Kendevanpass, 2800 m, 3.–8.vii.[19]36, [leg.] Schwingenschuss; 1 ♂/♀, same data, 2600 – 3100 m; 1 ♂/♀, Persia s. [Iran], Kendevan, ca. 3000 m, 3.–9.vii., Coll. Wagner, Wien; 1 ♂, Iran, prov. Esfahan, Zagros mts., Feridun Shar, Kamaran, val., 2770 m, N 32°45', E 49°59', 12.vii.2003, lux, leg. G. Ebert & R. Trusch; **all in SMNK.**

4 ♂/♀, Iran, prov. Esfahan S Fereydunshahr, Fereydun–shahr–Sibak, 2 km to Sibak, N32°54'07'', E50°04'48'', 2622 m, 19.–20.vi.2009, leg. H. Rajaei, J.U. Meineke, A. Hofmann; 2 ♂/♀, Iran, prov. Kordestan, Saghez–Baneh

road, 10 km to Baneh Garnadeh–Khan, N 36°04'13", E 45°59'31", 1976 mNN, 26–27.vi.2009, leg. H. Rajaei, J.U. Meineke & A. Hofmann; 1 ♂/♀, Iran, prov. Lorestan, Oshtorankuh, Dorud–Gahar, lake road, before Cheshmeh, Khorram, 2360 mNN, N 33°22'41", E 49°11'13" 22.–24.vi.2009, leg.H. Rajaei, J.U. Meineke & A. Hofmann; 2 ♂/♀, Iran, Azerbaijan–e Gharbi prov., Khoy to Ghotur road, Esteran vill., Alt. 1637 m, N 38°27' 03.1", E 44°44'33.6", 1.vii.2013, leg. H. Rajaei, J. U. Meineke, B. Hafezi; 2 ♂/♀, Iran, Lorestan, Dorud, Gahar road, 2281 m, 33°22'32.1"N, 49°11'34.8"E, 27.vii.2016, leg. Sh. Feizpour; 11 ♂/♀, Iran, prov. Chaharmahal–va–Bakhtiyari, Dehnau, 2248m, 12.v.2010, Leg. G. Petrányi, P. Hentschel; 44 ♂/♀, Iran, prov. Fars, Ardakan (Sepidan), 2400–2500m, 08–11.v.2010, Leg. G. Petrányi, P. Hentschel; 14 ♂/♀, Iran, prov. Zanjan, Ab Bar, 1053m, 17.v.2010, Leg. G. Petrányi, P. Hentschel; 1 ♂/♀, Iran, Elburs, Shemshak, 2700 m, 10.–11.viii.1978, leg. W. Thomas; 1 ♂/♀, Iran, Tabris, Azar Shahr, südl. Tabris, vii.1976, leg. Czipka; 1 ♂/♀, Iran, Elburs, vic. Kendevan, 21.–25.viii.1978, 2300–2800 m, leg. W. Thomas; **all in SMNS.**
1 ♂, Iran, Kerman, 5 km S Deh Bakri, 2300–2400 m, 28°59'N, 57°55'E, 31.v.–1.vi.1997, leg. A. Hofmann & P. Kautt, coll N. Pöll, g. prep. ZSM G 10726; **in ZSM.**

Scopula lactarioides
1 ♀, Iran, (Makran), Chahbar Küste, 21.–24.iii.1954, [leg.] Richter u. Schäuffele, g. prep. 0879/2020 D. Wanke; **in SMNK.**

Scopula diffinaria
1 ♂, 1 ♀, Asia min. c. [Turkey], Akschehir, 16.–30.vi, coll. Wagner, Wien, g. preps (♂) 0574, (♀) 0575/2020 D. Wanke; 1 ♂, Asia min. c. [Turkey], Akschehir, 3.–15.vi, coll. Wagner, Wien; 1 ♂, Asia min. c. [Turkey], Anatolia c., Akschehir Sultan Dagh, 15.–30.viii.[19]34, coll. E. Pfeiffer München; 3 ♀, W–Iran, Kordestan, Straße Zandjan–Bijar, 53 km S Zandjan, 28.–29.vi.1975, 1700 m, leg. Ebert & Falkner, g. preps 0647, 0648/2020 D. Wanke; 1 ♂, 2 ♀, W–Iran, Kordestan, Straße Saghez–Baneh, 21 km NE Baneh, 1950 m, 30–2.vii.1975, leg. Ebert & Falkner, g. preps (♀) 0650, 0653/2020 D. Wanke; 3 ♂/♀, N–Iran, Elburs–Mts. S–Rand, Tehran–Evin, 1600 m, 10.x.1972, leg. Ebert & Falkner; 3 ♂/♀, N–Iran, Elburs–Mts. S–Rand, Tehran–Evin, 1600 m, 30.vi.–5.vii.1972, leg. Ebert & Falkner; 1 ♀, N–Iran, Elburs–Mts. S–Rand, Tehran–Evin, 1600 m, 24.ix.1972, leg. G. Ebert, g. prep. 0686/2020 D. Wanke; 1 ♀, N–Iran, Elburs–Mts. S–Rand, Tehran–Evin, 1600 m, 27.viii.1972, leg. G. Ebert; 1 ♂, 1 ♀, N–Iran, Elburs–Mts, Masandaran, Polur, Damavand, 11.vii.1972, 2200 m, leg. Ebert & Falkner, g. prep. (♀) 0597/2020 D. Wanke; 1 ♂, N–Iran, Elburs–Mts., Prov. Tehran, Arangeh 25 km N Karadj, 1550 m, 1.–6.vi.1972, leg. Ebert & Falkner; 2 ♂, N–Iran, Elburs–Geb., Polour, 1600 m, 21.vi.1969, leg. H. G. Amsel, g. preps 0533, 0688/2020 D. Wanke; 1 ♀, N–Iran, E–Elburz mts., N. Shahrud, 5 km E Tash, Kuh–e Shawar, 2800 mNN, N36°35"06' E054°43'3.9", 25.vii.2006, LF, leg. R. Trusch, g. prep. 1165/2021 D. Wanke; 7 ♂/♀, Iran, Derbend, 25 km N v. Teheran, 2000 m, 7.–15.vi.1963, leg. Kasy & Vartian, g. preps (♂) ZSM HM 3753, (♀) 0583, 0601, 0602/2020 D. Wanke; 2 ♂/♀, Iran, Derbend, 25 km N v. Teheran, 2000 m, 1.–10.vii.1962, E. & A. Vartian, g. prep. (♀) 0576/2020 D. Wanke; 1 ♀, Nordiran, Elbursgebirge östl. Shemshak, 50 km nördl. Teheran, 2100–2500 m, 8.–24.vi.1973, leg. G. Junge, g. prep. 0522/2020 D. Wanke; 1 ♀, N–Iran, Salzsee, 90 km s. Teheran, 800 m, 18/23.vi.1969, leg. H. G. Amsel, g. prep. 0543/2020 D. Wanke; 2 ♀, NW–Iran, 15 km westl. Rezoiyeh, 1400 m, Artemisia–Steppe, 11.vi.1975, leg. H. G. Amsel, g. preps 0523, 0655/2020 D. Wanke; 1 ♂, NW–Iran, 15 km sö. Maku, 1050 m, 3.vi.1975, leg. H. G. Amsel; 1 ♀, NW–Iran, 17 km nw. Maku, 1400 m, 4.vi.1975, leg. H. G. Amsel; 1 ♂, Iran, prov. Tehran, Elburz mts. 3 km NNW Shemshak, N36°02' E051°28', 2860 m, 24.vii.2003, (lux), leg. G. Ebert & R. Trusch, g. prep. 0753/2020 D. Wanke; 1 ♀, E–Iran, NE Birjand, prov. Ostan–e Khorasan, S Haji Abad Gomenj vic., Kuh–e Mirza–e Arab, N 33°16'08", E 60°06'58", 2040 m, 7.iv.2007 leg. R. Trusch, g. prep. 0842/2020 D. Wanke; 1 ♀, Iran, prov. Mazandaran, Elburz mts., S Shah Kuh–e–Pain, 2750 m, N36°33' E054°26', 18.vii.2003, (lux), leg. G. Ebert & R. Trusch, g. prep. 0521/2020 D. Wanke; 1 ♀, Iran, prov. Mazandaran, Elburs Mts., S Shah Kuh–e Bala, 2400 m, N 36°33', E 54°36', 19.vii.2003, leg. G. Ebert & R Trusch (lux), g. prep. 1175/2021 D. Wanke; 1 ♀, N–Iran, Masandaran, Lar–Tal, NW Polur, 2200–2500 m, 20.vii.1975, leg. Müller, g. prep. 0531/2020 D. Wanke; 1 ♀, [Iran], Tehran, Karadj, Arangueh, 1550m, 15.6.1972, leg. Mirz., Abai., Kav.Ghaz, g. prep. 0524/2020 D. Wanke; 1 ♂, W–Iran, Kermanshahan, Surkhe Dizeh, 56 km NW Schahabad, 1320 m, 14.vii.1975, leg. Ebert & Falkner, g. prep. 0660/2020 D. Wanke; 5 ♂/♀, Iran, Fars, Straße, Ardekan–Talochosroe [Ardakan–Talle Khosrow], Comé [Komehr], 2600 m, viii.1937, coll. Brandt, g. preps (♀) 0577, 0578/2020 D. Wanke; 1 ♀, Iran, Fars, Straße Kazeroun–Bouchir Tchouroum, ca. 1000 m, 28.iii.1937, coll. Brandt, g. prep. 0582/2020 D. Wanke; 2 ♂, S–Iran, prov. Fars, Tange

Surkh, 50 km NW Ardekan, 2250 m, 12.–15.vi.1975, leg. Ebert/Falkner, g. prep. 0592/2020 D. Wanke; 1 ♀, S.W. Iran, Fars, Dasht–E–Bam, 4.v.[19]50, 4000 ft., [leg.] E.P. Wiltshire, g. prep. 1150/2021 D. Wanke; **all in SMNK.**
2 ♀, Iran, Kohkiluye va Boyerahmad, Yasuj, Sisakht, Dena, 2799 m, 30°57'23.6''N, 51°23'28.9'', 30.vii.2016, leg. Sh. Feizpour, g. preps 0713, 0734/2020 D. Wanke; 1 ♂/♀, Iran, Ghazwin–Alamut road, after Gardane Alamut, sandy road to Khanjar Bolagh village N 36°24'11''; E50°12'52'', 2024 m, 1.–2.vii.2009, H. Rajaei, J.–U. Meineke A. Hofmann; 2 ♂/♀, Iran, Azerbaijan–e Sharghi prov., S Ghareh Aghaj, after Argsnay–Sufla Alt. 2020 m, N 36°50'16.5'', E 46°58'07.5'', 4.vii.2013, leg. H. Rajaei, J.U. Meineke, B. Hafezi, g. prep. (♂) 0728/2020 D. Wanke; 3 ♂/♀, Iran, prov. Chaharmahal–va–Bakhtiyari, Dehnau, 2248m, 12.v.2010, Leg. G. Petrányi, P. Hentschel, g. prep. (♂) 0747, 0748/2020 D. Wanke; 1 ♂, Iran, prov. Esfahan, near Qamsar, 1781m, 06.v.2010, Leg. G. Petrányi, P. Hentschel, g. prep. 0744/2020 D. Wanke; 1 ♂, Iran, prov. Fars, Ardakan (Sepidan), 2400–2500m, 08–11.v.2010, Leg. G. Petrányi, P. Hentschel, g. prep. 0746/2020 D. Wanke; **in SMNS.**
3 ♂/♀, N–Iran, S. Elburs, Varamin, 700 m, semidesert, 11.–21.vii.1996, leg. Müller; **in ZSM.**

Scopula sacraria ariana
4 ♂/♀, S–Iran, prov. Fars, Tange Surkh, 50 km NW Ardekan, 12.–15.vi.1975, 2250 m NN, leg. Ebert & Falkner; 42 ♂/♀, S–Iran, prov. Khuzestan, Yasudj, Sisakht, 50 km NW, 15.–18.vi.1975, leg. Ebert & Falkner, g. preps (♂) 0598, 0599/2020 D. Wanke; 1 ♂, N–Iran, Elburs–Mts. S–Rand, Tehran–Evin, 25.–28.vi.1972, 1800 m, leg. Ebert & Falkner, g. prep. 0683/2020 D. Wanke; 1 ♀, same data, but 24.ix.1972, 1600 m, leg. Ebert & Falkner, g. prep. 0684/2020 D. Wanke; 1 ♂/♀, same data, but 29.ix.1972, 1600 m; 3 ♂/♀, same data, but 30.vi.–5.vii.1972, 1600 m; 1 ♀, same data, but 30.–31.vi.1972, 1600 m; 1 ♂/♀, N–Iran, 70 km s. Teheran, 29.v.1969, 1300 m, leg. Ebert; 3 ♂/♀, Iran, Derbend, 25 km N v. Teheran, 1.–10.vi.1962, 2000 m, E. & A. Vartian, g. prep. (♂) 0608/2020 D. Wanke; 1 ♀, Iran, prov. Hamadan, 8 km S of Arak, 02. – 03.vi.2005, leg. P. Gyulai & A. Garai, g. prep. 0807/2020 D. Wanke; 57 ♂/♀, Iran, prov. Boyerahmad–va–Kohgiluyeh, SE–Zagros, 35 km SE of Yasuj, 06.–07.vi.2005, 2600 m, leg. P. Gyulai & A. Garai, g. preps (♂) 0506, 0509, 0555, 0556, 0557, (♀) 0507, 0508, 0754, 0755/2020 D. Wanke; 24 ♂/♀, W–Iran, Lorestan, Dorud, 5 km SE Saravand, "Kohyeh", 29–30.vii.1975, 2300 m, leg. Ebert & Falkner, g. preps (♂) 0561, 0693/2020 D. Wanke; 8 ♂/♀, W–Iran, Lorestan, 28 km E Borudjerd, 2300 m, 27.7. 1975, leg. Ebert & Falkner, g. preps (♀) 0691, 0692/2020 D. Wanke; 3 ♂/♀, W–Iran, Lorestan, Dorud, 4 km SE Saravand, "Nermyeh", 4.–6.viii.1975, 2400 m, leg. Ebert & Falkner; 5 ♂/♀, W–Iran, Lorestan, 14 km E Dorud, 6.viii.1975, 1990 m, leg. Ebert & Falkner; 4 ♂/♀, W–Iran, Kordestan, Straße Baneh–Marivan, 86 km SE Baneh, 5.vii.1975, 1950 m, leg. Ebert & Falkner, g. preps (♂) 0643, (♀) 0644/2020 D. Wanke; 6 ♂/♀, W–Iran, Kordestan, Straße Baneh–Marivan, 25 km E Baneh, 4.vii.1975, 1950 m, leg. Ebert & Falkner, g. prep. (♀) 0649/2020 D. Wanke; 7 ♂/♀, W–Iran, Kordestan, Straße Saghez–Baneh, 21 km NE Baneh, 1950 m, 30–2.vii.1975, leg. Ebert & Falkner; g. preps (♂) 0651, (♀) 0652/2020 D. Wanke; 2 ♂/♀, W–Iran, 51 km westl. Kermanshah, 1500 m, Quercetum, 17.vi.1975, leg. H. G. Amsel; 3 ♂/♀, W–Iran, Kermanshahan, Ghalladje Pass, 40 km S Schahabad, 1880 m, 13.vii.1975, leg. Ebert & Falkner, g. prep. (♀) 0659/2020 D. Wanke; 5 ♂/♀, NW–Iran, 100 km Straße Mahabad–Sardascht, 1300 m, Quercetum, 13.vi.[19]75, leg. H. G. Amsel, g. prep. (♂) 0659/2020 D. Wanke; 2 ♂/♀, W–Iran, Kordestan, 95 km N Kermanschah, Straße nach Sanandaj, 11.vii.1975, 1350 m, leg. Ebert & Falkner, g. prep. (♂) 0645/2020 D. Wanke; 3 ♂/♀, W–Iran, Kordestan, Ariz, 27 km W Sanandaj, 10.vii.1975, 2200 m, leg. Ebert & Falkner, g. prep. (♂) 0646/2020 D. Wanke; 2 ♂/♀, W–Iran, 15 km nördl. Kermanshah, 1350 m, 16.vi.1975, leg. H. G. Amsel, g. prep. (♂) 0657/2020 D. Wanke; 2 ♂/♀, W–Iran, 60 km nördl. Kermanshah, 1400 m, 18.vi.1975, leg. H. G. Amsel, g. prep. (♀) 0656/2020 D. Wanke; 5 ♂/♀, W–Iran, W–Azarbaijan, 2 km W Sardasht, 1650 m, 3.vii.1975, leg. Ebert & Falkner, g. prep. (♂) 0656/2020 D. Wanke; 17 ♂/♀, S–Iran, Straße Shiraz–Kazerun, Imam Sade, 1200 m, 3.vi.1969, leg. G. Ebert, g. preps (♀) 0689, 0690/2020 D. Wanke; 101 ♂/♀, S–Iran, Miyan Kotal, 4.–7.vi.1969, 1900 m, östl. Kazerun, 51°40' öL., 29°30' nB., leg. G. Ebert, g. prep. (♀) 0600/2020 D. Wanke; 32 ♂/♀, S–Iran, Fars, Kaserun, Mian–Kotal, 1900 m, 11.vi.1972, leg. Ebert & Falkner, g. preps (♂) 0633, 0634 (♀) 0632, 0635, 0636/2020 D. Wanke; 6 ♂/♀, Iran, prov. Fars, S–Zagros, 40 km SW of Sivand, 09.–10.06. 2005, leg. P. Gyulai & A. Garai, g. prep. (♂) 0537/2020 D. Wanke; 3 ♂/♀, Iran, Fars, Shiraz ESE, Darab N (Pass), 1850 – 2100 m, 19.v.2005, leg. T. & A. Hofmann, g. preps (♂) 0541, (♀) 0750/2020 D. Wanke; 1 ♂, Iran, prov. Fars, Shiraz–Kazerun road, 5 km before Dashte Arjan, N 29°40'34'', E 052°02'18'', 2158 m, 23.v.2009, leg. Hossein Rajaei, g. prep. (♂) 0550/2020 D. Wanke; 1 ♂/♀, Iran, Fars, Umgebung von Chiraz, 10.iv.1937, ca. 1600 m, coll. Brandt; 2 ♀, Iran, Fars, Straße Chiraz–Kazeroun, Fort Sine–Sefid, ca. 2200 m, 4.ix.1937, coll. Brandt, g. preps 0581, 0590/2020 D. Wanke; 1 ♂, [Iran], Fars, Kazeroun, Mian–Kotal, 1900 m, 11.vi.1972, Mi.Li, leg. Ebert & Pazouki, g. prep. 0681/2020 D. Wanke;

1 ♂, S–Iran, Khusestan, Yassudj, Sisakht, 2250 m, 13./14.vi.1972, leg. Ebert & Falkner, g. prep. 0680/2020 D. Wanke; 6 ♂/♀, Iran, prov. Chahar Mahal, Zagros mts. NW Samsami, 2800 mNN, N 32°09', E050°11', 13.vii.2003 (lux), leg. G. Ebert & R. Trusch, g. prep. (♀) 0756/2020 D. Wanke; 1 ♂/♀, NE–Iran, prov. Ostan–e Khorasan, Kopet Dagh, NW Mashad, N Tschenaran, N Radkan, Dolmeh Olia, N 36°55'56.6", E 59°02'18.6", 8.v.2008, 1.560 mNN, lux, leg. R. Trusch M. Falkenberg & B. Müller; 10 ♂/♀, same data, but 9.v.2008, g. preps (♂) 0512, (♀) 0749/2020 D. Wanke; 24 ♂/♀, same data, but 10.v.2008, g. preps (♂) 0511, 0513, 0514, 0515/2020 D. Wanke; 9 ♂/♀, same data, but 11.v.2008, g. prep. (♂) 0517/2020 D. Wanke; 4 ♂/♀, Iran NE, Kopet Dagh, prov. Khorasan, ca. 50 km N Bojnurd, S Izmansufla, N 37°44'20", E 57°25'53", 1.240 mNN, 17.v.2005, leg. Trusch, Petschenka, Müller, g. preps (♂) 0529, (♀) 0530/2020 D. Wanke; 1 ♂/♀, Iran, prov. Tehran, Elburz mts. 3 km NNW Shemshak, N36°02', E051°28', 2860 mNN, 24.vii.2003 (lux), leg. G. Ebert & R. Trusch; 1 ♀, Iran, prov. Hamadan, 8 km S of Arak, 02–03.vi.2005, leg. P. Gyulai & A. Garai, g. prep. 0540/2020 D. Wanke; 2 ♂, Iran, prov. Hamadan, 8 km S of Arak, 02–03.vi.2005, leg. P. Gyulai & A. Garai, g. prep. 0544, 752/2020 D. Wanke; 1 ♀, Iran N, prov. Semnan, 30 km NW Damghan, Cheschme Ali, N 36°15'07", E 54°04'20", 1560 mNN, 23.v.05, leg. Trusch, Petschenka, Müller, g. prep. 0532/2020 D. Wanke; 1 ♂, Iran, prov. Lorestan, Oshtorankuh, Dorud–Gahar, lake road, before Cheshmeh Khorram, 2360 mNN, N33° 22'41", E49°11'13", 22.–24.vi. 2009, leg. H. Rajaei, J.U. Meineke & A. Hofmann, g. prep. 0551/2020 D. Wanke; 1 ♂, Iran, prov. Kohkiluyeh–va–Boyer–ahmad, 30 km S Yassuj, road Abshare–Tange–Tamoradi, 8km before Abshar [=waterfall], N30°31'53"; E51°25'11", 2254 mNN, 24.v.2009, leg. Hossein Rajaei, g. prep. 0552/2020 D. Wanke; 2 ♂/♀, S–Iran, 160 km n. Shiraz, 1900 m, s. Didegan, 8.vi.1969, leg. G. Ebert, g. prep. (♂) 0658/2020 D. Wanke; 1 ♂, [Iran], Fadiheh–T–H, 20.7.1971, leg. Paz., Ayat., g. prep. 0562/2020 D. Wanke; 1 ♀, N–Iran, Elburs–Mts., prov. Tehran, Arangeh 25 km N Karadj, 1550 m, 1.–6.vi.1972, leg. Ebert & Falkner, g. prep. 0687/2020 D. Wanke; 2 ♂/♀, NW–Iran, 17 km nw. Maku, 1400 m, 4.vi.1975, leg. H. G. Amsel, g. prep. (♀) 0661/2020 D. Wanke; 1 ♀, NW–Iran, 15 km sö. Maku, 1050 m, 3.vi.1975, leg. H. G. Amsel, g. prep. 1143/2021 D. Wanke; 2 ♂/♀, Iran–Centr., Prov. Yazd, N Yazd, Chak Chak, N 32°20' 07.8", E 54°22'58.0", 1.550 mNN, 10. – 11.iv.2007, leg. R. Trusch, SMNK E–Lep. 234, g. prep. (♀) 0545/2020 D. Wanke; 1 ♀, N–Iran, Elburs Mts., Prov. Tehran, 15 km E Gatschsar, 17.viii.1972, 2800 m, leg. Ebert, g. prep. 1164/2021 D. Wanke; 1 ♂/♀, [Iran], Karkas, 9.vi.1970, [leg.] Mirz. & Abai; 1 ♂, [Iran], Darrehgaz, 3.vii.1971, [leg.] Paz. & Abai, g. prep. 1147/2021 D. Wanke; **all in SMNK.**

3 ♂/♀, Iran, prov. Kohkiluyeh–va–Boyer–ahmad, 30 km S Yassuj, road Abshare–Tange–Tamoradi, 8km before Abshar [=waterfall], N30°31'53"; E51°25'11", 2254 mNN, 24.v.2009, leg. Hossein Rajaei, g. preps (♂) 0714, 0715/2020 D. Wanke; 4 ♂/♀, Iran, prov. Lorestan, Oshtorankuh, Dorud–Gahar, lake road, before Cheshmeh Khorram, 2360 mNN, N 33°22'41", E 49°11'13" 22.–24.vi.2009, leg.H. Rajaei, J.U. Meineke & A. Hofmann, g. prep. (♂)0724/2020 D. Wanke; 1 ♂/♀, Iran, Shahrud, Shahkouh, Tash, Ayoub Hosseini region, 2588m, 36°37'18"N, 54°33' 42.6"E, 11.07.2016, leg. Sh. Feizpour; 1 ♂, Iran, prov. Chaharmahal–va–Bakhtiyari, Dehnau, 2248m, 12.v.2010, Leg. G. Petrányi, P. Hentschel, g. prep. 0747/2020 D. Wanke; 1 ♂, Iran, prov. Esfahan, near Qamsar, 1781m, 06.v.2010, Leg. G. Petrányi, P. Hentschel, g. prep. 0745/2020 D. Wanke; 4 ♂/♀, Iran, prov. Hamedan, Nehavand, 1855m, 13.v.2010, Leg. G. Petrányi, P. Hentschel, g. prep. (♂) 0743/2020 D. Wanke; 8 ♂/♀, Iran, prov. Zanjan, Ab Bar, 1053m, 17.v.2010, Leg. G. Petrányi, P. Hentschel, g. preps (♂) 0739, (♀) 0738, 0740/2020 D. Wanke; **all in SMNS.**

2 ♂/♀, N–Iran, S. Elburs, Varamin, 700 m, semidesert, 11.–21.vii.1996, leg. Müller; **in ZSM.**

Scopula chalcographata

70 ♂/♀, Iran, Balutschestan, Khasch, 11 km NE Karvandar, 1300 m, 13.v.1972, leg. Ebert & Falkner, g. preps (♂) 0618, 0620, 0631, (♀) 0619, 0625, 0628, 0629, 0630/2020 D. Wanke; 1 ♂, 1 ♀, Iran, Baloutchistan, Straße Tchahbahar–Iranchar, Tahte–Malek, 750 m, Anfang April 1938, coll. Brandt; g. preps (♂) 0589, (♀) 0588/2020 D. Wanke; 3 ♂/♀, Iran, Balutschestan, Khasch, Guscheh, Kuhe Taftan, W–exp., 2000 m, 21.v.1972, leg. Ebert & Falkner, g. prep. (♀) 0677/2020 D. Wanke; 1 ♀, Iran, Balutschestan, Khasch, 3 km SE Eskal–Abad, 1700 m, 12.v.1972, leg. Ebert & Falkner, g. prep. 0676/2020 D. Wanke; 1 ♂, S–Iran, 100 km s. Abadeh, n. Didegan, 2000 m, 9.vi.1969, leg. G. Ebert, g. prep. 0678/2020 D. Wanke; 1 ♂, S–Iran, Issin, 240 m, Periplocaaphylla Steppe, 5.iv.1973, leg. H. G. Amsel, g. prep. 0679/2020 D. Wanke; 9 ♂/♀, Iran, Balutschestan, Nikschar, Tange–Sarheh, 1100m, 16.5.1972, leg. Ebert & Falkner, g. prep. (♀) 0566/2020 D. Wanke; 2 ♂/♀, Iran, Balutschestan, Khasch, 18 km NE Karvandar, 1400 m, 14.v.1972, leg. Ebert & Falkner; 6 ♂/♀, Iran, Balutschestan, Khasch, Kuhe Taftan, E–exp., 1800 m, 20.v.1972, leg. Ebert & Falkner, g. prep. (♂) 0573/2020 D. Wanke; 2 ♂/♀, S–Iran, Straße Shiraz–Kazerun, Imam Sade, 1200

m, 3.vi.1969, leg. G. Ebert; 9 ♂/♀, S–Iran, Bandar–Abbas, km 107 d. Strasse nach Sirdjan, 850 m, 7.iii.1973, leg. G. Ebert, g. preps (♂) 0667, 0668, (♀) 0593/2020 D. Wanke; 20 ♂/♀, S–Iran, Bandar–Abbas, Kuhe Genou, S–exp. 550 m, 1.u.5.iii.1973, leg. G. Ebert, g. prep. (♀) 0528/2020 D. Wanke; 1 ♂, S–Iran, Bandar–Abbas, 35 km N Minab, 60 m, 4.3.1973, leg. G. Ebert, g. prep. 0641/2020 D. Wanke; 1 ♂/♀, S–Iran, Fars, Kaserun, Mian–Kotal, 1900 m, 11.vi.1972, leg. Ebert & Falkner; 1 ♂/♀, S–Iran, Miyan Kotal, 4.–7.vi.1969, 1900 m, östl. Kazerun, 51°40' öL., 29°30' nB., leg. G. Ebert; 2 ♂/♀, S–Iran, Miyan Kotal, 4.–7.vi.1969, 1900 m, östl. Kazerun, 51°40' öL., 29°30' nB., leg. Vartian; 1 ♂/♀, S–Iran, Fars, Daschte Ardjan, Kotal–Pireshan, 2000 m, 18.vi.1982, leg. Ebert & Falkner; 1 ♀, S–Iran, 1600m, 2.6.1969, Persepolis, leg. G. Ebert, g. prep. 0536/2020 D. Wanke; 3 ♂, 1♀, Persia [Iran], [Fars], Shiraz, Rockysteppe, 14.v.1950, [leg.] E.P. Wiltshire, g. preps. (♂) 1148, 1149, 1154 (♀) 1152/2021 D. Wanke; 1 ♂, [Iran], Deh Bakri, S.W. Bam, Paßhöhe, Nachtfang, g. prep. 1153/2021 D. Wanke; **all in SMNK.**

1 ♂/♀, Iran, Khorasan Razavi, 65 km Kalat road, Khor, 1431m, 36°38'15.1''N, 59°54'04''E, 16.vi.2016, leg. Sh. Feizpour; 3 ♂/♀, Iran, Hormozgan, Bandar Abbas, Genu, 2128 m, 27°25'02''N, 56°10'160'', 01.v.2016, leg. Sh. Feizpour, g. preps (♂) 0707, 0709/2020 D. Wanke; 1 ♂, Iran, Kerman, Bam–Jiroft road, Kuhe Dehbakri, 2152m, 28°48'01''N, 57°56'05''E, 27.vi.2016, leg. Sh. Feizpour, g. prep. 0718/2020 D. Wanke; 1 ♂, Iran, Kerman, Sarbishan, Shingara, 2789m, 3°17'26''N 55°27'17''E, 28.vi.2016, leg. Sh. Feizpour, g. prep. 0719/2020 D. Wanke; 1 ♀, Iran, Sistan and Balouchistan, Zabol, Research field, 564 m, 31°05'07''N, 61°25'51''E, 24.05.2016, leg. Sh. Feizpour, g. prep. 0716/2020 D. Wanke; **all in SMNS.**

1 ♂/♀, S. Iran, Hormozgan, Beshagerd Mts. Angollran vill., 26°34'N, 57°54'E, 25.iii.–5.vi.2000, leg. Victor Siniaev; 1 ♀, Iran, Kerman, 5 km S Deh Bakri, 2300–2400 m, 28°59'N, 57°55'E, 31.v.–1.vi.1997, leg. A. Hofmann & P. Kautt, coll N. Pöll, g. prep. ZSM G 10725; **all in ZSM.**

Scopula gracilis

16 ♂/♀, Iran, Balutschestan, Nikschar, Tange–Saheh, 1100 m, 16.v.1972, leg. Ebert & Falkner, g. preps (♂) 0568, (♀) 0567, 0569/2020 D. Wanke; 2 ♂, 2♀, Iran, Balutschestan, Khasch, 11 km NE Karvandar, 1300 m, 13.v.1972, leg. Ebert & Falkner, g. preps (♂) 0622, 0624, (♀) 0621, 0623/2020 D. Wanke; 1 ♂/♀, Iran, Balutschestan, Khasch, 18 km NE Karvandar, 1400 m, 14.v.1972, leg. Ebert & Falkner; 1 ♂, Iran, Baloutchistan, Bender Tchahbahar, 24.ii.1938, coll. Brandt, g. prep. (♂) 0580/2020 D. Wanke; 1 ♂/♀, Iran, Baloutchistan, Bender Tchahbahar, 6.i.1938, g. prep. 62, 5.xi.1961 Dr. Issekutz; 1 ♀, Iran, Baloutchistan, Bender Tchahbahar, 3.i.1938, g. prep. 0579/2020 D. Wanke; 5 ♂/♀, Iran, Balutschestan, Bandar Tschabahar Tis, 10 m, 17.v.1972, leg. Ebert & Falkner, g. preps (♂) 0674, (♀) 0675/2020 D. Wanke; 1 ♂, Iran, Belutschistan, Jranshar, 11.–21.v.1954, 800 m, leg. Richter u. Schäuffele, g. prep. 0542/2020 D. Wanke; 30 ♂/♀, S–Iran, Bandar–Abbas, 35 km N Minab, 60 m, 4.iii.1973, leg. G. Ebert, g. preps (♂) 0571, 0638, (♀) 0570, 0637, 0639, 0640, 0642/2020 D. Wanke; 16 ♂/♀, S–Iran, Bandar–Abbas, Kuhe Genou, S–exp., 1.u.5.iii.1973, 550 m, leg. G. Ebert; 6 ♂/♀, S–Iran, Bandar–Abbas–Minab, 200 m, *Acacia arabica*–Steppe, 3.iv.1973, leg. H. G. Amsel, g. preps (♂) 0666, (♀) 0672/2020 D. Wanke, No. 3794 ZSM Hausmann; 6 ♂/♀, S–Iran, Bandar–Abbas, 10 km N Minab, 30 m, 3.iii.1973, leg. G. Ebert, g. preps (♀) 0595, 0596, 0694/2020 D. Wanke; 6 ♂/♀, S–Iran, Bandar Abbas, km 107 der Strasse nach Sirdjan, 850 m, 7.iii.1973, leg. G. Ebert, g. preps (♂) 0594, (♀) 0572/2020 D. Wanke; 4 ♂/♀, S–Iran, Bandar–Abbas–Sirjan, km 40, 300 m, 30.iii.1973, leg. H. G. Amsel, g. prep. (♀) 0671/2020 D. Wanke; 1 ♂, S–Iran, Bandar–Abbas–Sirjan, km 70, 500 m, 2.iv.1973, leg. H. G. Amsel, g. prep. 0669/2020 D. Wanke; 2 ♂/♀, S–Iran, Bandar–Abbas–Sirjan, km 24, 250 m, 2.iv.1973, leg. H. G. Amsel; 2 ♂/♀, S–Iran, [Bushehr], Dalaki–Brücke, 300 m, 21.iii.1973, leg. H. G. Amsel, g. prep. (♀) 0673/2020 D. Wanke; 1 ♂, S–Iran, Persepolis, 2.vi.1969, 1600 m, leg. G. Ebert, g. prep. 0751/2020 D. Wanke; **all in SMNK.**

1 ♂, 1 ♀, S. Iran, Hormozgan prov., Sirik, 50 m, 11.–20.iii.2001, leg. G. Müller, g. preps. (♂) 1308, (♀) 1307/2022 D. Wanke; 1 ♂/♀, S. Iran, Hormozgan, Beshagerd Mts., 600 m, Davari, 26°34'N, 57°54'E, 6.–11.vi.2000, leg. Siniaev & Plutenko, ex coll. A Schintlmeister; **all in ZSM.**

Scopula alfierii

2 ♂/♀, Republik of Yemen, 14°46'N, 49°18'E, 25 km NNE Al Mukalla, Al Ain 20 km NNW Ar Rayyan, 14.xi.1996, 150 m, TF/Li, leg. Bischof, Hacker, Schreier, g. prep. (♂) 1296/2022 D. Wanke; 2 ♀, Republik of Yemen, Gulf of Aden, 14°01'N, 48°18'E, 45 km WSW Al Mukalla, coastal dunes 2 km w Bir Ali, 15.xi.1996, 10 m, Li[cht], leg. Bischof, Hacker, Schreier, g. preps 1297, 1298/2022 D. Wanke; **all in ZSM.**

Original research paper 3

Taxonomy and systematics of the enigmatic emerald moth *Xenochlorodes graminaria* (Kollar, 1850) (Lepidoptera: Geometridae), and its assignment to a new genus

Dominic Wanke, Shamsi Feizpour, Axel Hausmann, Jaan Viidalepp, Hossein Rajaei

Published (2022) in Integrative Systematics 5 (1): 61–71
https://doi.org/10.18476/2022.857803

Painting of *Sabzia graminaria* by Ava Wanke (10 months old), outline drawing by Maria Werner.

RESEARCH ARTICLE

Taxonomy and systematics of the enigmatic emerald moth *Xenochlorodes graminaria* (Kollar, 1850) (Lepidoptera: Geometridae), and its assignment to a new genus

Dominic Wanke[1,2], Shamsi Feizpour[3], Axel Hausmann[4], Jaan Viidalepp[5] & Hossein Rajaei[1]

Abstract

A new genus, *Sabzia* Wanke & Rajaei, **gen. n.**, is described based on the Iranian species *Phorodesma graminaria* Kollar, 1850, which in recent taxonomy was combined with the genus *Xenochlorodes* Warren, 1897. Moreover, *Xenochlorodes albicostaria* Brandt, 1938, **syn. n.** is synonymized with *Sabzia graminaria* (Kollar, 1850), **comb. n.** The new genus is established based on external and internal characters of the adult specimens. Morphological traits including wing pattern, wing venation and male and female genitalia are described and illustrated.

Keywords: Iran, Middle East, new combination, new synonymy.

Zusammenfassung

Eine neue Gattung, *Sabzia* Wanke & Rajaei, **gen. n.**, wird anhand der iranischen Art *Phorodesma graminaria* Kollar, 1850 beschrieben. In vergangenen taxonomischen Untersuchungen wurde letztere in die Gattung *Xenochlorodes* Warren, 1897 gestellt. Außerdem wird *Xenochlorodes albicostaria* Brandt, 1938, **syn. n.** mit *Sabzia graminaria* (Kollar, 1850), **comb. n.** synonymisiert. Die neue Gattung wird, basierend auf äußeren und inneren Merkmalen adulter Exemplare, beschrieben. Morphologische Merkmale wie Flügelmuster, Flügeläderung, männliche und weibliche Genitalien werden beschrieben und illustriert.

Introduction

According to recent taxonomy, the genus *Xenochlorodes* Warren, 1897 consisted of nine species including *X. graminaria* (Kollar, 1850) and *X. albicostaria* Brandt, 1938, both described from, and endemic to, southern Iran (Scoble 1999; Scoble & Hausmann 2007). Viidalepp (1988) described the genus *Hissarica*, which was subsequently regarded as a subgenus of *Xenochlorodes* by Hausmann (1996). New results have demonstrated that *Hissarica* shows differences in wing shape, wing venation and genitalia characters, and it was therefore reinstated as a valid genus (Viidalepp & Kostjuk 2021).

In the framework of a revision of the subfamily Geometrinae in Iran (Feizpour et al., unpublished), we were faced with the unclear case of *X. graminaria* and *X. albicostaria*. Examination of specimens and of the relevant literature showed that *X. graminaria* and *X. albicostaria* most likely represent the same species. Moreover, this species differs greatly from other *Xenochlorodes* species in morphological characters (wing pattern and venation, male and female genitalia structures), as already suggested by Hausmann (1996), who questioned the generic assignment of *X. albicostaria*. In this study, we propose the synonymy of *X. albicostaria* with *X. graminaria* and assign *graminaria* to a new genus.

Material and methods

Type material and additional specimens examined in this study are deposited in the following collections: NHRS—Naturhistoriska Riksmuseet, Stockholm, Sweden; PCJM—Private collection of Jörg-Uwe Meineke, Kippenheim, Germany; SMNK—Staatliches Museum für Naturkunde Karlsruhe, Karlsruhe, Germany; SMNS—Staatliches Museum für Naturkunde Stuttgart, Stuttgart, Germany; ZSM—Zoologische Staatssammlung München, Munich, Germany (SNSB).

Morphological examination

Type material and the original descriptions served for the identification and comparison of specimens. Documentation of external characters was carried out using a Visionary Digital photography system (LK Imaging System, Dun. Inc.) equipped with a Canon EOS 5DSR camera, as well as an Olympus E3 digital camera. Genitalia preparations were carried out following standard techniques (e.g., Robinson 1976) and vesicae were everted following the method described by Sihvonen (2001). Before embedding, genitalia characters were photographed in their natural position using a Keyence VHX-5000 digital microscope, following the methods proposed by Wanke & Rajaei (2018) and Wanke et al. (2019, 2021). Genitalia were then embedded in Euparal on permanent slides and photographed with the same Keyence digital microscope.

DNA barcoding and analysis

Analysis of mitochondrial DNA was carried out by submitting one dry leg of each specimen to the Canadian Centre for DNA Barcoding, Guelph, Canada. Extraction and amplification of DNA and sequencing of the barcode fragment (658 base-pairs at the 5' terminus) of the mitochondrial gene *Cytochrome-C Oxidase I* were performed using standard protocols (e.g., Ivanova et al. 2006). MEGA X (Kumar et al. 2018; Stecher et al. 2020) was used for the maximum likelihood analysis (with 1000 bootstrap replications) and calculation of genetic distances based on the K2P model (Kimura 1980). A list of all specimens used for the analysis is presented in Appendix 1 along with their sampling sites and Process ID numbers. Sequences, photographs and label data are accessible on BOLD, as dataset DS-SABZIA (doi: https://dx.doi.org/10.5883/DS-SABZIA).

Systematic part

Sabzia Wanke & Rajaei, **gen. n.**
(Figs. 1–5, 10, 11A, 12, 15)

Type species
Phorodesma graminaria Kollar, 1850: 51, 53.

Description

Wingspan: 24–32 mm in males, 22–27 mm in females. Antennae dorsally scaled, bipectinate in both male and female, branches shorter in females (longest branch about 1 mm in males, 0.25 mm in females). Frons flat, scaled, reddish-brown. Chaetosemata developed as two separate patches behind the eyes. Length of labial palpi in lateral view approximately equal to diameter of eye. Proboscis absent. Epiphysis almost equal to length of foretibia. Midtibia with one pair of spurs almost equal in size. Hindtibia with one pair of spurs, the inner spur slightly shorter than the outer spur. Thorax grass-green.

Wings grass-green, without transverse lines or discal spots. Forewing more densely scaled and slightly darker in colour than hindwing, costa beige. Like in many Geometrinae, the wing colour may vary due to killing and preservation methods and aging. Here, the colour varies from beige to yellow (Figs. 1–5). Fringes slightly lighter than wings. Wings rather long and narrow. Venation of forewing with discocellular vein strongly angled. Vein R1 basally fused with vein Sc, the latter distally not reaching costa. Areole absent. Vein R2 fused with vein R3, veins R2–M1 on a common stalk and veins M3 and CuA1 stalked. Hindwing veins Rs–M1 and M3–CuA1 stalked (Fig. 11A). Frenulum absent in both sexes.

In the male genitalia (Fig. 12), the uncus and gnathos are strongly sclerotized and pincer-shaped, both apically pointed. Uncus in lateral view curved and thick. Gnathos ventrally covered with tiny, sclerotized spines; hook-shaped in lateral view, with a serrated inner edge (Fig. 12c). Socii present, membranous and broad. Valva elongated but not exceeding tip of uncus, basal part strongly sclerotized towards centre, apical part membranous. Valva slightly concave ventrally and with a heavily sclerotized central ridge (harpe). Tip of harpe broad, apical part dentate and curved towards centre of valva. Saccus rounded (Fig. 12a). Aedeagus sclerotized and short, thin at base, broadening towards apex (Fig. 12b). Vesica without cornuti. Second tergite without interior processes (apodemes). Posterior margin of sternum A8 concave (Fig. 12d).

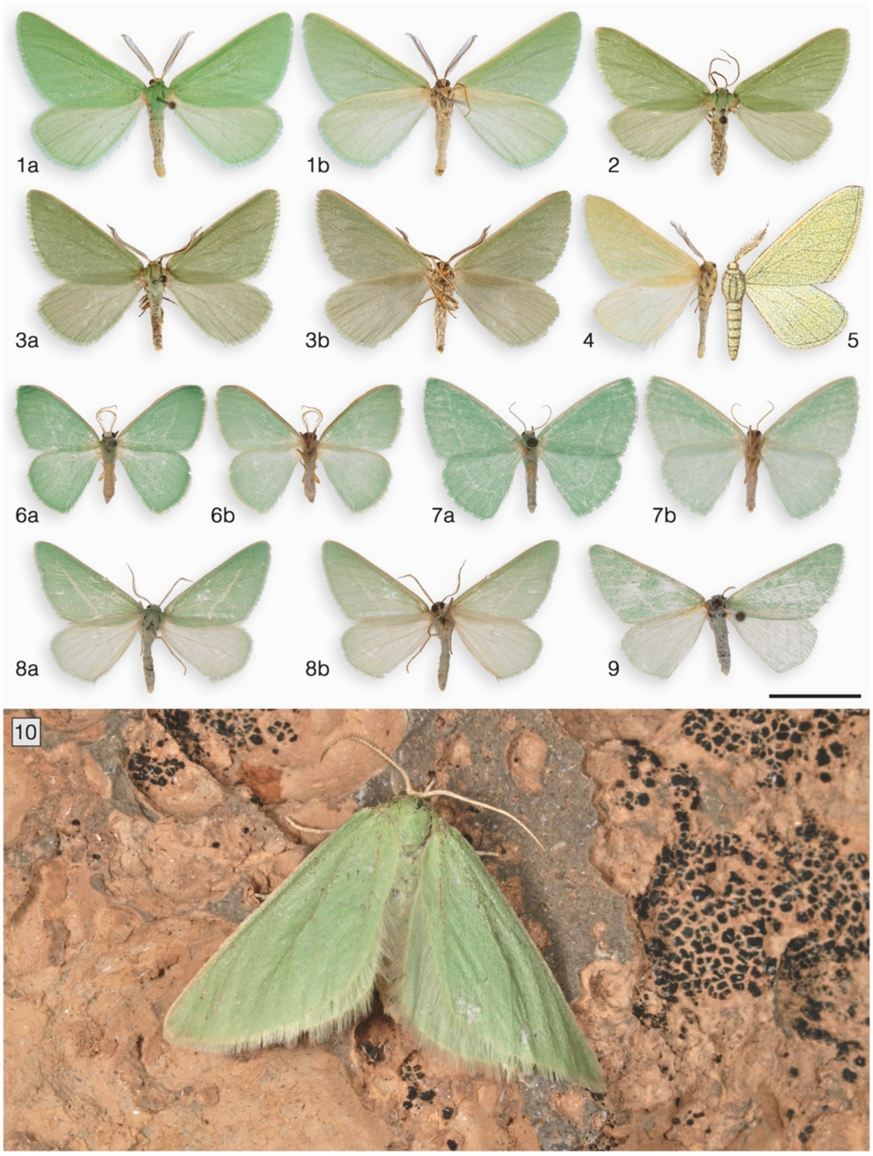
Female genitalia with broad papillae anales, length of apophyses anteriores approximately 1/2 length of apophyses posteriores. Lamella antevaginalis sclerotized. Ductus bursae broad and tubular, membranous; corpus bursae oval, membranous, without signa (Fig. 15).

Diagnosis

The new genus is compared to the closest genera, *Xenochlorodes* and *Hissarica*. Viidalepp & Kostjuk (2021) recently restored *Hissarica* from synonymy with *Xenochlorodes*, where it had been placed as a valid subgenus (Hausmann 1996). *Sabzia graminaria* **comb. n.** had been previously assigned to the genus *Xenochlorodes* (Prout 1938). However, *S. graminaria* **comb. n.** differs from *Xenochlorodes* species and the monotypic genus *Hissarica* by the narrow and elongated wings without transverse lines (Figs. 1–10). In the forewing venation, *Sabzia* **gen. n.** differs from *Xenochlorodes* and *Hissarica* in the absence of an areole, the fusion of vein R2 with vein R3, and in having veins M3 and CuA1 stalked (areole present, vein R1 fused with veins R2+R3, and veins M3 and CuA1 connate in *Xenochlorodes*; areole present, vein R1 fused with veins R2+R3, and veins M3 and CuA1 arising separately from cell in *Hissarica*). In the hindwing of *Sabzia* **gen. n.**, veins M3 and CuA1 are stalked (arising from cell in *Xenochlorodes*; arising separately from cell in *Hissarica*) (Fig. 11). In the male genitalia of *Sabzia* **gen. n.** the gnathos is laterally hook-shaped with a serrated inner edge, the valva has a sclerotized harpe with a broad tip, and the saccus is rounded (gnathos laterally curved, harpe absent, saccus forked in *Xenochlorodes*; gnathos laterally curved, harpe thin, its tip tapered, and saccus rounded in *Hissarica*). In *Sabzia* **gen. n.** the aedeagus is short, basally thin, broadening towards the apex (aedeagus long and slender in *Xenochlorodes*; aedeagus long and thick in *Hissarica*). The second tergite in males of *Sabzia* **gen. n.** lacks interior processes (apodemes) and the posterior margin of sternum A8 is concave (second tergite with paired, club-shaped apodemes and sternum A8 bilobed in *Xenochlorodes*; second tergite without any processes and sternum A8 concave with tip in the centre in *Hissarica*) (Figs. 12–14).

In the female genitalia of *Sabzia* **gen. n.** the ductus bursae is tubular and membranous and the corpus bursae is oval (ductus bursae narrowing proximally and strongly sclerotized, corpus bursae oval in *Xenochlorodes*; ductus bursae sclerotized, corpus bursae elongated in *Hissarica*) (Figs. 15–17).

In addition to morphological characters, we used DNA barcode data from the BOLD database to check whether



Figs. 1–10. Wing colouration and pattern of *Sabzia* Wanke & Rajaei, **gen. n.**, *Xenochlorodes* Warren and *Hissarica* Viidalepp spp. (**a** = upperside; **b** = underside). – **1–5**. *S. graminaria* (Kollar, 1850), **comb. n.** [1–3: Iran, Fars, Komehr; 2: g. prep. 11052; 3: g. prep. 11051; 4: Iran, Fars, Miyan Kotal, g. prep. 272/2016 S.F.; 5: Illustration from Prout (1935)]. **6–7**. *X. olympiaria* (Herrich-Schäffer, [1852]) [6: Krk, Fiumebucht, g. prep. 1087/2021, D. Wanke; 7: Turkey, Mugla, vic. Esen, g. prep. 1088/2021, D. Wanke]. **8–9**. *H. postalbida* Viidalepp, 1988 [all Tadjikistan, Kondara; 8: g. prep. 1091/2021, D. Wanke; 9: g. prep. 1090/2021, D. Wanke]. **10**. Adult of *S. graminaria* **comb. n.** from Iran (Kerman, Hanna protected area; photo by H. Rajaei). Scale bar: 1 cm.

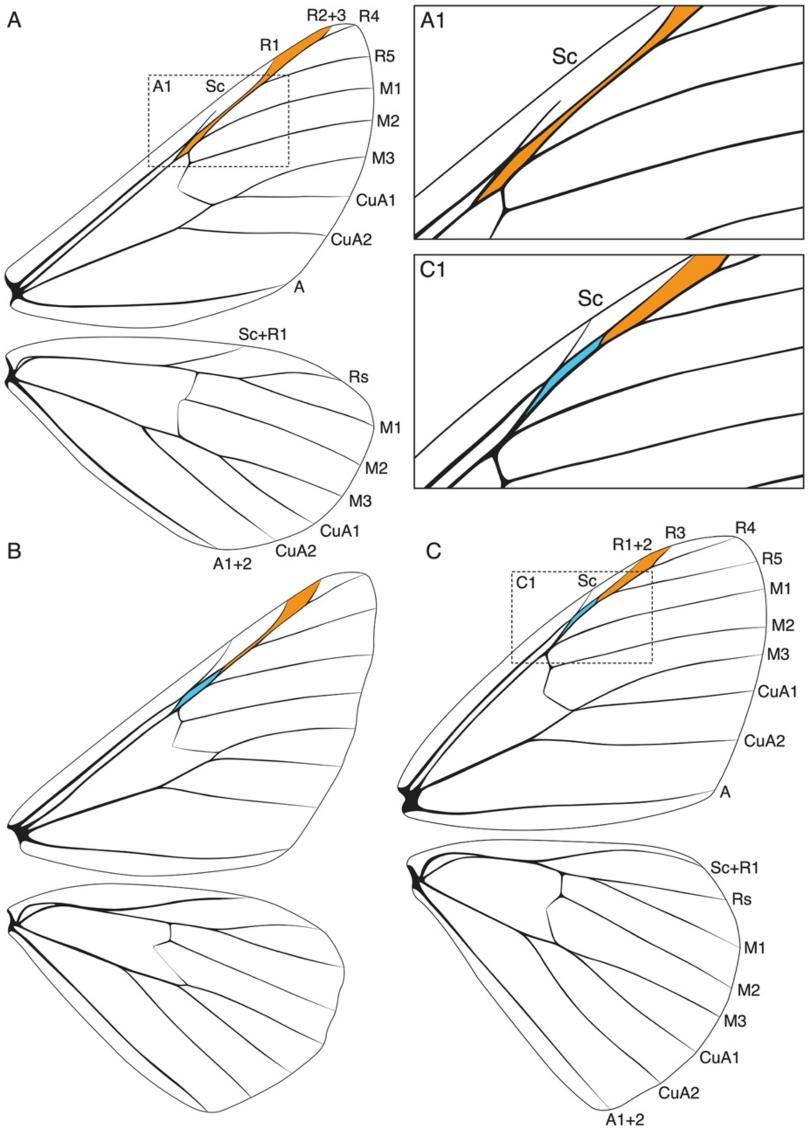
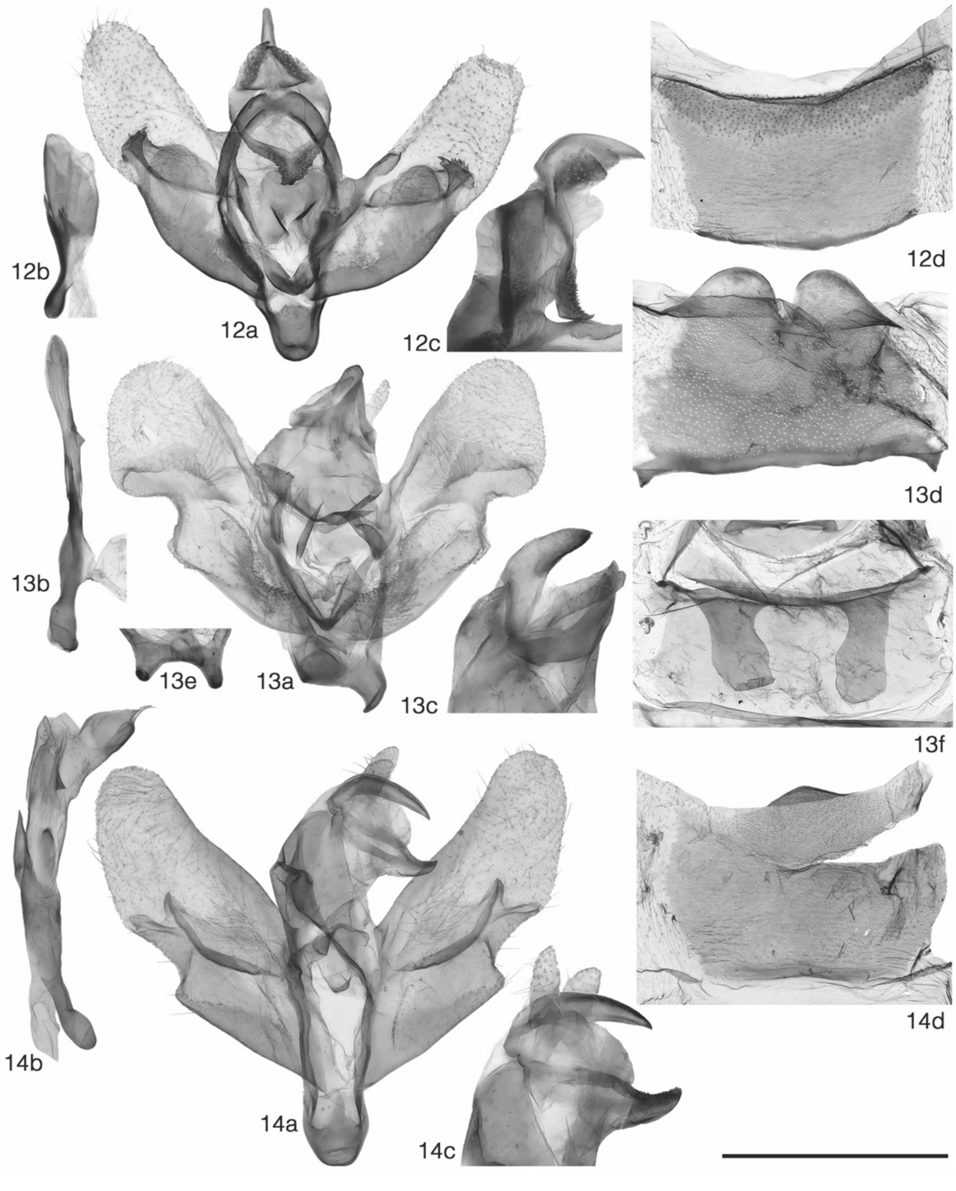


Fig. 11. Wing venation of (**A**) *Sabzia graminaria* (Kollar, 1850), **comb. n.**, (**B**) *Hissarica postalbida* Viidalepp, 1988 and (**C**) *Xenochlorodes olympiaria* (Herrich-Schäffer, [1852]). Areole blue coloured; area between R1 to R3 veins orange coloured. No areole is present in *S. graminaria* **comb. n.** (rectangle **A1**) and one areole (blue coloured) is present in *Xenochlorodes* (rectangle **C1**). Remark: according to Viidalepp & Kostjuk (2021), veins R2–M1 in the genus *Hissarica* (C) are stalked from the cell apex, R2 diverges after M1 and anastomoses with R1 towards the costa, therefore we here name this vein as R1+2. In *Sabzia* Wanke & Rajaei, **gen. n.** (B), veins R2–M1 are also stalked from the cell apex, but R2 does not diverge after M1 but reaches the costa along with R3; therefore, we here name this vein as R2+3.



Figs. 12–14. Male genitalia of *Sabzia* Wanke & Rajaei, **gen. n.**, *Xenochlorodes* Warren and *Hissarica* Viidalepp spp. – **12**. *S. graminaria* (Kollar, 1850), **comb. n.** (a, c, d: Iran, Kerman, Jiroft, g. prep. 1092/2021, D. Wanke; b: Iran, Fars, Komehr, g. prep. 11051). **13**. *X. olympiaria* (Herrich-Schäffer, [1852]) (a–d: Krk, Fiumebucht, g. prep. 1087/2021, D. Wanke; e–f: Spain, Girona, Puigventós, g. prep. 1086/2021, D. Wanke). **14**. *H. postalbida* Viidalepp, 1988 (a–d: Tadjikistan, Kondara, g. prep. 1091/2021, D. Wanke). **a** = genitalia capsule; **b** = aedeagus; **c** = uncus, lateral view; **d** = sternum A8; **e** = saccus; **f** = tergite 2. Scale bar: 1 mm; c, d, f are out of scale.

Figs. 15–17. Female genitalia of *Sabzia* Wanke & Rajaei, **gen. n.**, *Xenochlorodes* Warren and *Hissarica* Viidalepp spp. – **15**. *S. graminaria* (Kollar, 1850), **comb. n.** (Iran, Esfahan, vic. Sar Chesmeh, g. prep. 1093/2021, D. Wanke). **16**. *X. olympiaria* (Herrich-Schäffer, [1852]) (Turkey, Mugla, vic. Esen, g. prep. 1088/2021, D. Wanke). **17**. *H. postalbida* Viidalepp, 1988 (Tadjikistan, Kondara; g. prep. 1090/2021, D. Wanke). Scale bar: 1 mm.

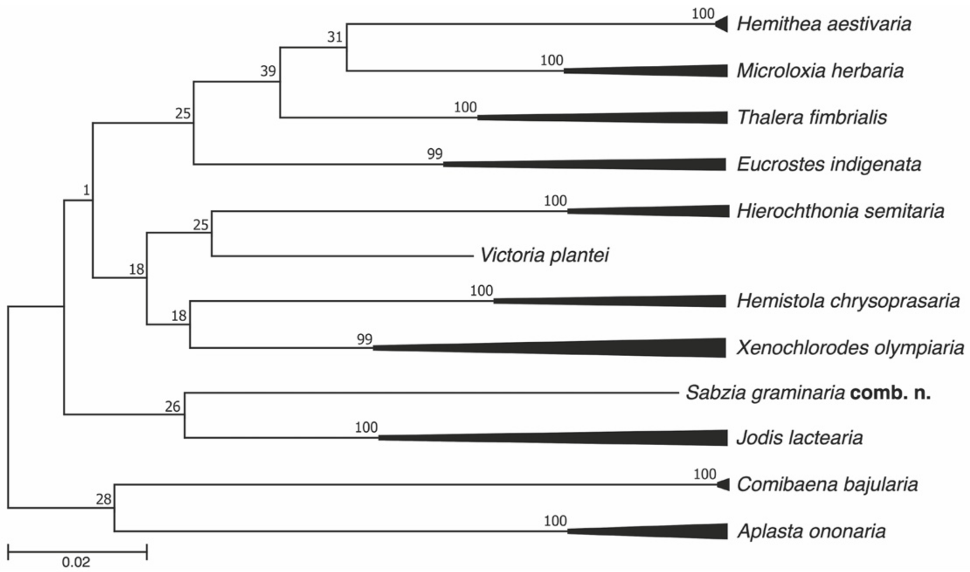


Fig. 18. Maximum likelihood analysis of *Sabzia* Wanke & Rajaei, **gen. n.** and closely related Palearctic species from different genera and tribes, based on *COI* 5' sequences (built with MEGA X; Kimura 2-parameter model; bootstrap method, 1000 replications). Remark: the *COI* data used here were only used to check whether or not *S. graminaria* (Kollar, 1850), **comb. n.** clustered with the genus *Xenochlorodes* Warren, and not for phylogenetic purposes; for a sound phylogenetic analysis of Hemitheini, see Murillo-Ramos et al. (2019).

or not *Sabzia graminaria* **comb. n.** clusters with the genus *Xenochlorodes*. The results of this analysis support our hypothesis to combine *S. graminaria* with a new genus, as it diverges by 11% from the type species of *Xenochlorodes*, *X. olympiaria* (Herrich-Schäffer, [1852]) (Fig. 18). Furthermore, the genetic distance from all other Palearctic Geometrinae is approximately 10%. We emphasize here that these results from *COI* barcoding alone should not be regarded as sound data for drawing any phylogenetic conclusions.

Tribal assignment

While placed within the genus *Xenochlorodes*, *Sabzia graminaria* was previously assigned to the tribe Hemistolini. According to the results of Murillo-Ramos et al. (2019), who subordinated Hemistolini under Hemitheini, we tentatively assign *Sabzia* **gen. n.** to the tribe Hemitheini. However, a comprehensive molecular phylogenetic study including *Sabzia* **gen. n.** is recommended for a reliable tribal assignment of the new genus.

Etymology

The name of this genus derives from the Persian word "Sabz", meaning green, and refers to the wing colour of type species *Sabzia graminaria* **comb. n.**

Sabzia graminaria (Kollar, 1850), **comb. n.**

Phorodesma graminaria Kollar, 1850: Kollar 1850: 51, 53. Holotype ♂ (South West Persia: Schiraz). Holotype not traced, possibly lost.

Xenochlorodes albicostaria Brandt, 1938: Brandt 1938: 55. Syntypes ♂♀ ([Iran]: Comèe [Komehr], Bam-i-Firus). Hereby regarded as a new synonym of *Sabzia graminaria*, **syn. n.** based on morphological examination and sympatric occurrence (see taxonomic note, below).

Material examined

Paratype ♂ of *X. albicostaria* Brandt, 1938: Iran, Fars, Straße Ardekan-Talochosroe [Tall Khosrow], Comèe [Komehr], 3600 m, 25.vi.1937, coll. Brandt, g. prep. ZSM G No. 1545 (ZSM).

1 ♂, 1 ♀, same data as paratype of *X. albicostaria*, 2600 m, 30.vi.1937, coll. Brandt, g. preps (♂) 11051, (♀) 11052 (NHRS).

2 ♀, Iran, Prov. Esfahan, NE of Naraq, Kuh-e Goran, 34°05′N 50°54′E, 2500 m, 06.vii.2003, leg. G. Ebert & R. Trusch; 1 ♀, Iran, Esfahan, Esfahan, Daran, Ashan vic., 2490–2500 m, 25.vi.2005, leg. A. Hofmann; 1 ♀, Iran, Boyer Ahmad-va-Kohgiluyeh, Yasuj E, Abnar Region, Kakan-Baba Hassan, 2550–2800 m, 24.vi.2005, leg. A. Hofmann; 1 ♂, Iran, Fars, Straße Ardekan-Talochosroe [Tall Khosrow], Comèe [Komehr], ca. 2600 m, 30.vi.1937, coll. Brandt; 1 ♂, Iran, 4–7.vi.1969, Miyan Kotal, 1900 m, östl. Kazerun, 29°30‘ N 51°40‘E, leg. G. Ebert, g. prep. 272/2016 S.F.; 1 ♀, Iran, Fars, Kaserun, Mian-Kotal, 1900 m, 11.vi.1972, leg. Ebert & Falkner, g. prep. 273/2016 S.F. (all SMNK).

1 ♀, Iran, Boyer Ahmad-va-Kohgiluyeh, Yasuj E, Abnar Region, Kakan–Baba Hassan, 2550–2800 m, 24.vi.2005, leg. A. Hofmann; 1 ♀, Iran, Esfahan, Miyandasht NW Afous, Chebleh-Kuh, Sar Chesmeh vic., 2700–2900 m, 12./13.vii.2003, leg. A. Hofmann, J.-U. Meineke, G. Tremewan, g. prep. 1093/2021 D. Wanke; 1 ♂, Iran, Kerman, Jiroft W, Shingera, 2800 m, 26./27.v. 2004, leg. A. Hofmann, J.-U. Meineke, G. Tremewan, g. prep. 1092/2021 D. Wanke (all SMNS).

1 ♀, Iran, Markazi, Tafresh 10 km SSE (Pass), 2400 m, 31.v.2005, leg. A. Hofmann, J.-U. Meineke; 1 ♂, 2 ♀, Iran, Boyeramabad va Kuhgiluye, Kuh-e Dinar, Paß E Sisahkt, 2800–3200 m, 14.vii.2000, leg. ten Hagen, g. preps (♂) 101, (♀) 100/2016 S.F.; 1 ♀, Iran, Boyer Ahmad-va-Kohgiluyeh, Gardaneh, Meymand, 2450–2800 m, 14./15.vi.2001, leg. A. Hofmann, J.-U. Meineke, G. Tremewan, g. prep. 162/2016 S.F.; 1 ♂, Iran, Esfahan, N Fereydun Shahr, vic. Shoohroud, 2700–3200 m, 5./6.vii.2002, leg. ten Hagen, g. prep. 102/2016 S.F.; 1 ♂, 1 ♀, Iran, Kerman, Kuh-e Bochrasman, S Darbmazar, 2800–3000 m, 1.vi.2004, leg. W. ten Hagen, g. prep. (♂) 106/2016 S.F.; 1 ♂, 1 ♀, Iran, Kerman, Jiroft NW, Gardaneh, Sarbishan, Shingara vic., 2700–2900 m, 3./4.vi.2002, leg., J.-U. Meineke, A. Hofmann, A. Kallies et al., g. prep. (♂) 103/2016 S.F.; 1 ♀, Iran, Kerman, Bam SW, Deh Bakri, 2000–2200 m, 1.-3.vi.2002, leg. J.-U. Meineke, A. Hofmann, A. Kallies et al., g. prep. 105/2016 S.F.; 1 ♂, 1 ♀, Iran, Kerman, Jiroft W, Shingera, 2800 m, 26./27.v. 2004, leg. A. Hofmann, J.-U. Meineke, G. Tremewan, g. prep. (♂) 104/2016 S.F. (all PCJM).

Taxonomic note

Kollar (1850) described *Phorodesma graminaria* based on one damaged male, the holotype, from southern Iran. According to Prout (1935), the holotype was left without a type label and, as already mentioned by Kollar (1850), was in damaged condition (five legs and the abdomen missing). Unfortunately, we could not find the holotype in any of the examined collections. Nevertheless, the original description and the additional notes of Prout, as well as his illustration (Prout 1935: 18, row h), served for identification of this species in the present study. Additionally, our revision of all known Iranian Geometrinae species has shown that *S. graminaria* is the only species with entirely green wings without markings, and that it therefore cannot be confused with other Geometrinae in this region. Considering all of the above, a neotype designation is not considered necessary, as the taxonomy of this species is stable and future retrieval of the holotype cannot be ruled out.

Surprisingly, *X. albicostaria*, described by Brandt (1938) from the southern Iranian province Fars, shows a high similarity with *S. graminaria*. It matches in all external characters, such as the long and narrow wing shape, the green colouration of the wings, the lack of transverse lines on the wings, the two terminal spurs on the hindleg, the absence of a frenulum, the strongly angled discocellular vein, vein R2 situated near the cell apex and vein M1 arising from the common stalk of veins R2–5 (Figs. 1–5). We therefore synonymize *X. albicostaria* with *S. graminaria*, **syn. n.**

Description and diagnosis

See generic part.

Phenology and habitat

Flying from May to July at altitudes from 1900 to 3600 m.

Biology

Unknown

Distribution

Species endemic to Iran, occurring from western to southern Iran along the Zagros Mountains.

Acknowledgements

We wish to express our deepest gratitude to Robert Trusch and Michael Falkenberg (both Staatliches Museum für Naturkunde Karlsruhe, Germany), Tobias Malm and Johannes Bergsten (both Naturhistoriska Riksmuseet, Stockholm, Sweden) and Jörg-Uwe Meineke (Kippenheim, Germany) for the loan of valuable specimens from their collections. Many thanks to Norbert Pöll (Bad Ischl, Austria) for sharing the barcode data of *S. graminaria* with us. We thank Hamid Valipoor (Quchan, Iran) for accompanying the last author on several expeditions in Iran. Thanks to James E. O'Hara (Ottawa, Canada) for providing an indispensable translation of the Latin in the original description of *S. graminaria*. We are grateful to the editor-in-chief of Integrative Systematics Daniel Whitmore and to two anonymous reviewers for their critical review of the submitted version of the paper and constructive comments.

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Manuscript received: 08.X.2021; accepted: 18.II.2022.

Appendix 1. List of specimens used for the maximum likelihood analysis, with species, sampling site and Process ID. Data taken from BOLD, generated by Axel Hausmann except GWORU553-10, generated by Norbert Pöll.

Species	Sampling Site	Process ID
Aplasta ononaria (Fuessly, 1783)	Israel, Northern, Hermon, 30.vi.2003, leg. Mueller, Kravchenko	GWOR317-07
Aplasta ononaria	Israel, Northern, Hermon, 30.vi.2003, leg. Mueller, Kravchenko	GWOR505-07
Aplasta ononaria	Israel, Northern, Hermon, 30.vi.2003, leg. Mueller, Kravchenko	GWOR517-07
Aplasta ononaria	Italy, Calabria, Cosenza, Fiumara Trionto, 09.ix.1999, leg. Scalercio, Intusino & Vuono	GWOTD327-12
Comibaena bajularia Fletcher, 1963	Germany, Thuringia, Bad Blankenburg, Schwarzatal, Schieferbrueche, 07.vii.2013, leg. S. Erlacher	GBLAC257-13
Comibaena bajularia	Germany, Brandenburg, Barnim, Zerpenschleuse, 20.vi.2013, leg. Rainer Busse	GBLAF456-14
Comibaena bajularia	Italy, Calabria, Cosenza, 6km S Cosenza, Pianette di Dipignano, 01.vi.2015, leg. G. Posa	GBLAA2691-15
Eucrostes indigenata (De Villers, 1789)	Greece, Crete, Western Crete, Levka Ori Gebirge Kalikratis, 13.v.2010, leg. Leipnitz	GWOSC945-10
Eucrostes indigenata	Italy, Abruzzi, Majella, vic. Lettopalena, 27.vi.2004, leg. N. Zahm	GWOTH289-12
Eucrostes indigenata	Greece, Thessaly, Strymon-Muendung, 24.ix.2005, leg. Weigert	GWOSO513-11
Hemithea aestivaria (Hübner, 1789)	Italy, Sardinia, Torpe, Baddore, 24.v.2007, leg. O. Cao	GWORD581-08
Hemithea aestivaria	Germany, Bavaria, centr, Woerth/Donau, Gmuender Au, 04.vi.2000, leg. A. Segerer	GWORG021-08
Hemithea aestivaria	Germany, Bavaria, centr, Traunstein, Traunstein - Uebersee, 03.vii.1997, leg. A. Segerer	GWORG022-08
Hemithea aestivaria	Germany, Bavaria, Upper Bavaria, Oberschleissheim, MW33, 13.vi.2007, leg. Axel Hausmann	GWOR4082-09
Hemistola chrysoprasaria (Esper, 1795)	Italy, Calabria, Cosenza, FmeArgentino, 3Km E Orsomarso, 10.viii.2007, leg. A. Hausmann	GWORC681-07
Hemistola chrysoprasaria	United Kingdom, 03.viii.2007, leg. OTL	CGUKA737-09
Hemistola chrysoprasaria	Germany, Bavaria, Upper Bavaria, Schlagenhofen a. Woerthsee, 06.vii.2008, leg. Karl Ambil	GWOR3778-09
Hierochthonia semitaria (Püngeler, 1901)	Israel, Jerusalem, Bet Shemesh, 30.vi.2003, leg. Mueller, Kravchenko	GWOR175-07
Hierochthonia semitaria	Israel, Haifa, Carmel, Carmel Haifa, 15 Km South of Haifa, 30.vi.2003, leg. Mueller, Kravchenko	GWOR176-07
Hierochthonia semitaria	Jordan, Al Karak, Al Karak, Al Karak, 31.v.2003, Li, leg. Mueller, Kravchenko	GWOR179-07
Jodis lactearia (Linnaeus, 1758)	Italy, Calabria, Lago dell`Angitola, 19.viii.2002, leg. S. Scalercio, M. Infusino & J. Tuscano	GWOTI892-12
Jodis lactearia	Germany, Bavaria, Upper Bavaria, Oberschleissheim, Flugahfen-Ost, 27.v.2008, leg. Axel Hausmann	GBLGC129-12
Jodis lactearia	Germany, Thuringia, Bad Blankenburg, Boehlscheiben, Schieferbrueche, 14.vi.2013, leg. B. Kirchner	GBLAD252-14

Species	Sampling Site	Process ID
Jodis lactearia	Italy, Lombardy, Lago d`Iseo, Solto Collina, 28.v.2015, leg. A. Hausmann	GBLAA1970-15
Microloxia herbaria (Hübner, [1813])	Kazakhstan, European Part, Ryn-kum sandy Steppe NW. Kandagash Loc., 17.vi.1999, leg. J. Miatlenski & V. Karalius	GWOSF890-10
Microloxia herbaria	Ukraine, Crimea, Feodosiya, Primorskiy, 08.viii.2011, leg. V. Savchuk	GWOTA861-13
Microloxia herbaria	Kazakhstan, Almaty, Tien Shan, Bakhanas, 05.v.2011, leg. G. Nazymbetova	GWOR5395-13
Thalera fimbrialis (Scopoli, 1763)	Turkey, Isparta, Akdeniz, Isparta, Kirazlidere, 26.vi.2007, leg. F. Can	GWORC577-07
Thalera fimbrialis	Kyrgyzstan, Naryn, Moldo-Too Mts., Koro-Goo Pass, 09.vii.2014, leg. S. Korb	GWOTO827-15
Thalera fimbrialis	Germany, Saarland, Saarpfalz-Kreis, Mandelbachtal, Hecken-dalheim, Lauterbachsklamm, 26.vii.2013, leg. Andreas Werno	FGMLG068-15
Victoria plantei Herbulot, 1976	Israel, Southern, Arava, Yotvata, 22.iv.1992, leg. G. Mueller	GWORL752-09
Xenochlorodes olympiaria (Herrich-Schäffer, [1852])	Italy, Basilicata, Valle Noce Trecchina, 12.vi.1996, leg. A. Hausmann	GWORB1676-08
Xenochlorodes olympiaria	Italy, Sardinia, Olbia, Porto San Paolo, 11.v.2000, leg. L. Weigert	GWOSI925-10
Xenochlorodes olympiaria	Italy, Calabria, Fiumara Trionto, 13.v.1999, leg. S. Scalercio, M. Infusino & M. Vuono	GWOTI894-12
Xenochlorodes olympiaria	Spain, Catalonia, Girona, Llanca, 30.v.1986, leg. Weigert	GWOSO517-11
Xenochlorodes olympiaria	Turkey, Adana, Akdeniz, Adana, Feke, 30.v.2002, leg. F. Can	GWORC602-07
Sabzia graminaria (Kollar, 1850), **comb. n.**	Iran, Fars, Dast-e-Arzan vic., 05.vi.1997, leg. A. Hoffmann, P. Kautt	GWORU553-10

Original research paper 4

Taxonomic revision of the genus *Nychiodes* Lederer, 1853 (Geometridae: Ennominae: Boarmiini) with description of three new species—an integrative approach

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Published (2020) in Zootaxa 4812 (1): 1–61

https://doi.org/10.11646/zootaxa.4812.1.1

Painting of *Nychiodes admirabila* by Marina Moser

Zootaxa 4812 (1): 001–061
https://www.mapress.com/j/zt/

Monograph

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

https://doi.org/10.11646/zootaxa.4812.1.1
http://zoobank.org/urn:lsid:zoobank.org:pub:74FE6D6A-B41D-4FC9-BC26-B07DDEB9A0F6

ZOOTAXA

4812

Taxonomic revision of the genus *Nychiodes* Lederer, 1853 (Geometridae: Ennominae: Boarmiini) with description of three new species—an integrative approach

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Magnolia Press
Auckland, New Zealand

Accepted by R. Zahiri: 10 Jun. 2020; published:14 Jul. 2020

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(*Zootaxa* 4812)

61 pp.; 30 cm.

14 Jul. 2020

ISBN 978-1-77670-985-4 (paperback)

ISBN 978-1-77670-986-1 (Online edition)

FIRST PUBLISHED IN 2020 BY

Magnolia Press

P.O. Box 41-383

Auckland 1346

New Zealand

e-mail: magnolia@mapress.com

https://www.mapress.com/j/zt

ISSN 1175-5326 (Print edition)

ISSN 1175-5334 (Online edition)

Table of Contents

Abstract

The non-European taxa of the genus *Nychiodes* Lederer, 1853 are revised. Type specimens of all described species and a large series of about 800 additional specimens were morphologically examined. More than 400 genitalia preparations were made and analyzed along with distributional and DNA barcode data. As a result of our integrative taxonomic approach, *Nychiodes waltheri saerdabica* Wehrli, 1938 **syn. nov.**, is synonymized with *N. waltheri* Wagner, 1919; *N. palaestinensis libanotica* Zerny, 1933 **syn. nov.** is synonymized with *N. palaestinensis* Wagner, 1919 and the synonymy of *N. persuavis* Wehrli, 1929 **syn. rev.** with *N. palaestinensis* is confirmed; *N. admirabila safidaria* Wiltshire, 1943 **syn. nov.** is synonymized with *N. admirabila* Brandt, 1938; *N. agatcha* Brandt, 1938 **syn. nov.**, *N. subvirida disjuncta* Wehrli, 1941 **syn. nov.** and *N. subvirida taftana* Brandt, 1941 **syn. nov.** are synonymized with *N. subvirida* Brandt, 1938. Also, *N. variabila variabila* Brandt, 1938 **syn. nov.**, *N. variabila opulenta* Brandt, 1941 **syn. nov.**, *N. divergaria elbursica* Wehrli, 1937 **syn. nov.**, *N. divergaria fallax* Wehrli, 1939 **syn. nov.** and *N. divergaria achtyca* Wehrli, 1939 **syn. nov.** are synonymized with *N. divergaria* Staudinger, 1892. *Nychiodes convergata* **sp. nov.** from Israel, *N. mirzayansi* **sp. nov.** from the Iran and *N. eberti* **sp. nov.** from Turkey are described. Lecto- and paralectotypes are designated for *N. palaestinensis*, *N. antiquaria*, *N. divergaria*. Furthermore, *N. antiquaria* is reported as a new species for Pakistan, *N. rayatica* is reported as a new species for Iran and the hypothetical occurrence of *N. amygdalaria* in Iran is confirmed. Additionally, *N. tyttha* needs to be excluded from the genus. Wing pattern, male and female genitalia and diagnostic characters of all examined species are illustrated and distribution maps are provided. Illustrated keys based on genitalia, as well as a complete checklist of the genus is given here.

Key words: Lepidoptera, DNA barcoding, integrative taxonomy, lectotype designations, new combinations, new species, new synonyms

Introduction

The genus *Nychiodes* is currently assigned to the Boarmiini, an especially diverse tribe of geometrid moths comprising more than 5,000 species in 150 genera (Müller *et al.* 2019; Murillo-Ramos *et al.* 2019). The distribution area of *Nychiodes* extends from western Europe and northern Africa into Iran, Afghanistan and Pakistan (Müller *et al.* 2019).

Nychiodes species are large and robust moths, like most of the Boarmiini, which based on external morphology are a variable group without any clear-cut differential characters (Lederer 1853; Müller *et al.* 2019).

Nychiodes species are mainly characterized by their prominent ante- and postmedial lines on the forewing (Müller *et al.* 2019). Despite the conspicuousness of this genus, the taxonomic acquisition is difficult due to their morphological variablity. Moreover, unreliable features for their diagnosis, the lack of identification keys and doubtful status of species strengthen this. Therefore, for clear species diagnoses, the study of genitalia structures is crucial.

The genus *Nychiodes* has been described in 1853 by Lederer based on the type species *Geometra lividaria* Hübner, 1799 which is a synonym of *N. obscuraria* (Villers, 1789). In his catalogue, Staudinger (1871) listed *N. lividaria* and *N. amygdalaria* under this genus and later (Staudinger 1901) added *N. gigantaria* and five variations of *N. lividaria*. Prout (1915) listed eight species, which was supplemented by Wehrli (1954) to a total of 16 species and 29 subspecies. Scoble (1999) listed 26 species and 18 subspecies for the genus, which was later raised to 27 species by Scoble & Hausmann (2007). Müller *et al.* (2019) synonymized one species and five subspecies, downgraded one species to subspecies level and upgraded one subspecies to species level. As a result (and prior to the present study), the genus *Nychiodes* consisted of 27 species and 14 subspecies.

Recently, the genus has been subject of a revision in Europe and the urgency of a further revisionary study on this genus outside Europe has been stated (Müller *et al.* 2019).

Here we present a full revision of the non-European taxa of this genus and update and complement the current knowledge on these taxa. Most type specimens and a large number of additional material were investigated to gain a better understanding of each species. The comparison of external and internal morphological characters, combined with data acquired by DNA barcoding and distribution patterns, was used for this purpose. As a result of this study the genus consists of 25 species and 3 subspecies. Full decriptions for new species, morphological variation of already known species resulting from the comprehensive study of male and female genitalia are given. A complete checklist of the species within the genus is presented here.

Material and Methods

Type material and additional specimens were borrowed and examined from the following collections (acronyms after Evenhuis 2007, as far as included):

BMNH	Natural History Museum, London, England
IMCA	Insect and Mite Collection Ahvaz University, Iran
MNHN	Muséum National d'Histoire Naturelle, Paris, France
MNHU	Museum für Naturkunde der Humboldt-Universität, Berlin, Germany
NHMV	Natural History Museum Vienna, Austria
NHRS	Naturhistoriska Riksmuseet, Stockholm, Sweden
PCBM	Private collection of Bernd Müller, Berlin, Germany
PCDS	Private collection of Dirk Stadie, Eisleben, Germany
PCJG	Private collection of Jörg Gelbrecht, Königs Wusterhausen, Germany
PCJM	Private collection of Jörg-Uwe Meineke, Kippenheim, Germany
PCML	Private collection of Michael Leipnitz, Stuttgart, Germany
PCPG	Private collection of Gergely Petrányi, Budapest, Hungary
PCPS	Private collection of Peder Skou, Vester Skerninge, Denmark
PCRF	Private collection of Ralf Fiebig, Rossleben, Germany
PCTM	Private collection of Toni Mayr, Feldkirch, Austria
SMNK	Staatliches Museum für Naturkunde Karlsruhe, Germany
SMNS	Staatliches Museum für Naturkunde Stuttgart, Germany
ZFMK	Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany
ZSM	Zoologische Staatssammlung München, Germany

In the presentation of label data and original citations square brackets […] are used to explain or correct the spelling of the original information. The abbreviation "g. prep." refers to the number of a genitalia preparation.

Morphological examination. The type material of all investigated species and original descriptions were used for the identification and comparison of specimens. External characters were photographed with a Visionary Digital photography system (LK Imaging System, Dun. Inc., equipped with a Canon EOS 5DSR) and an Olympus E3 digital camera. Preparations of male and female genitalia were carried out following Robinson (1976), embedded as permanent slides in Euparal and photographed with a Leica digital microscope (Z16 APO) or a Keyence digital microscope (VHX-5000). Vesica everting followed the method described by Sihvonen (2001). For positioning and photography of different genitalia structures in liquid the method described by Wanke and Rajaei (2018) was followed. The uncus in lateral view, was photographed following the method proposed by Wanke *et al.* (2019). In the diagnosis paragraphs, each species is compared with externally or internally similar species as well as with sympatric species of the same species group.

Distribution pattern. After identification of species, the geographical coordinates (if not mentioned on the specimen label) were traced using 'Google Earth Pro' (vers. 7.3.1.4507 for Mac). Distribution patterns were plotted and prepared in QGIS (vers 2.18.15 for Mac). Global Multi-resolution Terrain Elevation Data 2010 (GMTED2010) were downloaded from https://earthexplorer.usgs.gov for the preparation of the elevation profile in QGIS. Distribution data were used especially for evaluation of the subspecies status.

DNA barcoding. Standard protocols (e.g., Ivanova *et al.* 2006) were used for extraction of DNA and amplification of the "barcode" fragment (658 base-pairs of the 5' terminus) of the mitochondrial cytochrome-c oxidase, subunit I. PCR products of several specimens were amplified and sent to Macrogen for sequencing. The remaining specimens were amplified and sequenced at the Canadian Centre of DNA barcoding (CCDB, Guelph), in the framework of the Lepidoptera campaign of the international Barcode of Life program (iBOL; www.lepbarcoding.org). All specimens used for DNA analysis are presented in the Appendix along with their label data and process identification numbers. All sequences and metadata are accessible on BOLD in the public dataset DS-NYCHEAST (dx.doi.org/10.5883/DS-NYCHEAST). Software MEGA X (Kumar *et al.* 2018) was used for the reconstruction of the neighbour-joining (NJ) tree (Using K2P model: Kimura 1980) (fig. 145) and for the calculation of genetic distances.

Results and Discussion

Nychiodes Lederer, 1853

Nychiodes Lederer, 1853. Verhandlungen des Zoologisch-Botanischen Vereins in Wien, 3: 177, 216, 219. Type species: *Geometra lividaria* Hübner, 1799 [Europe]. Genus synonyms after Scoble (1999).
Comeesia Wehrli, 1941. in: Seitz, A. (Ed.), Die Großschmetterlinge der Erde 4 (Supplement): 440. Type species: *Nychiodes admirabila* Brandt, 1938.
Eunychiodes Wehrli, 1941. in: Seitz, A. (Ed.), Die Großschmetterlinge der Erde 4 (Supplement): 441. Type species: *Boarmia amygdalaria* Herrich-Schäffer, 1948.
Fritzwagneria Wehrli, 1941. in: Seitz, A. (Ed.), Die Großschmetterlinge der Erde 4 (Supplement): 438. Type species: *Nychiodes dalmatina* Wagner, 1909.

Description. (after Müller *et al.* 2019 with complementary characters): *Wings and body.* Medium to large sized moths (wingspan between 24–50 mm), females slightly larger than males. Antennae bipectinate in males and females (fig. 1A-C). Proboscis entirely reduced. Frons, thorax and abdomen concolourus with the wings. Chaetosemata arranged as two separated patches. Ground colour of wings differing from bright yellow to different kinds of brown or grey. Transverse lines, if present, differing from bright white to dark brown and even black. Terminal line often dark highlighted. Discal spots mostly visible, sometimes faint or absent. In the forewing, veins R1 and R2 with a common stalk arising from the cell; R3–5 with a common stalk arising from the cell; vein A characteristically curved in the basal area. In hindwing Sc+R1 strongly curved in basal area, approximating to the cell in the postbasal area; short A3 and A1+2 originating separately (fig. 2).

Male genitalia (fig. 1D-E). Uncus short, basally broad and triangular, apically pointed and bent to ventral side (visible only in natural position before embedding). Gnathos well developed and strongly sclerotized, medially tongue-shaped. Valva equipped with two main processes on its ventral part, namely ampulla superior and ampulla inferior; a third process, the sacculus process, is present only in the *obscuraria* and *waltheri* species-group (see below). Costa of valva strongly sclerotized. Juxta anchor-shaped, stalk (connection between apical and basal parts of juxta) is diagnostic. Aedeagus equipped with one sclerotized cornutus.

Female genitalia (fig. 1F). Large in size, with a rounded or ovally elongated ovipositor. The apophyses anteriores and posteriores ratio is a diagnostic character in species level. Lamella postvaginalis sclerotized, its shape is a diagnostic character. Ductus bursae membranous, partial sclerotization possible. Corpus bursae membranous with a stellate signum.

Diagnosis. The genus *Nychiodes* is regarded as sister genus to *Eurranthis* (Müller *et al.* 2019; Murillo-Ramos *et al.* 2019) and these two genera can be diagnosed as follows: *Nychiodes* species are mainly nocturnal (*Eurranthis* species diurnal). Ground colour pale yellow to almost black in *Nychiodes* (very characteristic orange-white, with thick black medial lines in *Eurranthis*). In female genitalia of *Nychiodes*, lamella postvaginalis sclerotized, elongated laterally or elongated antero-posteriorly (as sclerotized plate, concave posteriorly in *Eurranthis*). In *Nychiodes*, corpus bursae membranous, rather bag-like; signum stellate (corpus bursae membranous, tubular; signum weak in *Eurranthis*).

Species-groups of the genus *Nychiodes*

Based on the genitalia patterns of *Nychiodes* species, the genus has been subdivided into three different species-groups: *obscuraria* species-group, *waltheri* species-group and the *amygdalaria* species-group (Wehrli 1929a-c; Müller *et al.* 2019). However, this grouping should not be regarded as a phylogeny, before getting confirmation from a comprehensive molecular phylogenetic study. This morphological grouping should rather serve as a tool for species identification. The species are therefore listed here under each species-group.

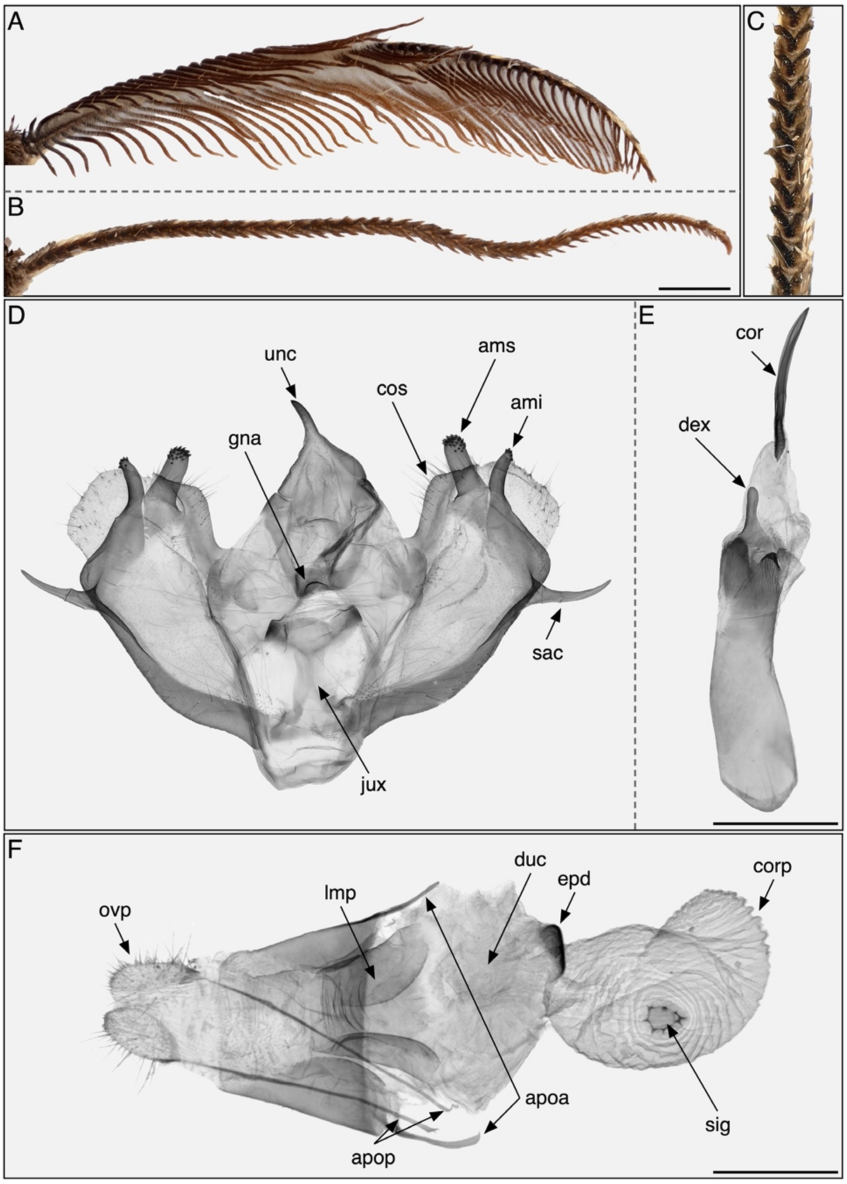

FIGURE 1. Morphological characters of *Nychiodes* species. A-C: Bipectinate antennae of *N. obscuraria*. A: male; B: female; C: ventral close-up of the female; D-F: terminology of male and female genitalia of *N. waltheri*. D: male genitalia capsule; E: aedeagus; F: female genitalia. Abbreviations (after Schmidt 2017; Wanke *et al.* 2019): *ami*–ampulla inferior; *ams*–ampulla superior; *apoa*–apophyses anteriores; *apop*–apophyses posteriores; *cor*–cornutus; *corp*–corpus bursae; *cos*–costa of valva; *dex*–digitiform extension; *duc*–ductus bursae; *epd*–extended sclerotized patch of ductus bursae; *gna*–gnathos; *jux*–juxta; *lmp*–lamella postvaginalis; *ovp*–ovipositor; *sac*–sacculus projection/process; *sig*–signum; *unc*–uncus. Scale-bar 1 mm.

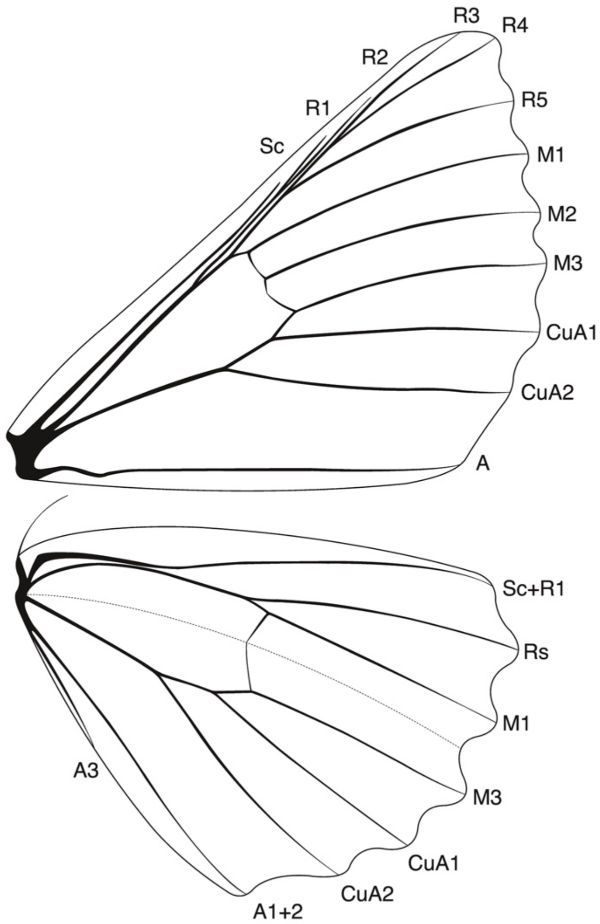

FIGURE 2. Wing venation of male specimen of genus *Nychiodes*: *Nychiodes obscuraria* (type species for the genus).

Key to the *Nychiodes* species-groups based on male genitalia

1. Sacculus process of genitalia capsule absent . . . . *amygdalaria* species-group (figs 96–126)
   Sacculus process present 2
2. Sacculus process short, pointed; apex of aedeagus triangularly extended, acute at tip . . . . . .*obscuraria* species-group (fig. 88)
   Sacculus process strongly pronounced, slender and pointed; apex of aedeagus extended, digitiform . . . .*waltheri* species-group (figs 89–95)

Key to the *Nychiodes* species-groups based on female genitalia

1. Ductus bursae very short (shorter than half length of corpus bursae). . . . .*waltheri* species-group (figs 128–131)
   Ductus bursae long (half length of corpus bursae or longer) 2
2. Lamella postvaginalis strongly extended laterally . . . . *obscuraria* species-group(fig. 127)
   Lamella postvaginalis extended antero-posteriorly . . . . *amygdalaria* species-group (figs 132–144)

Species account

The *obscuraria* species-group

The species of this group can be diagnosed by the following characters (after Müller *et al.* 2019): In male genitalia, costa of valva is sclerotized up to subapical part, humped medially; apex of ampulla superior covered with setae; ampulla inferior not setose, pointed; sacculus process pointed; tip of aedeagus with acute triangular extension. In female genitalia, ductus bursae long and membranous (same size or longer than corpus bursae); lamella postvaginalis laterally strongly extended, sclerotized.

The following species are included in this group: *N. obscuraria* (Villers, 1789), *N. ragusaria* Millière, 1884, *N. andalusiaria* Millière, 1865, *N. notarioi* Expósito, 2005, *N. mauretanica* Wehrli, 1929, *N. hispanica* Wehrli, 1929.

Remarks. All species of this group, except *N. mauretanica* Wehrli, 1929, have been revised previously (see Redondo *et al.* 2009; Müller *et al.* 2019). Therefore, we include here only *N. mauretanica*.

***Nychiodes mauretanica* Wehrli, 1929**
(figs 3, 88, 127)

Nychiodes mauretanica Wehrli, 1929. Internationale Entomologische Zeitschrift 22 (42): 386. Lectotype ♂, designated by Fazekas (1997) (Algeria: Lambèse, juillet 1912, Harold Powel, gen. prep. Fazekas I. No. 2593), Paralectotypes 3 ♂, 2 ♀ (Tunisia: Ain-Drahan; Algeria: Lambèse; Yakouren; Selo el Ghelem) (in ZFMK, examined).

Type material examined. Lectotype (designated by Fazekas 1997), 1 ♂, Algeria, Lambèse, juillet 1912, Harold Powel, g. prep. Fazekas I. No. 2593; in ZFMK.

Diagnosis. Wingspan ♂ 46 mm, ♀ 41–45 mm (fig. 3). Ground colour of the wings pale brown with yellow tinge intermixed with brown scales (grey-brown to dark beige in *N. obscuraria*; light to dark brown in *N. ragusaria*; light brown to brown in *N. andalusaria*; dark beige to grey in *N. notarioi*; grey, sometimes irrorated with yellowish brown in *N. hispanica*). Basal area of the wings slightly brighter. Forewing with postmedial line curved outwards near costa; antemedial line faint. Hindwing with postmedial line well pronounced, medially curved inwards, acute-angled near costa. In male genitalia of *N. mauretanica* (fig. 88), uncus broad, triangular, tapered at tip, costa of valva strongly sclerotized, medially humped (basal part sclerotized, humped in *N. obscuraria*; only basal part sclerotized, basally humped in *N. ragusaria*; basal part sclerotized, strongly humped at centre in *N. andalusaria* and *N. notarioi*; sclerotized up to subapical part, medially humped in *N. hispanica* (see Müller *et al.* 2019: pages 667–668)). Ampulla superior clubbed, long, reaching clearly over the ampulla inferior; apex of both ampulla superior and inferior apically spinose; ampulla inferior short, digitiform (ampulla superior short, clubbed, covered with tiny setae, ampulla inferior very short in *N. obscuraria* and *N. ragusaria*; ampulla superior tubular covered with setae, ampulla inferior acute in *N. andalusaria* and *N. notarioi*; ampulla superior tubular covered with setae, ampulla inferior acute and long in *N. hispanica* (see Müller *et al.* 2019: pages 667–668). Sacculus process strongly sclerotized, short, basally triangular, apically acute (strongly reduced in *N. obscuraria* and *N. ragusaria*; acute and curved in *N. andalusaria*, *N. notarioi* and *N. hispanica* (see Müller *et al.* 2019: pages 667–668). Juxta anchor-shaped, stalk thin and long. Aedeagus short and broad, submedially curved; cornutus slightly shorter than aedeagus. In female genitalia of *N. mauretanica* (fig. 127) lamella postvaginalis sclerotized only at its medial part, without lateral extensions (sclerotized, with arch-shaped extension in *N. obscuraria*; apically split and bilobed in *N. ragusaria*; with lateral arch-shaped extension in *N. andalusiaria*; medially rectangular, with lateral arch-shaped extension in *N. notarioi*; medially heart-shaped, with lateral arch-shaped extension in *N. hispanica* (see Müller *et al.* 2019: pages 732–733). Corpus bursae membranous, oval (more spherical in other species of this group). Signum stellate.

Phenology, biology, habitat. Unknown.

Distribution. Known from Algeria and Tunisia (Wehrli 1929; Fazekas, 1997). Fazekas (1997) mentioned an isolated population in the French Pyrenees, which was considered as doubtful by Leraut (2009) and could not be confirmed by Redondo *et al.* (2009) and Müller *et al.* (2019).

DNA barcoding. Nearest species: *N. ragusaria* (4.6%) and *N. hispanica* (4.7%) (fig. 145).


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8a
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9b
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12b
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19a
19b
20a
20b
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22a
22b

◄

FIGURES 3-22. Wing coloration and pattern of *Nychiodes* species. 3: Lectotype of *N. mauretanica* (Algeria, Lambèse, g. prep. Fazekas I. No. 2593); 4: Holotype of *N. waltheri saerdabica* **syn. nov.** of *N. waltheri* (Iran, Tacht i Suleiman); 5: Paratype (labeled as Allotype) of *N. waltheri saerdabica* **syn. nov.** of *N. waltheri* (Iran, Tacht i Suleiman); 6-8: *N. waltheri* (6: Turkey, van Gölü, g.prep. 0166/2018 D. Wanke; 7: Turkey, Cavdir, g.prep. 0329/2019 D. Wanke; 8: Bulgaria, Ostrhodope, g.prep. 2140/2017 H. Rajaei); 9: Lectotype (herewith designated) of *N. palaestinensis* (Israel, Jerusalem, g.prep. 0225/2019 D. Wanke); 10: Paralectotype (herewith designated) of *N. palaestinensis* (Israel, Jerusalem, g.prep. 0226/2019 D. Wanke); 11: Lectotype of *N. persuavis* **syn. rev.** (Lebanon, Beirut, g.prep. 4065); 12: Paratype (labeled as Allotype) of *N. persuavis* **syn. rev.** (Lebanon, Beirut); 13: Paratype of *N. palaestinensis libanotica* **syn. nov.** of *N. palaestinensis* (Lebanon, Becharré); 14-17: *N. palaestinensis* (14: Jordan, at-Tafila, g.prep. 0389/2019 D. Wanke; 15: Jordan, Ajlun, g.prep. 0392/2019 D. Wanke; 16: Jordan, at-Tafila, g.prep. 0390/2019 D. Wanke; 17: Israel, Mt. Hermon, g.prep. 0242/2019 D. Wanke); 18: Paratype of *N. muelleri* (S-Jordan, Shoubak, g.prep. 5394 Hausmann); 19: Paratype of *N. muelleri* (S-Jordan, Shoubak, g.prep. 5396 Hausmann); 20: Paratype of *N. aphrodite* (Cyprus, Paphos); 21-22: *N. aphrodite* (21: Cyprus, Paphos, g.prep. 2003/2016 H. Rajaei; 22: Cyprus, Paphos, g.prep. 2004/2016 H. Rajaei;). a = upperside; b = underside. Scale-bar 1 cm.

The *waltheri* species-group

The species of this group can be diagnosed by the following characters (after Müller *et al.* 2019): In male genitalia, the costa of the valva is sclerotized up to the subapical part, humped medially (in most species); apex of ampulla superior and ampulla inferior spinose; sacculus process strongly pronounced, slender and pointed (Müller *et al.* 2019); tip of aedeagus with digitiform extension (straight or curved). In female genitalia, ductus bursae shorter than half length of corpus bursae; lamella postvaginalis conically broadened, strongly sclerotized.

The following species are included in this group: *N. waltheri* Wagner, 1919, *N. palaestinensis* Wagner, 1919, *N. muelleri* Hausmann, 1991 and *N. aphrodite* Hausmann & Wimmer, 1994.

Remarks. Two species, *N. dalmatina* and *N. waltheri* were included in the recent revision of European species (Müller *et al.* 2019). However, as *N. waltheri* is the iconic species of this group and mainly distributed outside Europe, we included this species also to the present study.

Key to the *Nychiodes waltheri* species-group based on male genitalia

1. Digitiform extension on the apical part of aedeagus straight 2
   Digitiform extension on the apical part of aedeagus curved 3
2. Costa of valva sclerotized towards centre, humped medially . . . . *N. waltheri* (fig. 89)
   Costa of valva sclerotized up to apex of valva, not humped . . . . *N. aphrodite* (fig. 95)
3. Costa of valva apically thickened. . . . . *N. palaestinensis* (figs 91, 93)
   Costa of valva apically not-thickened (rather flat). . . . . *N. muelleri* (fig. 94)

Key to the *Nychiodes waltheri* species-group based on female genitalia

Characters of female genitalia are only slightly diagnostic in this group, therefore some distributional data is added for support.

1. Ductus bursae very short, with extended sclerotized patch (in Bulgaria, eastern Greece, Turkey, northern Iran) . . . . *N. waltheri* (fig. 128)
   Clearly longer, without extended sclerotized patch (in Levant or Cyprus) 2
2. Lamella postvaginalis apically tongue shaped (on Cyprus). . . . . *N. aphrodite* (fig. 131)
   lamella postvaginalis strongly sclerotized conically extended (Palestine, northern Jordan, Lebanon, southwest Syria) . . . . *N. palaestinensis* (fig. 129)
   Lamella postvaginalis strongly sclerotized conical widely extended (in southern Jordan) . . . . *N. muelleri* (fig. 130)

***Nychiodes waltheri* Wagner, 1919**
(figs 4–8, 89, 90, 128; map 1)

Nychiodes obscuraria waltheri Wagner, 1919. Deutsche entomologische Zeitschrift Iris 33: 110 (Turkey: Istanbul). Lectotype ♂ (Turkey: Haidar-Pascha), Paralectotypes 1 ♂ 2 ♀ (in BMNH).

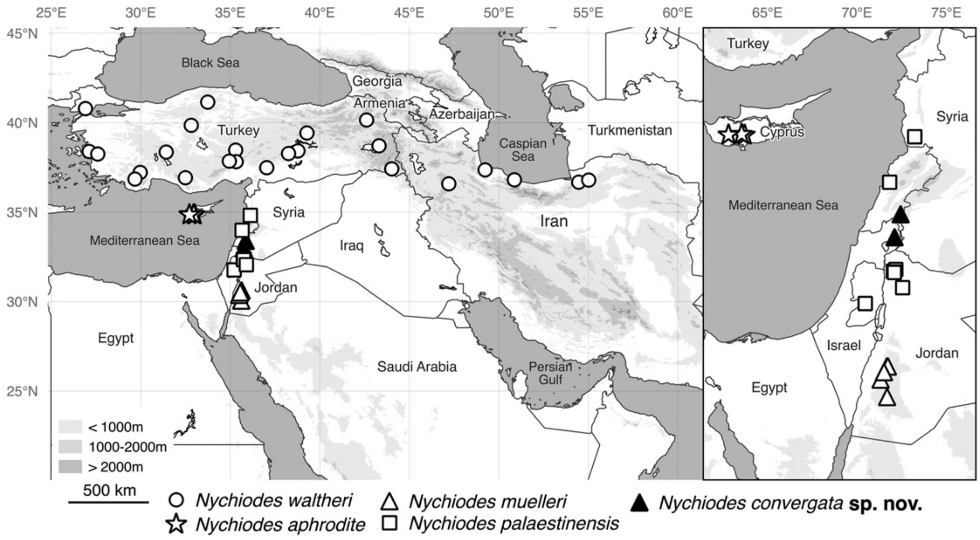
Nychiodes waltheri transcaspia Wehrli, 1929. Internationale entomologische Zeitschrift 22 (42): 386 (Turkmenistan: Ashkhabad). Holotype ♂ (in ZFMK, examined). Valid at subspecific rank in Müller *et al.* 2019. As no more material from the type locality was available we keep it valid at subspecific rank.

Nychiodes waltheri osthelderi Wehrli, 1929. Mitteilungen der Münchner entomologischen Gesellschaft 19 (2-4): 42, pl. 3, fig. 6 (Turkey: Toros Daglari, Marasch). Holotype ♂ (in ZSM, examined). Regarded as a synonym of *waltheri* in Müller *et al.* 2019.

Nychiodes waltheri syriaca Wehrli, 1929. Mitteilungen der Münchner entomologischen Gesellschaft 19(2-4): 41 (Turkish/Syrian border: Akbès). Holotype ♀ (in ZFMK, examined). Regarded as a synonym of *waltheri* in Müller *et al.* 2019.

Nychiodes waltheri saerdabica Wehrli, 1938. Entomologische Rundschau 55 (31): 355 (Iran: Tacht i Suleiman; Särdab-Tal). Syntypes 2 ♂ 1 ♀ (in ZFMK, examined). Hereby regarded as a **new synonym** of *Nychiodes waltheri* based on morphological examination and sympatric occurrence of these forms.

Nychiodes cuencaensis Leraut, 2009. Moths of Europe 146 ('Spain: Castile', mislabelled), Holotype ♀ (in MNHN, examined). Regarded as a synonym of *waltheri* in Müller *et al.* 2019.



MAP 1. Distribution patterns of *N. waltheri*, *N. palaestinensis*, *N. muelleri*, *N. aphrodite* and *N. convergata* **sp. nov.**. Rectangle: Enlarged section of the Levant.

Type material examined. *Nychiodes waltheri transcaspia* Holotype, ♂, Turkmenistan, Ashkhabad, g.prep. 4064; *N. waltheri osthelderi* Holotype, ♂, Syria sept., Taurus, Marasch, 29.vii.[19]28, 800 m, leg. L. Osthelder; *N. waltheri syriaca* Holotype ♂, Syrie, Akbès, 1896; Paratype (labeled as Allotype), 1 ♀, Syria sept., Taurus, Marasch, 15.-30.vii.[19]29; all in ZFMK.

Nychiodes waltheri saerdabica Holotype, ♂, [Iran], Persia sept., Elburs, mts.c.s., Tacht i Suleiman, Särdab Tal (Hasankif), 10-1400 m, 7.-10.vii.[19]37, leg. E. Pfeiffer & W. Forster München; Paratype (labeled as Allotype), 1 ♀, [Iran], Persia sept., Elburs, mts.c.s., Tacht i Suleiman, Särdab Tal (Hasankif), 10-1400 m, 7.-10.vii.[19]37, leg. E. Pfeiffer & W. Forster München; all in ZFMK.

Nychiodes waltheri cuencaensis Holotype, ♀, Hispania, Serrania de Cuenca, Huelamo, 7.vii.[19]60, 1400m, leg. G. Hesselbarth, g.prep. 10821 P. Leraut; in MNHN.

Additional material studied: 41 ♂, 10 ♀ (see appendix).

Diagnosis. Wingspan ♂ 35–46 mm, ♀ 41–48 mm (forewing length ♂ 21–24 mm, ♀ 23–25 mm) (figs 4–8). Wings light to dark brown, basal and terminal areas of forewing and terminal area of hindwing irrorated with red brown scales; medial area of forewing and basal and medial areas of hindwing brighter than rest of the wings (medial area of forewing and basal and medial areas of hindwings not clearly delimited in *N. palaestinensis* and *N. muelleri*; wings clearly smaller, darker and with strongly pronounced lines in *N. aphrodite*) (figs 4–22).

Male genitalia of *N. waltheri* with costa of valva sclerotized only up to the centre, medially humped (costa of valva sclerotized towards the apex, medially humped in *N. palaestinensis*, and *N. muelleri*; costa of valva sclerotized towards the apex, not humped in *N. aphrodite*) (figs 89–95). *N. waltheri* with ampulla superior twice as thick as ampulla inferior (narrowed at the centre in *N. palaestinensis*; narrowing towards the apex in *N. muelleri*; strongly curved in *N. aphrodite*). In *N. waltheri* aedeagus apically with short digitiform extension (strongly curved digitiform in *N. palaestinensis*; curved in *N. muelleri*; digitiform in *N. aphrodite*).

Female genitalia of *N. waltheri* with short and broad ovipositor (same in *N. palaestinensis* and *N. muelleri*; clearly longer in *N. aphrodite*). *N. waltheri* with apophyses anteriores 1/3 the length of apophyses posteriores (same condition in N. aphrodite; 1/4 in *N. palaestinensis*, and 1/6 in *N. muelleri*) (see figs 128–131). In *N. waltheri* lamella postvaginalis strongly sclerotized conically extended (same condition, but much wider in *N. palaestinensis*, and *N. muelleri*; lamella postvaginalis apically tongue shape in *N. aphrodite*). In *N. waltheri* ductus bursae very short with extended sclerotized patch (clearly longer, without extended sclerotized patch in *N. palaestinensis*, *N. muelleri* and *N. aphrodite*).

Phenology. Depending on the locality bi- or trivoltine, flying from late May to mid-November (Fazekas 1996, Müller *et al.* 2019).

Biology. Larvae oligophagous on Rosaceae. In captivity, bred on *Prunus spinosa*, *P. domestica*, *P. mahaleb*, *P. tenella* and *Cotoneaster* sp. (see Müller *et al.* 2019).

Habitat. Occurs in Mediterranean evergreen sclerophyllous forests, sub-Mediterranean deciduous mixed forests and Continental mixed forests and forest steppe, in altitudes up to 2000 m (Fazekas 1996, Müller *et al.* 2019).

Distribution. Distributed from Bulgaria and eastern Greece to Turkey and northern Iran (map 1).

DNA barcoding. Nearest species (minimum pairwise distances): *N. dalmatina* (6.5%), *N. amygdalaria* (6.8%) and *N. aphrodite* (6.9%) (fig. 145).

Nychiodes palaestinensis Wagner, 1919

(figs 9–17, 91–93, 129; map 1)

Nychiodes palaestinensis Wagner, 1919. Deutsche entomologische Zeitschrift Iris 33: 112. Holotype ♂ (Palestine [Israel]: Jerusalem) (in MNHU, examined).

Nychiodes palaestinensis libanotica Zerny, 1933. Deutsche entomologische Zeitschrift Iris, 47: 97. Syntypes ♂, ♀ (Lebanon). (in BMNH, examined). Hereby regarded as a **new synonym** of *Nychiodes palaestinensis* based on sympatric occurrence of these forms.

Nychiodes persuavis Wehrli, 1929. Internationale Entomologische Zeitschrift 22 (42): 385. Syntypes 1 ♂, 1 ♀ ([Lebanon]: Beirut) (in ZFMK, examined). Regarded as synonym of *Nychiodes palaestinensis* by Zerny (1933), herewith we confirm it.

Type material examined. *Nychiodes palaestinensis* Lectotype (herewith designated), ♂, Palaestina, (Jerusalem), 1898, leg. J. Paulus, g.prep. 0225/2019 D. Wanke; Paralectotype (herewith designated), ♀, Palaestina, (Jerusalem), 1898, leg. J. Paulus, g.prep. 0226/2019 D. Wanke; all in MNHU.

Nychiodes palaestinensis libanotica Paratype ♂, Nord Libanon, Becharré, 1400 m, 3.-10.vi.[19]31, Zerny; in BMNH.

N. persuavis Lectotype (designated by Wehrli), ♂, [Lebanon], Beirut, genital prep. 4065; Paralectotype, 1 ♀, [Lebanon], Beirut; all in ZFMK.

Additional material studied: 21 ♂, 15 ♀ (see appendix).

Diagnosis. Wingspan ♂ 33–40 mm, ♀ 32–45 mm (forewing length ♂ 22–25 mm, ♀ 20–26 mm) (figs 9–17). In *N. palaestinensis* wings light brown, orange brown to chocolate brown, transverse lines faint, medial area of forewing and basal and medial areas of hindwings are not clearly delimited (light brown, medial area of forewing and basal and medial areas of hindwings are not clearly delimited in *N. muelleri*; light to dark brown, basal and terminal areas of forewing and terminal area of hindwing irrorated with red brown scales; medial area of forewing and basal and medial areas of hindwing brighter than rest of the wings in *N. waltheri*; light to chocolate brown, transverse lines strongly pronounced in *N. aphrodite*) (figs 4–22).

On male genitalia, *N. palaestinensis* has a costa of valva sclerotized towards the apex, medially humped (same condition in *N. muelleri*; costa of valva sclerotized only up to the middle, medially humped *N. waltheri*; sclerotized towards the apex, not humped in *N. aphrodite*) (figs 89–95). *N. palaestinensis* with ampulla superior narrowed at the centre (narrowing towards the apex in *N. muelleri*; ampulla superior twice as thick as ampulla inferior in *N. waltheri*; strongly curved in *N. aphrodite*). *N. palaestinensis* aedeagus apically with strongly curved digitiform extension (extension curved in *N. muelleri*; extension digitiform, not curved in *N. waltheri* and *N. aphrodite*).

Female genitalia of *N. palaestinensis* with short and broad ovipositor (the same in *N. muelleri* and *N. waltheri*; clearly longer in *N. aphrodite*). *N. palaestinensis* with apophyses anteriores one fourth length of apophyses posteriores (1/6 in *N. muelleri*; 1/3 in *N. waltheri* and *N. aphrodite*) (see figs 128–131). In *N. palaestinensis* lamella postvaginalis strongly sclerotized, conically extended (same condition, but much wider in *N. muelleri* and much narrower in *N. waltheri*; lamella postvaginalis apically tongue-shaped in *N. aphrodite*). In *N. palaestinensis* ductus bursae long, without extended sclerotized patch (same condition in *N. muelleri* and *N. aphrodite*; very short with extended sclerotized patch in *N. waltheri*).

Phenology. Univoltine, from April to June.

Biology. Unknown.

Habitat. In altitudes from 500 up to 1000m.

Distribution. Restricted to the Levant (Israel, Palestine, northern Jordan, few records from Lebanon and southwestern Syria) (map 1).

DNA barcoding. Nearest species (minimum pairwise distances): *N. dalmatina* (5.9%), *N. waltheri* (6.9%) and *N. aphrodite* (6.9%) (fig. 145). No barcoding data of *N. muelleri* is available.

Nychiodes muelleri **Hausmann, 1991**

(figs 18, 19, 94, 130; map 1)

Nychiodes muelleri Hausmann, 1991. Mitteilungen der Münchner Entomologischen Gesellschaft 81: 140. Holotype ♂ (Jordan (central): Shaubak) (in ZSM, examined).

Type material examined. Holotype, ♂, S-Jordanien, Schauback [Shobak], 24.v.1968, leg. J. Klapperich; Paratypes, 1 ♂, same locality, 4.v.1968, leg. J. Klapperich; 1 ♂, 3 ♀, same locality, 17.v.1968, leg. J. Klapperich, g.prep. (♀) 5396 Hausmann; 8 ♂, 3 ♀, S-Jordanien, Schauback [Shobak], 24.v.1968, leg. J. Klapperich, (♂) g.preps 5394 Hausmann, 5395 Hausmann, 14416 Hausmann, (♀) g.prep. 5396 Hausmann; all in ZSM.

Diagnosis. Wingspan ♂ 42 mm, ♀ 45 mm (forewing length ♂ 23 mm, ♀ 25 mm) (figs 18, 19).

Wings light brown, transverse lines faint, medial area of forewing and basal and medial areas of hindwings are not clearly delimited (light brown, orange brown to chocolate brown, medial area of forewing and basal and medial areas of hindwings are not clearly delimited in *N. palaestinensis*; light to dark brown, basal and terminal areas of forewing and terminal area of hindwing irrorated with red brown scales; medial area of forewing and basal and medial areas of hindwing brighter than rest of the wings in *N. waltheri*; light to chocolate brown, transverse lines strongly pronounced in *N. aphrodite*) (figs 4–22).

Male genitalia of *N. muelleri* with costa of valva sclerotized towards the apex, medially humped (same condition in *N. palaestinensis*; costa of valva sclerotized only up to the centre, medially humped *N. waltheri*; sclerotized towards the apex, not humped in *N. aphrodite*) (figs 89–95). *N. muelleri* with ampulla superior narrowing towards the apex (ampulla superior narrowed at the centre in *N. palaestinensis*; ampulla superior twice as thick as ampulla inferior in *N. waltheri*; strongly curved in *N. aphrodite*). *N. muelleri* aedeagus apically with curved digitiform extension (aedeagus apically with a strongly curved digitiform extension in *N. palaestinensis*; digitiform, not curved in *N. waltheri* and *N. aphrodite*).

Female genitalia of *N. muelleri* with short and broad ovipositor (same in *N. palaestinensis* and *N. waltheri*; clearly longer in *N. aphrodite*). *N. muelleri* with apophyses anteriores 1/6 length of apophyses posteriores (1/4 in *N. palaestinensis*; 1/3 in *N. waltheri* and *N. aphrodite*) (see figs 128–131). In *N. muelleri* lamella postvaginalis strongly sclerotized conically extended (same condition, but slightly narrower in *N. palaestinensis* and much narrower in *N. waltheri*; lamella postvaginalis apically tongue-shaped in *N. aphrodite*). In *N. muelleri* ductus bursae fairly long, without extended sclerotized patch (same condition in *N. palaestinensis* and *N. aphrodite*; very short with extended sclerotized patch in *N. waltheri*).

Phenology. Scarce data from early to late May.
Biology. Unknown.
Habitat. In altitudes from 1000 up to 1660 m.
Distribution. Endemic species in southern Jordan (see map 1).
DNA barcoding. No data available.
Taxonomic Remark. There are only few morphological differences between *N. muelleri* and *N. palaestinensis* (its hypothetical sister species). For this species, only the type specimens were available. The status of this species needs further clarification, by means of DNA barcoding of the holotype of *N. muelleri*.

Nychiodes aphrodite Hausmann & Wimmer, 1994
(figs 20–22, 95, 131; map 1)

Nychiodes aphrodite Hausmann & Wimmer, 1994. Zeitschrift der Arbeitsgemeinschaft der österreichischen Entomologen 46: 90. Holotype ♂ (Cyprus: Paphos) (in ZSM, examined).

Type material examined. Holotype, ♂, Zypern, Paphos, e.o. 3.viii.1989, leg. J. Wimmer; Paratypes, 3 ♂, 2 ♀, Zypern, Paphos, e.o., 1.-3.viii.1989, leg. J. Wimmer; in ZSM.
Additional material studied: 2 ♂, 3 ♀ (see appendix).
Diagnosis. Wingspan ♂ 29–32 mm, ♀ 34–42 mm (forewing length ♂ 16–21 mm, ♀ 19–23 mm) (figs 20–22). Wings light to chocolate brown, transverse lines strongly pronounced (light to dark brown, basal and terminal areas of forewing and terminal area of hindwing irrorated with red brown scales, medial area of forewing and basal and medial areas of hindwing brighter than rest of the wings in *N. waltheri*; light brown, orange brown to chocolate brown, transverse lines faint, medial area of forewing and basal and medial areas of hindwings are not clearly delimited in *N. muelleri* and *N. palaestinensis*) (figs 4–22).
Male genitalia of *N. aphrodite* with costa of valva sclerotized towards the apex, not humped (costa of valva sclerotized only up to the centre, medially humped *N. waltheri*; costa of valva sclerotized towards the apex, medially humped in *N. muelleri* and *N. palaestinensis*) (figs 89–95). *N. aphrodite* with strongly curved ampulla superior (ampulla superior twice as thick as ampulla inferior in *N. waltheri*; ampulla superior narrowing towards the apex in *N. muelleri*; ampulla superior narrowed at the centre in *N. palaestinensis*). In *N. aphrodite* aedeagus apically with a straight digitiform extension (same condition in *N. waltheri*; digitiform extension curved in *N. muelleri*; strongly curved in *N. palaestinensis*).
Female genitalia of *N. aphrodite* with an elongated ovipositor (short and broad ovipositor in *N. waltheri*, *N. palaestinensis* and *N. muelleri*). Apophyses anteriores 1/3 length of apophyses posteriores (same condition in *N. waltheri*; 1/4 in *N. palaestinensis*; 1/6 in *N. muelleri*) (see figs 128–131). Lamella postvaginalis apically tongue-shaped (strongly sclerotized, conically extended, apically not tongue-shaped in *N. waltheri*, *N. muelleri*, *N. palaestinensis*). Ductus bursae fairly long, without extended sclerotized patch (same condition in *N. palaestinensis* and *N. muelleri*; very short with extended sclerotized patch in *N. waltheri*).
Phenology. Flying in the natural habitat during May. A second generation has been observed in breeding experiments, which probably flies during august (Hausmann 1994).
Biology. Larva bred on Rosaceae (*Crataegus* sp., *Prunus spinosa*). Occurrence of Mediterranean *Crataegus* sp. in their natural habitats may be an indication on being the natural food plants (see Hausmann 1994).
Habitat. In altitudes from 390 up to 850 m.
Distribution. Endemic species on Cyprus (Hausmann, 1994) (map 1).
DNA barcoding. Nearest species (minimum pairwise distances): *N. waltheri* (6.9%) (fig. 145).

The *amygdalaria* species-group

The species of this group can be diagnosed by the following characters (after Müller *et al.* 2019): In male genitalia, costa of valva sclerotized up to apex, usually straight (humped only in few species, see below); apex of ampulla superior and inferior spinose; sacculus process absent; tip of aedeagus without clear extension. In female genitalia, lamella postvaginalis antero-posteriorly broadened, strongly sclerotized.

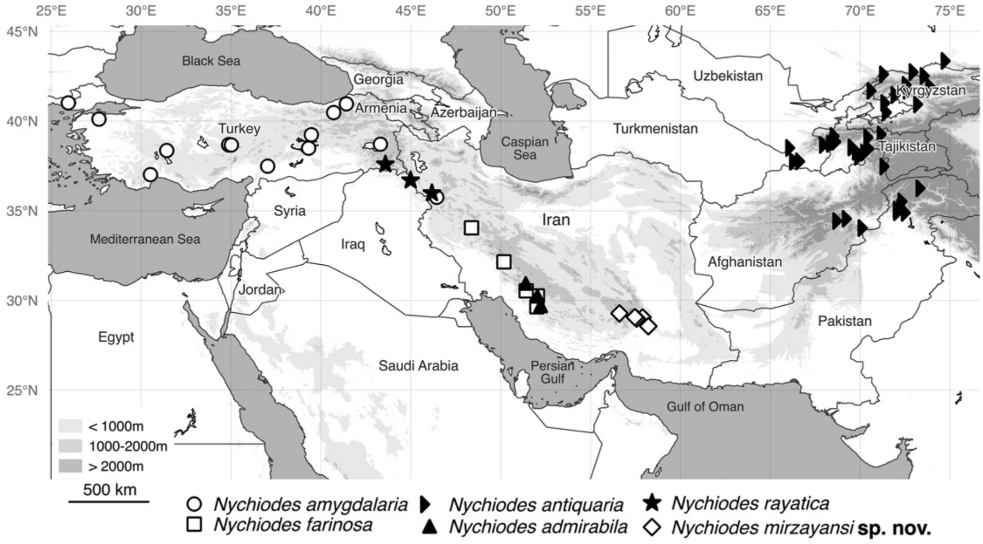
The following species are included in this group: *N. amygdalaria* (Herrich-Schäffer, 1848), *N. dalmatina* Wagner, 1909, *N. farinosa* Brandt, 1938, *N. antiquaria* Staudinger, 1892, *N. princeps* Wiltshire, 1966, *N. quettensis* Wiltshire, 1966, *N. admirabila* Brandt, 1938, *N. rayatica* Wiltshire, 1957, *N. subfusca* Brandt, 1938, *N. leviata* Brandt, 1938, *N. subvirida* Brandt, 1938, *N. divergaria* Staudinger, 1892, *N. convergata* **sp. nov.**, *N. eberti* **sp. nov.**, *N. mirzayansi* **sp. nov.**.

Nychiodes amygdalaria **(Herrich-Schäffer, 1848)**
(figs 23–25, 96, 97, 132; map 2)

Boarmia amygdalaria Herrich-Schäffer, 1848. Systematische Bearbeitung der Schmetterlinge von Europa (31): 82. Syntype(s) ([Greece]: Crete).

Nychiodes amygdalaria almensis Wehrli, 1941 In: Seitz, A. (Ed.), Die Großschmetterlinge der Erde. Supplement zu Band 4: 441. Syntype(s) 1 ♂, 1 ♀ (Syria; Lebanon; Palestine) (in ZFMK, examined). Regarded as a synonym of *amygdalaria* in Müller *et al.* 2019.

Nychiodes amygdalaria malatyaca Wehrli, 1941 In: Seitz, A. (Ed.), Die Großschmetterlinge der Erde. Supplement zu Band 4: 441. Holotype ♂, Paratype 1 ♂ (Turkey: Malatya-Tecde), (in ZFMK, examined). Regarded as a synonym of *amygdalaria* in Müller *et al.* 2019.

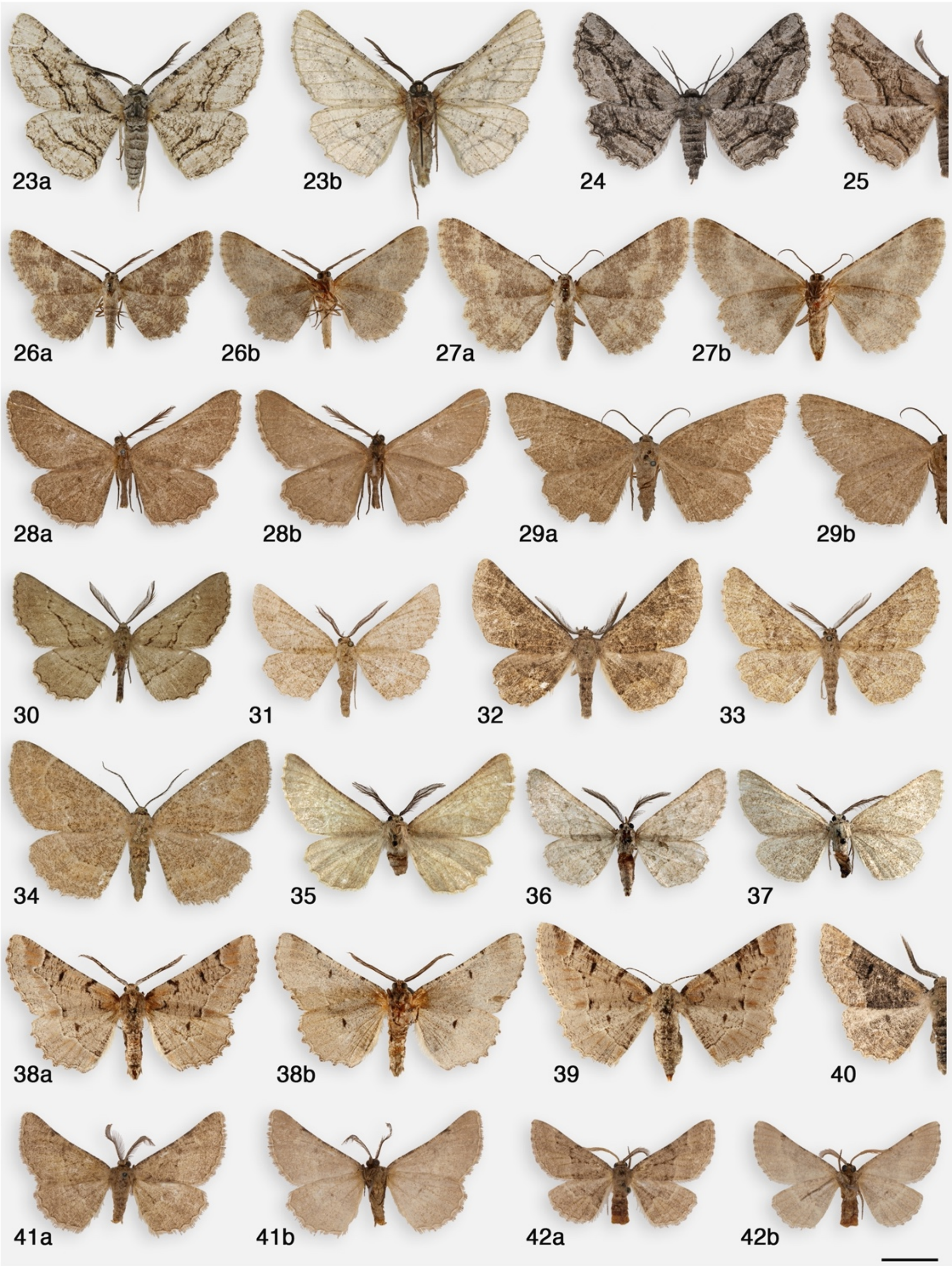


MAP 2. Distribution patterns of *N. amygdalaria*, *N. farinosa*, *N. antiquaria*, *N. admirabila*, *N. rayatica* and *N. mirzayansi* **sp. nov.**.

Type material examined. *Nychiodes amygdalaria almensis* Syntype, 1 ♂, Syria sept, Amanus mts., Düldül Dagh, viii.[19]30, leg. Eing. Slr.; 1 ♀, Syria s., Amanus s., Düldül Dagh, Jeschil dere, viii.[19]34, coll. E. Pfeiffer; all in ZFMK.

Nychiodes amygdalaria malatyaca Holotype, 1 ♂, Asia minor, Malatya-Tecde, 17.ix.[year missing]; in ZFMK.

Material studied: 20 ♂, 2 ♀ (see appendix).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42a
42b

FIGURES 23-42. Wing coloration and pattern of *Nychiodes* species. 23-25: *N. amygdalaria* (23: Iran, Kordestan, g.prep. 0153/2018 D. Wanke; 25: Turkey, Aksehir, g.prep. 2089/2017 H. Rajaei); 26: Holotype of *N. farinosa* (Iran, Fars, g. prep. 10924); 27: Paratype (labeled as Allotype) of *N. farinosa* (Iran, Fars, g.prep. 10925); 28: Paralectotype (herewith designated) of *N. antiquaria* (Uzbekistan, Margelan); 29: Lectotype (herewith designated) of *N. antiquaria* (Uzbekistan, Namangan, g.prep. 0227/2019 D. Wanke); 30-34: *N. antiquaria* (30: Afghanistan, Safed Koh, g.prep. 0159/2018 D. Wanke; 31: Afghanistan, Tang i Gharu, g.prep. 0136/2018 D. Wanke; 32: Kyrgyzstan, Kyzyl-Oi, g.prep. 0326/2019 D. Wanke; 33: Uzbekistan, Maydan, g.prep. 0096/2018 D. Wanke; 34: Pakistan, Swat, g.prep. 0430/2019 D. Wanke); 35: Holotype of *N. princeps* (Afghanistan, Band-i-Amir, g.prep. WW36); 36: Holotype of *N. quettensis* (Pakistan, Quetta); 37: Paratype of *N. quettensis* (Pakistan, Quetta, g.prep. WW223); 38: Paratype of *N. admirabila* (Iran, Fars, g.prep. 10920); 39: Paratype of *N. admirabila* (Iran, Fars, g.prep. 10921); 40: *N. admirabila* (Iran, Kohkiluye va Boyerahmad, g.prep. 0301/2019 D. Wanke); 41: Holotype of *N. rayatica* (Iraq, Rayat, g.prep. 11019); 42: Paratype of *N. rayatica* (Iraq, Rayat, Präparat E.P. Wiltshire 889). a = upperside; b = underside. Scale-bar 1 cm.

Diagnosis. Wingspan ♂ 31–46 mm, ♀ 38–47 mm (forewing length ♂ 16–26 mm, ♀ 22–26 mm). Regarding its geographic distribution, (see map 2), wing pattern and colour, *Nychiodes amygdalaria* cannot be confused with any other *Nychiodes* species. Ground colour of wings light to dark ivory, with some grey brown highlights; transverse lines well pronounced (see figs 23–25). Male genitalia (figs 96, 97) with uncus very large in lateral view, broad at base, curved and slightly thickened dorsally. The most important diagnostic character of this species is the shape of the costa of valva, which is strongly sclerotized and swollen over the apical part of valva (fig. 96a). Cornutus very short, one third length of aedeagus (this condition is similar only in *N. convergata* **sp. nov.,** but the latter species shows completely different external and internal character combination, see the description and diagnosis of this new species).

Female genitalia of *N. amygdalaria* (fig. 132) extremely large, with ovipositor characteristically elongated (more than in the other *Nychiodes* species). The only species with similar female genitalia is *N. admirabila*. In *N. amygdalaria* length of apophyses anteriores half length of apophyses posteriores, lamella postvaginalis anteriorly and posteriorly extended (apophyses anteriores one fourth length of apophyses posteriores, lamella postvaginalis quadratic, posteriorly concave in *N. admirabila*). Furthermore, *N. amygdalaria* and *N. admirabila* show non-overlapping distribution patterns.

Phenology. Uni- or bivoltine, flying from mid-May to late September (Müller *et al.* 2019).

Biology. Larva oligophagous on Rosaceae, reared on *Prunus spinosa*, *P. domestica* and *Crataegus* sp. (Müller *et al.* 2019).

Habitat. Open woodlands (Müller *et al.* 2019). Occurs from sea-level up to 2150 m.

Distribution. From eastern Europe (Balkan Peninsula) to Turkey, Georgia, Armenia and westernmost part of Iran (new record for Iran) (map 2).

DNA barcoding. Nearest species (minimum pairwise distances): *N. eberti* **sp. nov.** (6.5%), *N. subfusca* (6.6%), *N. mauretanica* (6.6%), *N. admirabila* (6.8%) and *N. waltheri* (6.8%) (fig. 145).

Nychiodes farinosa Brandt, 1938

(figs 26, 27, 98, 99, 133; map 2)

Nychiodes farinosa Brandt, 1938. Entomologische Rundschau, 55 (51), 37. Holotype ♂, ([Iran]: Comèe [Komehr]) (in NHRS, examined).

Type material examined. Holotype, ♂, Iran, Fars, Straße Ardekan-Talochosroe [Tall Khosrow], Comèe [Komehr], ca. 2600 m, 30.vi.1937, coll. Brandt, g.prep. 10924; Paratypes, 1 ♀, same locality, 3.vii.1937, coll. Brandt (labeled as Allotype), g.prep. 10925; 1 ♂, same locality, 26.vi.1937, coll. Brandt; all in NHRS. 1 ♂, same locality, 30.vi.1937, coll. Brandt; in ZFMK.

Additional material studied: 11 ♂, 2 ♀ (see appendix).

Diagnosis. Wingspan ♂ 30–35 mm, ♀ 37–43 mm (forewing length ♂ 19–21 mm, ♀ 21–24 mm) (figs 26, 27). Externally, the colour combination of *N. farinosa* can be confused with that of *N. subvirida*, both with yellow- to light brown wings, intermixed with darker brown. In *N. farinosa* basal and postmedial areas lighter than medial and subterminal areas; postmedial line yellow, thick, without clear border from subterminal area (in *N. subvirida*, basal, medial and subterminal areas concolorous; postmedial line yellow, thin, clearly bordered from subterminal area) (see figs 26, 27 and 47–51). Additionally, *N. subvirida* shows completely different male and female genitalia (see figs 98, 99 and 110–112).

In male genitalia (fig. 98), uncus short, in lateral view curved (fig. 99), which is similar to that of *N. antiquaria* and *N. subfusca* (both of species show different character combinations in wings (figs 28–34 and 43, 44) and genitalia (figs 100, 101, 106, 107). Diagnostic features of male genitalia of *N. farinosa* from other similar species: In *N. farinosa* valva narrow, with both ampullae located apically, in the upper third of the valva, sacculus straight (valva broad, with both ampullae located in medial part of valva, sacculus curved outwards in *N. antiquaria* and *N. princeps*) (figs 98, 100, 102). The endemic Pakistanian species *N. quettensis* shows a completely different wing pattern (fig. 36, 37) but shares a similar male genitalia capsule with *N. farinosa*, however, the latter having a shorter and thicker aedeagus (very thin and long in *N. quettensis*) (figs 98, 103).

Female genitalia of *N. farinosa* (fig. 133) are reminiscent of those of *N. subvirida* (figs 138–140), the latter species with reduced anteriores apophyses.

Three other species occur sympatric with *N. farinosa*: *N. admirabila* (characterized by a unique wing pattern with light brown wings and prominent markings in the medial area and black transverse lines, figs 23–25), *Nychiodes leviata* (rather small wingspan, with dark brown to black medial area on forewing, and strongly differing male and female genitalia, figs. 45, 46, 108,) and *N. divergaria* (highly variable species, but easily diagnosed based on both male and female genitalia, see figs 113–119, 141, 142).

Phenology. Univoltine, from May to July.

Biology. Unknown.

Habitat. In altitudes from 1850 up to 2800 m.

Distribution. Endemic species in Iran, in the western part of the Zagros Mountains (map 2).

DNA barcoding. Nearest species (minimum pairwise distances): *N. leviata* (5.9%) (fig. 145).

Nychiodes antiquaria Staudinger, 1892

(figs 28–34, 100, 101, 134; map 2)

Nychiodes antiquaria Staudinger, 1892. Deutsche Entomologische Zeitschrift Iris 5, 171. Syntypes 1♂ 2♀ ([Central Asia]: Namangan, Margelan, Samarkand) (in MNHU, examined).

Phthonandria confusa Warren, 1902. Novitates zoologicae: a journal of zoology in connection with the Tring Museum 9, 367. Holotype ♂ ([Pakistan]: Chitral). Regarded as a junior synonym by Wehrli 1929c.

Nychiodes antiquarius. Incorrect subsequent spelling in Viidalepp, 1996. Checklist of the Geometridae (Lepidoptera) of the former U.S.S.R. Apollo Books, Stenstrup, 111 pp.

Type material examined. Lectotype (herewith designated), ♀, Origin, [Uzbekistan], Margelan, g.prep. 0227/2019 D. Wanke; Paralectotype (herewith designated), 1 ♂, Typus, Origin, [Uzbekistan], Namangan, [18]84, [last segments of abdomen with genitalia missing]; all in MNHU.

Additional material studied: 106 ♂, 39 ♀ (see appendix).

Diagnosis. Wingspan ♂ 33–45 mm, ♀ 37–46 mm (forewing length ♂ 18–25 mm, ♀ 20–26 mm) (figs 28–34). Ground colour of wings highly variable from bright yellow and light brown to darker brown (figs 28–34), easily confused with many other *Nychiodes* species. However, unique male and female genitalia (figs 100, 101) of *N. antiquaria* and its distribution pattern (only in most eastern part of Central Asia) differentiate this species from all other congeners.

Male genitalia slightly variable (also within populations), but always showing a similar ground plan, characterized by the apical part of costa of valva, exceeding apex of valva (fig. 100). This pattern is similar to that of *N. rayatica*, *N. convergata* **sp. nov.** and *N. eberti* **sp. nov.**, but all these species differ in the character combination of the ampulla superior and inferior (see figs 100, 105, 120–124). Moreover, the aedeagus of *N. antiquaria* is characteristically long and the length of the cornutus is longer than half length of aedeagus. In female genitalia (fig. 134), *N. antiquaria* has a characteristically large corpus bursae compared with that of *N. subfusca*, but these two species can be diagnosed based on the length of apophyses anteriores (figs 134, 136).

Phenology. Flying from May to September.

Biology. Unknown.

Habitat. In altitudes from 550 up to 2350 m.

Distribution. Distributed in south-eastern Uzbekistan, western Tajikistan, in the north to western Kyrgyzstan and south-eastern Kazakhstan, in the south to eastern Afghanistan and northern Pakistan (new record for the fauna of Pakistan) (map 2). Wehrli (1929c) stated a distribution also in northern India and Kashmir, but we had no material to confirm this hypothesis.

DNA barcoding. Nearest species (minimum pairwise distances): *N. subfusca* (5.4%) and *N. admirabila* (5.8%) (fig. 145).

Nychiodes princeps Wiltshire, 1966

(figs 35, 102; map 3)

Nychiodes princeps Wiltshire, 1966. Zeitschrift der Wiener entomologischen Gesellschaft, 51, 142. Holotype ♂ (Afghanistan: Band-i-Amir), (in NHMV, examined).

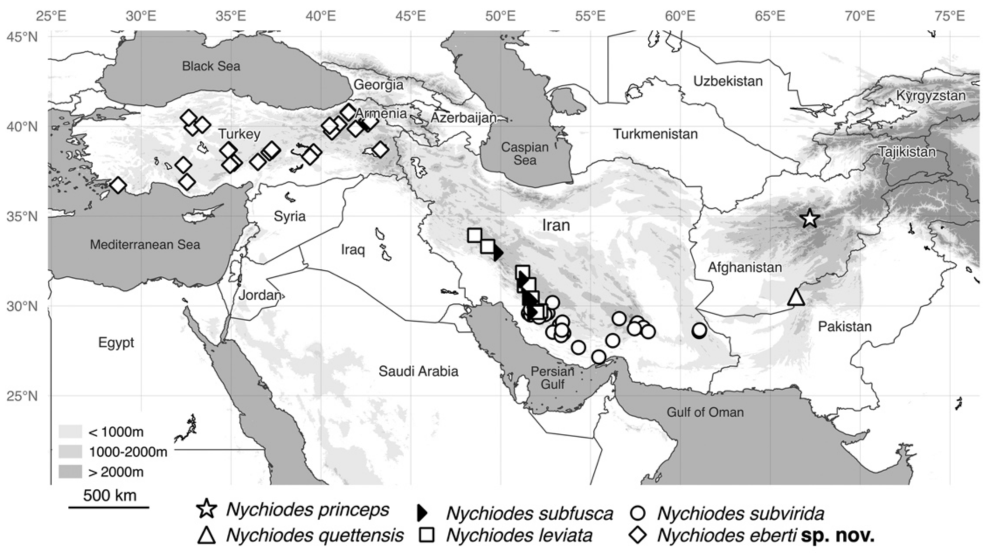
Type material examined. Holotype, ♂, Afghanistan, 30.vii.1963, centr[al], Band-i-Amir, 3000 m, leg. Kasy & Vartian, [genital] preparation WW-36; in NHMV.

Diagnosis. For this species, only the holotype is available, therefore a confidential diagnosis is not possible. However, the holotype shows clear diagnostic characters, which we present here. Wingspan ♂ 41 mm (fig. 35). Ground colour of wings pale yellow, slightly suffused with grey. Based on its geographic distribution, this species can be confused with *N. quettensis* and *N. antiquaria*, but all of these species show different genitalia patterns. In male genitalia these three species can be diagnosed based on the apex of costa of valva (exceeding apex of valva in *N. antiquaria*, in contrast to *N. princeps*, *N. quettensis*) (figs 100–103). *N. princeps* and *N. quettensis* can be separated based on the aedeagus/cornutus ratio, which is clearly larger in *N. quettensis* (see figs 102b, 103b). Female genitalia of *N. princeps* unknown.

Phenology, biology and habitat. Unknown.

Distribution. Only known from the type locality in central Afghanistan (map 3). Distribution in Afghanistan, needs further investigation.

DNA barcoding. No data available.



MAP 3. Distribution patterns of *N. princeps*, *N. quettensis*, *N. subfusca*, *N. leviata*, *N. subvirida* and *N. eberti* **sp. nov.**.

***Nychiodes quettensis* Wiltshire, 1966**
(figs 36, 37, 103; map 3)

Nychiodes quettensis Wiltshire, 1966. Zeitschrift der Wiener entomologischen Gesellschaft, 51, 142. Holotype ♂ (Pakistan: 80 km NW von Quetta), (in NHMV, examined).

Type material examined. Holotype, ♂, Pakistan, 15.v.1965, 80 km NW v. Quetta, 2100 m, leg. Kasy & Vartian. Paratype, 1 ♂, same locality, leg. Kasy & Vartian, [genital] preparation WW-223; in NHMV.

Diagnosis. Wingspan ♂ 34–36 mm. Ground colour of wings pale yellowish grey (figs 36, 37). For this species, only the type series is available, showing, however, clear diagnostic characters (see diagnosis of *N. princeps*). Female genitalia of *N. quettensis* unknown.

Phenology, biology and habitat. Unknown.

Distribution. Only known from the type locality in Pakistan (map 3). Distribution in Pakistan needs further investigation.

DNA barcoding. No data available.

***Nychiodes admirabila* Brandt, 1938**
(figs 38–40, 104, 135; map 2)

Nychiodes admirabila Brandt, 1938. Entomologische Rundschau 55 (51): 36. Holotype ♂ ([Iran]: Fort Sine-Sefid, Comèe) (in NHRS, examined).
Nychiodes admirabila safidaria Wiltshire, 1943. Journal of the Bombay Natural History Society, Bombay, 43, 633, (in BMNH). Hereby regarded as a **new synonym** of *Nychiodes admirabila* based on sympatric occurrence of these forms.
Nychiodes admirabilis Wiltshire, 1943. Journal of the Bombay Natural History Society, Bombay, 43, 632. Incorrect subsequent spelling.

Type material examined. Paratypes, 1 ♂, Iran, Fars, Straße Chiraz Kazeroun, Fort Sine-Sefid, ca. 2200 m, 16.vi.1937, coll. Brandt, g.prep. 10920; 1 ♀, [labeled as allotype], Fars, Straße Chiraz Kazeroun, Fort Sine-Sefid, Comee [Komehr], ca. 2600 m, 30.vii.1937, coll. Brandt, g.prep. 10921; all in NHRS. 1 ♂, same locality, ca. 2200 m, Sept.1937, coll. Brandt; 2 ♂, I same locality, ca 2600 m, Juli.1937, coll. Brandt; 1 ♂, same locality, 2.viii.1937, coll. Brandt; all in ZFMK. 1 ♂, same locality, ca. 2200 m, 10.ix.1937, coll. Brandt; in ZSM.

Additional material studied: 3 ♂ (see appendix).

Diagnosis. Wingspan ♂ 40–41 mm, ♀ 45 mm (forewing length ♂ 20–21 mm, ♀ 23 mm) (figs 38–40). Wing colour and pattern characteristic, no confusion possible with any other *Nychiodes* species. Ground colour of wings light brown, with ochre-red scales in basal and subterminal areas, medial area grey-brown intermixed with dark brown to black scales, discal spots on all wings dark brown to black, exceptionally large (figs 38, 39). In rare cases medial area covered with black scales (fig. 40). Male genitalia of *N. admirabila* are very large and show clear diagnostic characters for a discrimination from the species occurring in southern and south-western Iran species (*N. farinosa*, *N. subfusca*, *N. leviata*, *N. subvirida* and *N. divergaria*): in *N. admirabila* costa of valva medially humped (not humped in *N. farinosa*, *N. subfusca*, *N. leviata* and *N. divergaria*; humped in *N. subvirida*) (see figs 98, 104, 106, 108, 113–119). *N. admirabila* with ampulla inferior stout and curved (small, not curved in *N. subvirida*) (figs 104, 110, 111). Female genitalia of *N. admirabila* with a characteristic quadratic, apically concave lamella postvaginalis (antero-posteriorly extended in *N. subvirida*, and *N. divergaria*; not extended in *N. farinosa*; rounded with foldings in *N. subfusca*; not extended, small in *N. leviata*). In *N. admirabila* apophyses anteriores 1/4 length of apophyses posteriores (1/3 in *N. farinosa* and *N. leviata*; 1/9 in *N. subfusca*; apophyses anteriores strongly reduced in *N. subvirida* and *N. divergaria*) (see figs 135–142).

Phenology. Flying from May to September.

Biology. Unknown.

Habitat. In altitudes from 1890 up to 2800 m.

Distribution. Distributed in south-western Iran (map 2).

DNA barcoding. Nearest species (minimum pairwise distances): *N. subfusca* (5.1%), *N. eberti* **sp. nov.** (5.8%) and *N. antiquaria* (5.8%) (fig. 145).

***Nychiodes rayatica* Wiltshire, 1957**
(figs 41, 42, 105; map 2)

Nychiodes rayatica Wiltshire, 1957. The Lepidoptera of Iraq, 111. Holotype ♂, Paratypes 2 ♂ (Iraq, Haj Omran), (in BMNH, examined).

Type material examined. Holotype, ♂, Iraq, Kurdistan, Rayat, 24.vi.[19]35, E.P. Wiltshire, Geometridae genitalia slide No. 11019; Paratype, 1 ♂, Iraq, Rayat, Haj Omran, 5000-6000 ft. [1524-1829 m], larva 2-13.vi.[19]56, hatched 1.vii.[19]56, E.P. Wiltshire; all in BMNH.

Additional material studied: 2 ♂ (see appendix).

Diagnosis. Wingspan ♂ 33–35 mm (Wiltshire (1957) measured 38–40 mm) (forewing length ♂ 18–21) (figs 41, 42). Ground colour of wings beige to light brown with slightly darker basal and medial areas. The species can be confused, in external appearance, with several *Nychiodes* species (*N. antiquaria*, *N. divergaria, N. leviata, N. convergata* **sp. nov.** and *N. eberti* **sp. nov.**), but unique male genitalia of *N. rayatica* differentiate it from all the others (examination of male genitalia is necessary for reliable identification). The male genitalia of *N. rayatica* is characterized by a large and broad apical part of the costa of valva, which is exceeding the apex of the valva (see fig. 105), this character is similar in *N. antiquaria*, *N. convergata* **sp. nov.** and *N. eberti* **sp. nov.**, but all these species differ in the shape of ampulla superior and inferior (see figs 100, 120–123). Furthermore, the aedeagus of *N. rayatica* is very small and short compared to those in *N. antiquaria*, *N. convergata* **sp. nov.** and *N. eberti* **sp. nov.** (figs 100b, 105b, 120b–123b). Female genitalia of *N. rayatica* are unknown.

Phenology. Univoltine (Wiltshire 1957). Specimens collected during June and July.

Biology. Larva recorded on *Amygdalus* sp. (Wiltshire 1957).

Habitat. Recorded in altitudes from 1524 up to 2300 m.

Distribution. Wiltshire (1957) suggested an occurrence of this species on neighbouring mountains in north-western Iran and eastern Turkey, which we confirmed here. Recorded in Iraq, eastern Turkey and here we report this species from north-western Iran as a new element for the fauna of this country (map 2).

DNA barcoding. No data available.

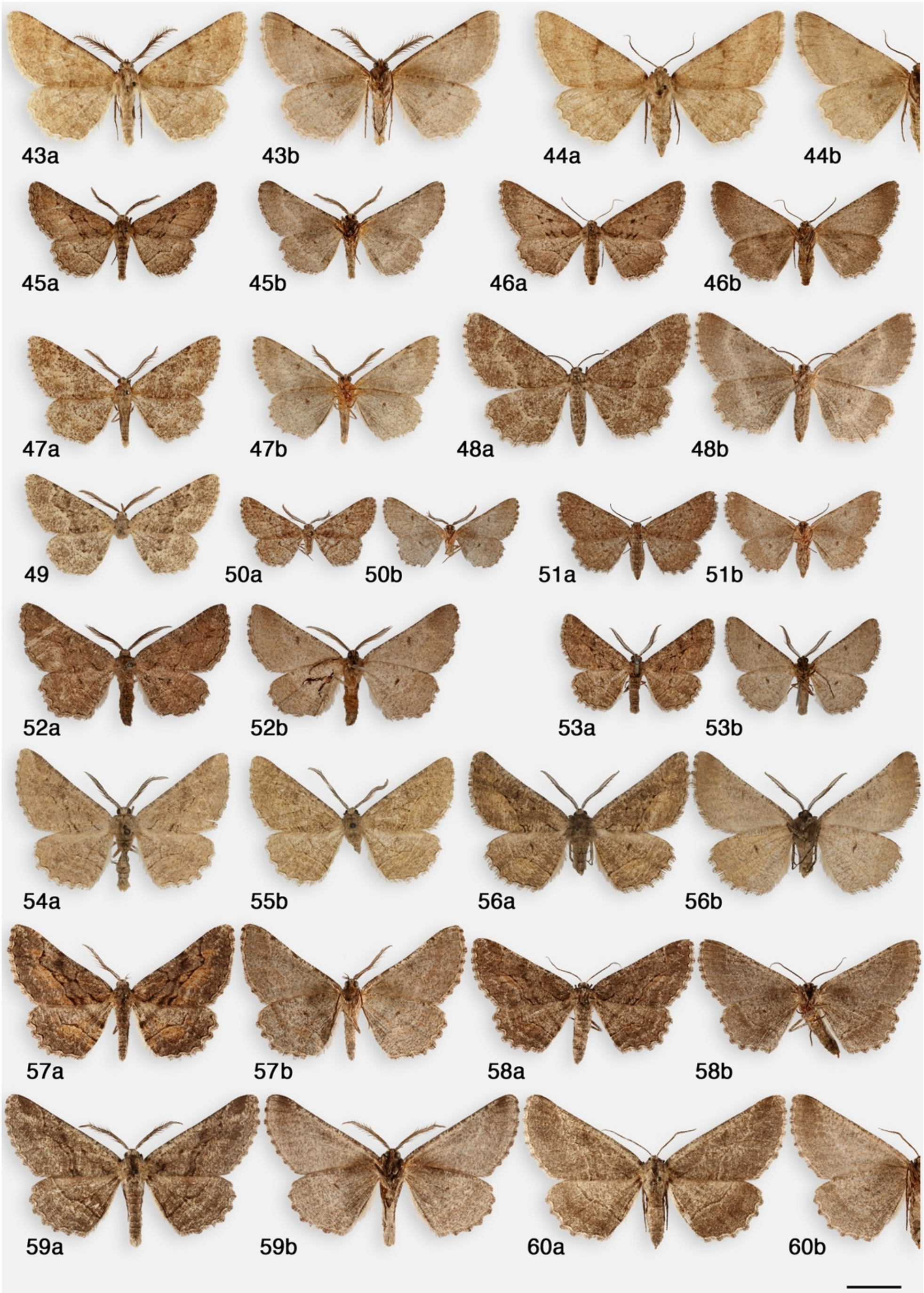
***Nychiodes subfusca* Brandt, 1938**
(figs 43, 44, 106, 107, 136; map 3)

Nychiodes subfusca Brandt, 1938. Entomologische Rundschau, 55 (51), 36. Holotype ♂ ([Iran]: Comée, Fort Sine-Sefid) (in NHRS, examined).

Type material examined. Paratypes, 1 ♂, Iran, Fars, Straße Ardekan-Talochosroe [Tall Khosrow], Comée [Komehr], ca 2600 m, 30.vi.1937, coll Brandt, g.prep. 10932; 1 ♀, same locality, 3750 m, 12.vi.1937, coll Brandt, g.prep. 10933; all in NHRS. 1 ♂, Iran, same locality, (Barm i Firus), ca. 3750 m, 12-20.vii.1937, coll Brandt; 1 ♂, same locality, ca. 2600 m, 5.vii.1937, coll Brandt; all in ZFMK. 1 ♂, same locality, ca. 2600 m, 30.vi.1937, coll Brandt; in ZSM.

Additional material studied*:* 13 ♂, 6 ♀ (see appendix).

Diagnosis. Wingspan ♂ 36–39 mm, ♀ 36–42 mm (forewing length ♂ 19–21 mm, ♀ 22–24 mm) (figs 43, 44). Ground colour of wings sandy-yellow. The species can be confused with some forms of *N. divergaria* and *N. eberti* **sp. nov.**, but *N. subfusca* differs from these two species by clearly unique male and female genitalia (see below). Male genitalia of *N. subfusca* with uncus curved, needle-like, broad at the base in lateral view (fig. 107) (kinked, apex broad and pointed in *N. eberti* **sp. nov.** and *N. divergaria*, see figs 116, 121). Additionally, costa of valva in *N. subfusca* apically tapered and directed to uncus; ampulla superior thin and long, ampulla inferior thick and short, both ampullae located at the centre of valva (see fig. 106) (costa of valva apically digitiform and straight, both ampullae with similar length and located in the distal half of valva in *N. eberti* **sp. nov.** (see figs 120, 122); costa of valva broadened towards apex, ampulla superior thick and long, ampulla inferior highly variable, but in most specimens absent in *N. divergaria*, (see figs 115–119)). *N. subfusca* in female genitalia with a characteristic narrow ductus bursae and a large bag-shaped corpus bursae; lamella postvaginalis round with foldings (fig. 136) (ductus bursae broad, corpus bursae small, lamella postvaginalis antero-posteriorly extended without foldings in *N. eberti* **sp. nov.** and *N. divergaria*). In *N. subfusca* apophyses anteriores 1/9 the length of apophyses posteriores (1/5 in *N. eberti* **sp. nov.**; apophyses anteriores strongly reduced in *N. divergaria*) (see figs 141–143).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FIGURES 43-60. Wing coloration and pattern of *Nychiodes* species. 43: Paratype of *N. subfusca* (Iran, Komehr, g.prep. 10932); 44: Paratype of *N. subfusca* (Iran, Komehr, g.prep. 10933); 45: Paratype of *N. leviata* (Iran, Shiraz, g.prep. 10926); 46: Allotype of *N. leviata* (Iran, Shiraz, g.prep. 10927); 47: Paratype of *N. subvirida* (Iran, Bouchir Tchouroum, g.prep. 10934); 48: Paratype (labeled as Allotype) of *N. subvirida* (Iran, Bouchir Tchouroum, g.prep. 10935); 49: Paratype of *N. subvirida* (Iran, Bouchir Tchouroum, g.prep. 2556); 50: Holotype of *N. agatcha* **syn. nov.** of *N. subvirida* (Iran, Fars); 51: Allotype of *N. agatcha* **syn. nov.** of *N. subvirida* (Iran, Fars, g.prep. 10923); 52: Lectotype of *N. divergaria* (g.prep. 2106/2017 H. Rajaei; herewith designated); 53: Paralectotype of *N. divergaria* (g.prep. 2107/2017 H. Rajaei; herewith designated); 54: Holotype of *N. divergaria achtyca* **syn. nov.** of *N. divergaria*; 55: Holotype of *N. divergaria elbursica* **syn. nov.** of *N. divergaria*; 56: Holotype of *N. divergaria fallax* **syn. nov.** of *N. divergaria*; 57: Holotype of *N. variabila* **syn. nov.** of *N. divergaria* (g.prep. 10930; according to morphological examination this specimen belongs to *N. divergaria*); 58: Paratype (labeled as Allotype) of *N. variabila* **syn. nov.** of *N. divergaria* (g.prep. 10931; according to morphological examination this specimen belongs to *N. divergaria*); 59: Holotype of *N. variabila opulenta* **syn. nov.** of *N. divergaria* (g.prep. 10928); 60: Paratype (labeled as Allotype) of *N. variabila opulenta* **syn. nov.** of *N. divergaria* (g.prep. 10929); a = upperside; b = underside. Scale-bar 1 cm.

In south-western Iran, in addition to *N. divergaria*, at least four other species (*N. farinosa*, *N. admirabila*, *N. leviata*, *N. subvirida*) are sympatric with *N. subfusca*, but none of them can be externally confused with the latter species (see figs 26, 27, 38–40, 45–51).

Phenology. Flying from June to August. Wiltshire (1943) noted a record of the first brood in mid-June in Fars.

Biology. Larvae bred and described by Wiltshire (1943); feeding on *Amygdalus* and *Prunus*.

Habitat. In altitudes from 2000 up to 3750 m.

Distribution. Endemic species in south-western Iran (from Fars to Esfahan) (see map 3).

DNA barcoding. Nearest species (minimum pairwise distances): *N. admirabila* (5.1%) and *N. antiquaria* (5.4%) (fig. 145).

Nychiodes leviata Brandt, 1938

(figs 45, 46, 108, 109, 137; map 3)

Nychiodes leviata Brandt, 1938. Entomologische Rundschau, 55 (51), 37. Holotype ♂ ([Iran]: Sine Sefid) (in NHRS, examined). Originally regarded as subspecies of *Nychiodes variabila*. Raised to species rank by Wehrli (1954). Here confirmed valid at species rank.

Type material examined. Paratypes, 1 ♀, Iran, Fars, Straße Chiraz [Shiraz]-Kazeroun, Fort Sine-Sefid, ca. 2200 m, v.1937, coll. Brandt (labeled as Allotype), g.prep. 10927; 1 ♂, same locality, 23.v.1937, coll. Brandt, g.prep. 10926; 1 ♂, same locality, 5.vi.1937, coll. Brandt; all in NHRS. 1 ♂, same locality, 3.vi.1937, coll. Brandt; 1 ♀, same locality, 23.v.1937, coll. Brandt; 1 ♂, 1 ♀, same locality, 12.vi.1937, coll. Brandt; all in ZFMK.

Additional material studied: 19 ♂ (see appendix).

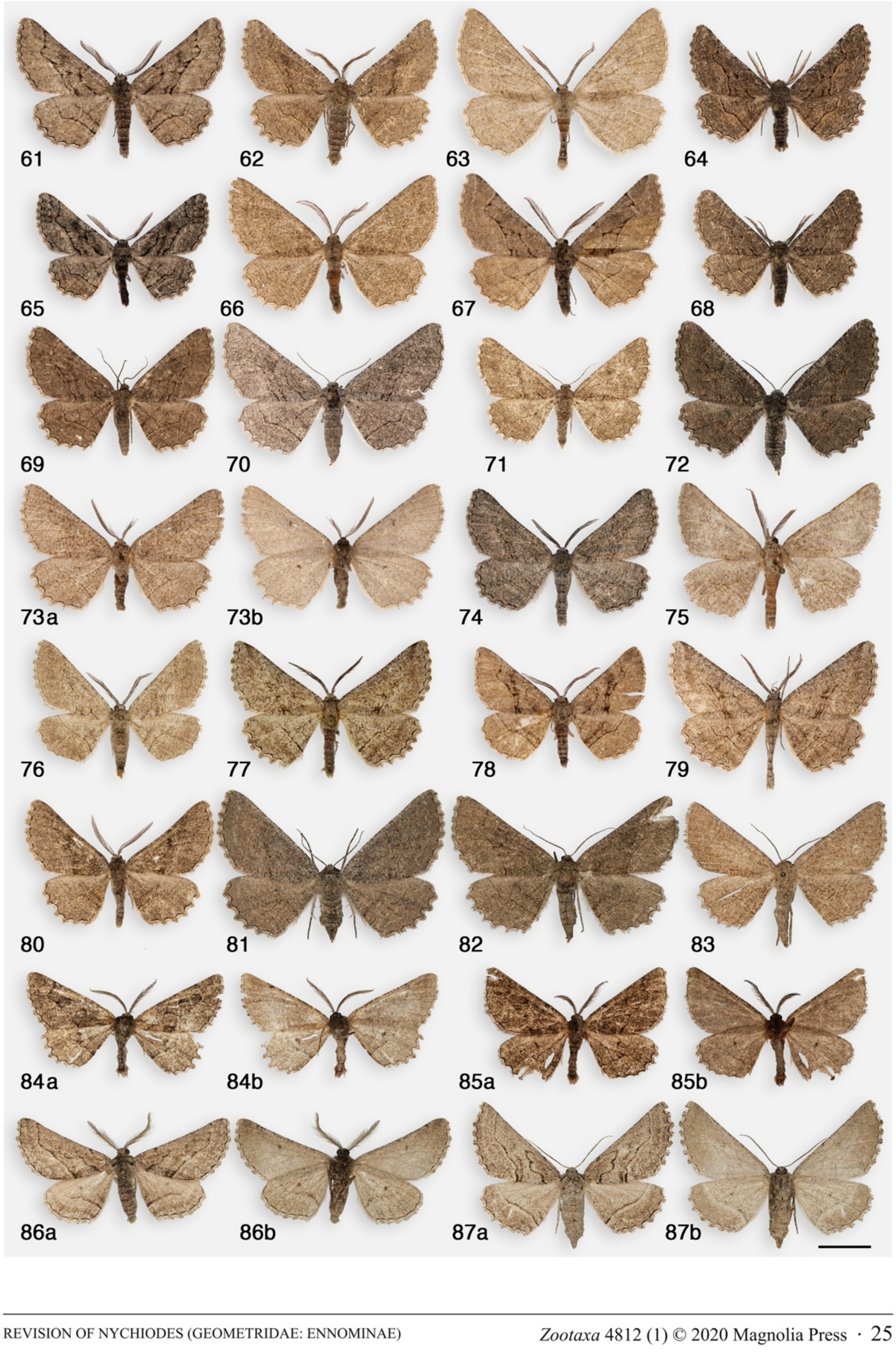
Diagnosis. Characteristically small species with wingspan ♂ 26–33, ♀ 34 (forewing length ♂ 16–19, ♀ 17) (figs 45, 46). Ground colour of wings beige-brown, medial area slightly darker. Resemble to some small specimens of *N. divergaria* (these two species can be diagnosed as below). In the male genitalia of *N. leviata* uncus thin, finely curved (in lateral view); ampulla superior almost same length as ampulla inferior, both clearly curved (uncus stout, curved; ampulla superior long, straight, ampulla inferior highly variable in size or absent, in *N. divergaria*) (see figs 108, 109, 113–119).

In female genitalia of *N. leviata*, apophyses anteriores 1/3 the length of apophyses posteriores; lamella postvaginalis small, not extended; signum circular, very large (apophyses anteriores strongly reduced; lamella postvaginalis antero-posteriorly extended; signum small in *N. divergaria*) (see figs 137, 141, 142).

In southwestern Iran, except *N. divergaria*, at least four other species (*N. farinosa*, *N. admirabila*, *N. subfusca*, *N. subvirida*) are co-distributed with *N. leviata*, but none of them can be externally confused with the latter species (see figs 26, 27, 38–40, 43, 44, 47–51).

Phenology. Flying from May to July.

Biology. Unknown.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FIGURES 61-87. Wing coloration and pattern of *Nychiodes* species. 61-72: *N. divergaria* (61: Iran, Kerman, g.prep. 0125/2018 D. Wanke; 62: Armenia, Yeghegnadzor, g.prep. 0375/2019 D. Wanke; 63: Iran, Mazandaran, g.prep. 2187/2018 H. Rajaei; 64: Turkey, Adiyaman, g.prep. 0324/2019 D. Wanke; 65: Iran, Hormozgan, g.prep. 0115/2018 D. Wanke; 66: Iran, Kendevan, g.prep. 0256/2019 D. Wanke; 67: Turkey, Hakkari, g.prep. 0068/2018 D. Wanke; 68: Turkey, Adiyaman, g.prep. 0321/2019 D. Wanke; 69: Turkey, Sirnak, g.prep. 0251/2019 D. Wanke; 70: Iran, Hormozgan, g.prep. 0295/2019 D. Wanke; 71: Iran, Kordestan, g.prep. 2183/2018 H. Rajaei; 72: Turkey, Adiyaman, g.prep. 0441/2019 D. Wanke); 73: Holotype of *N. eberti* **sp. nov.** (Turkey, Ascale, g.prep. 0267/2019 D. Wanke); 74-83: Paratypes of *N. eberti* **sp. nov.** (74: Turkey, Nevsehir, g.prep. 0398/2019 D. Wanke; 75: Turkey, Nidge, g.prep. 0341/2019 D. Wanke; 76: Turkey, g.prep. 0464/2019 D. Wanke; 77: Turkey, Ankara, g.prep. 0161/2018 D. Wanke; 78: Turkey, Kötek, g.prep. 0080/2018 D. Wanke; 79: Turkey, Ankara, g.prep. 0283/2019 D. Wanke; 80: Turkey, Kars, g.prep. 0079/2018 D. Wanke; 81: Turkey, Erzurum, g.prep. 0457/2019 D. Wanke; 82: Turkey, Kopdagi-Paß, g.prep. 0435/2019 D. Wanke; 83: Turkey, Sivas, g.prep. 0445/2019 D. Wanke); 84: Holotype of *N. convergata* **sp. nov.** (Israel, Mt. Hermon, g.prep. 463/2019 D. Wanke); 85: Paratype of *N. convergata* **sp. nov.** (Israel, Mt. Hermon, g.prep. 0243/2019 D. Wanke); 86: Holotype of *N. mirzayansi* **sp. nov.** (Iran, Kerman); 87: Paratype of *N. mirzayansi* **sp. nov.** (Iran, Kerman, g.prep. 2252/2019 H. Rajaei); a = upperside; b = underside. Scale-bar 1 cm.

Habitat. Specimens collected in altitudes from 1850-2450 m.

Distribution. In Iran, alongside the western part of the Zagros Mountains (map 3).

DNA barcoding. Nearest species (minimum pairwise distances): *N. eberti* **sp. nov.** (4.0%) and *N. mirzayansi* sp. nov. (4.1%) (fig. 145).

Nychiodes subvirida Brandt, 1938

(figs 47–51, 110–112, 138–140; map 3)

Nychiodes subvirida Brandt, 1938. Entomologische Rundschau, 55 (51), 36. Syntypes ♂, ♀ ([Iran]: Tschurum, Chriaz, Fort Mian-Kotal) (in NHRS, examined).

Nychiodes subvirida disjuncta Wehrli, 1941. In: Seitz, A. (Ed.), Die Großschmetterlinge der Erde. Supplement zu Band 4: 443. Holotype 1 ♂ (Iran, Borasdjen [Borazjan], Daliki) (in ZFMK, examined). Hereby regarded as a **new synonym** of *Nychiodes subvirida* based on morphological examination and sympatric occurrence of these forms.

Nychiodes subvirida taftana Brandt, 1941. Mitteilungen der Münchner Entomologischen Gesellschaft, 31, 878. Iran (Taftan Mt.), (in NHRS, examined). Hereby regarded as a **new synonym** of *Nychiodes subvirida* based on sympatric occurrence of these forms.

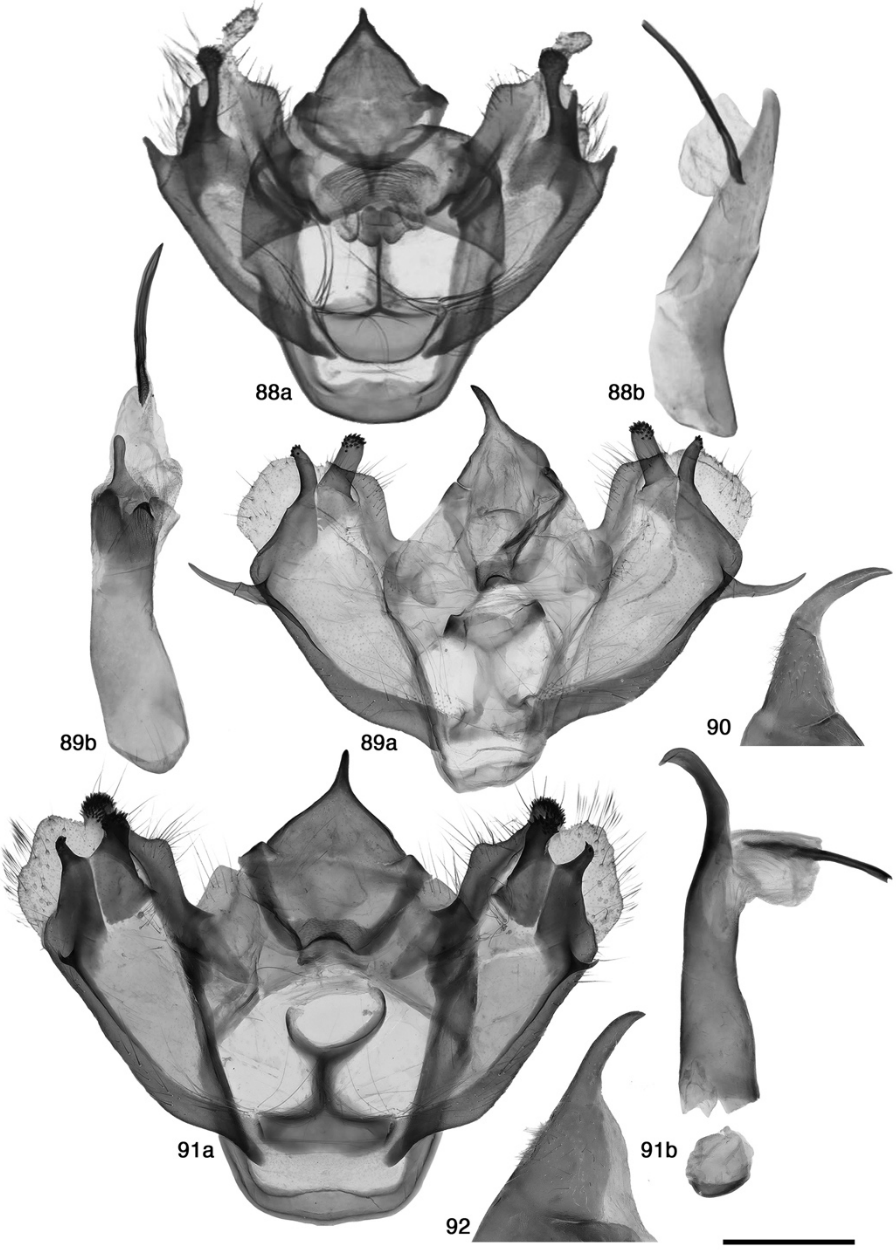
Nychiodes agatcha Brandt, 1938. Entomologische Rundschau, 55 (51), 37. Holotype ♂, Allotype ♀ (Iran, Fars, Fort Sine-Sefid) (in NHRS, examined). Hereby regarded as a **new synonym** of *Nychiodes subvirida* based on morphological examination and sympatric occurrence of these forms.

Type material examined. *Nychiodes subvirida* Paratypes, 2 ♂, Iran, Fars, Straße Kazeroun, Bouchir Tchouroum, ca. 1000 m, 18.-30.iii.1937, coll. Brandt, g.preps 2556, 10934; 1 ♀, same locality, (labeled as allotype), g.prep. 10935; all in NHRS. 1 ♂, same locality, 26.iii.-6.iv.1937, coll. Brandt; in ZFMK. 1 ♂, same locality, 18.-30.iii.1937, coll. Brandt; in ZSM.

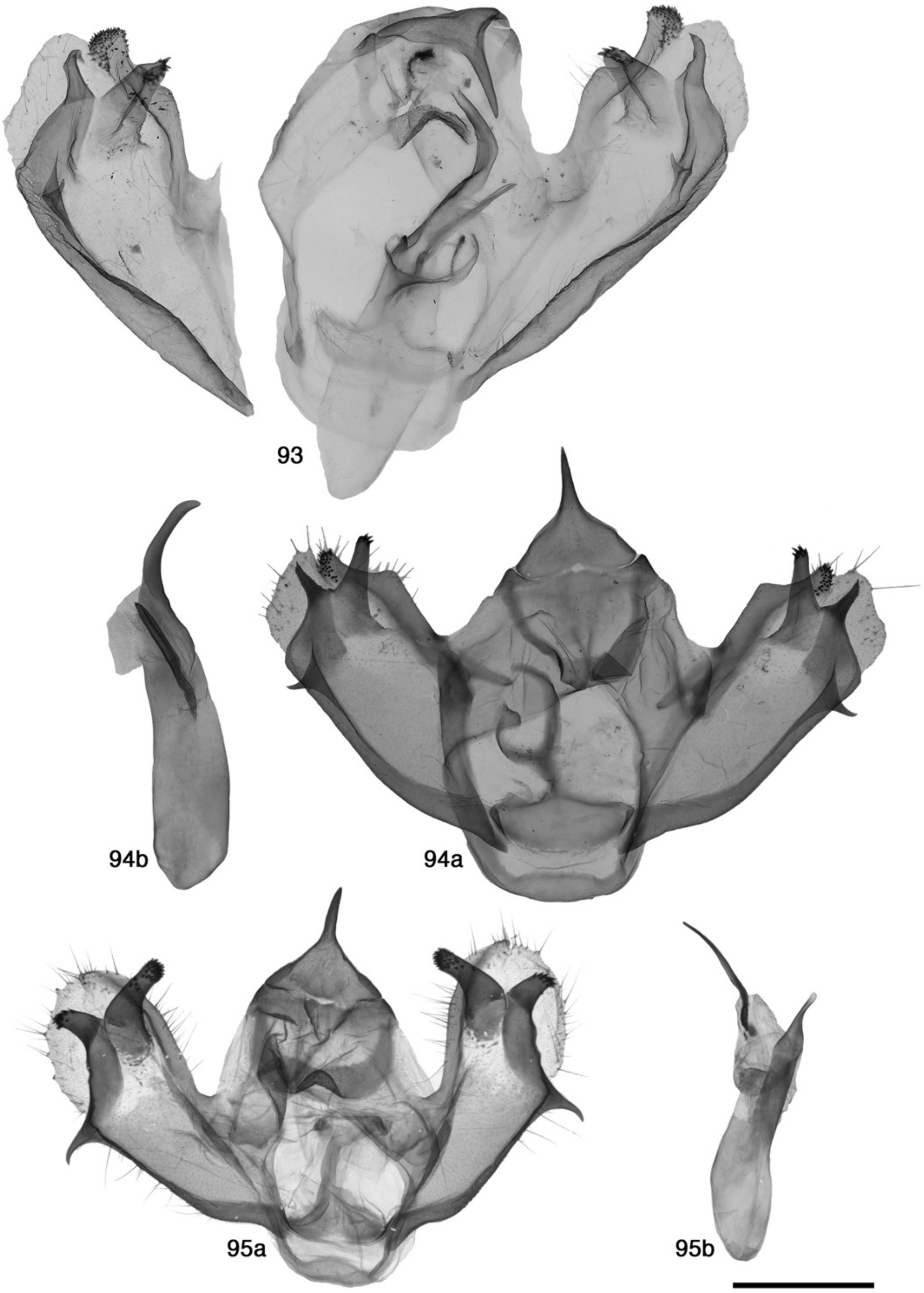
N. subvirida disjuncta Holotype, ♂, Jran [Iran] mer. occ., Borasdjen [Borazjan], Daliki, 120 m, 13.-17.iii.[19]38, g.prep. 7271; Paratype, 1♀, Jran [Iran] mer. occ., Schiras, Taschteba, Ende April [19]38, (labeled as Allotype), g.prep. 0504/2020 D. Wanke; in ZFMK.

N. subvirida taftana 1 ♂, Iran, Balotchistan, Kouh i Taftan (Khach), 2500 m, 15.v.1938, coll. Brandt; in NHRS.

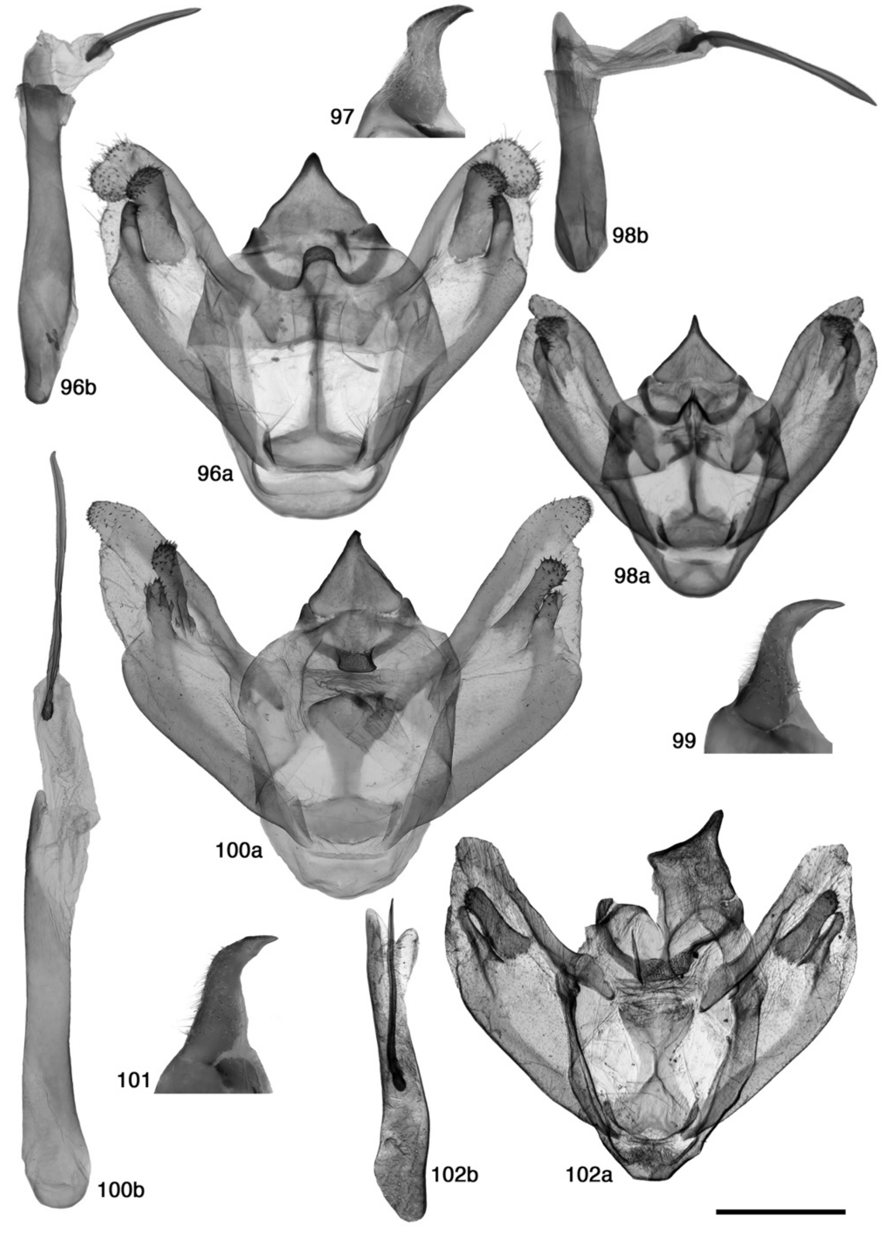
N. agatcha Holotype, ♂, Iran, Fars, Straße Chiraz Kazeroun, Fort Sine-Sefid, ca 2200 m, v.1937, coll. Brandt; Paratype, 1♀, same locality, ix.1937, (labeled as Allotype), g.prep. 10923; in NHRS.



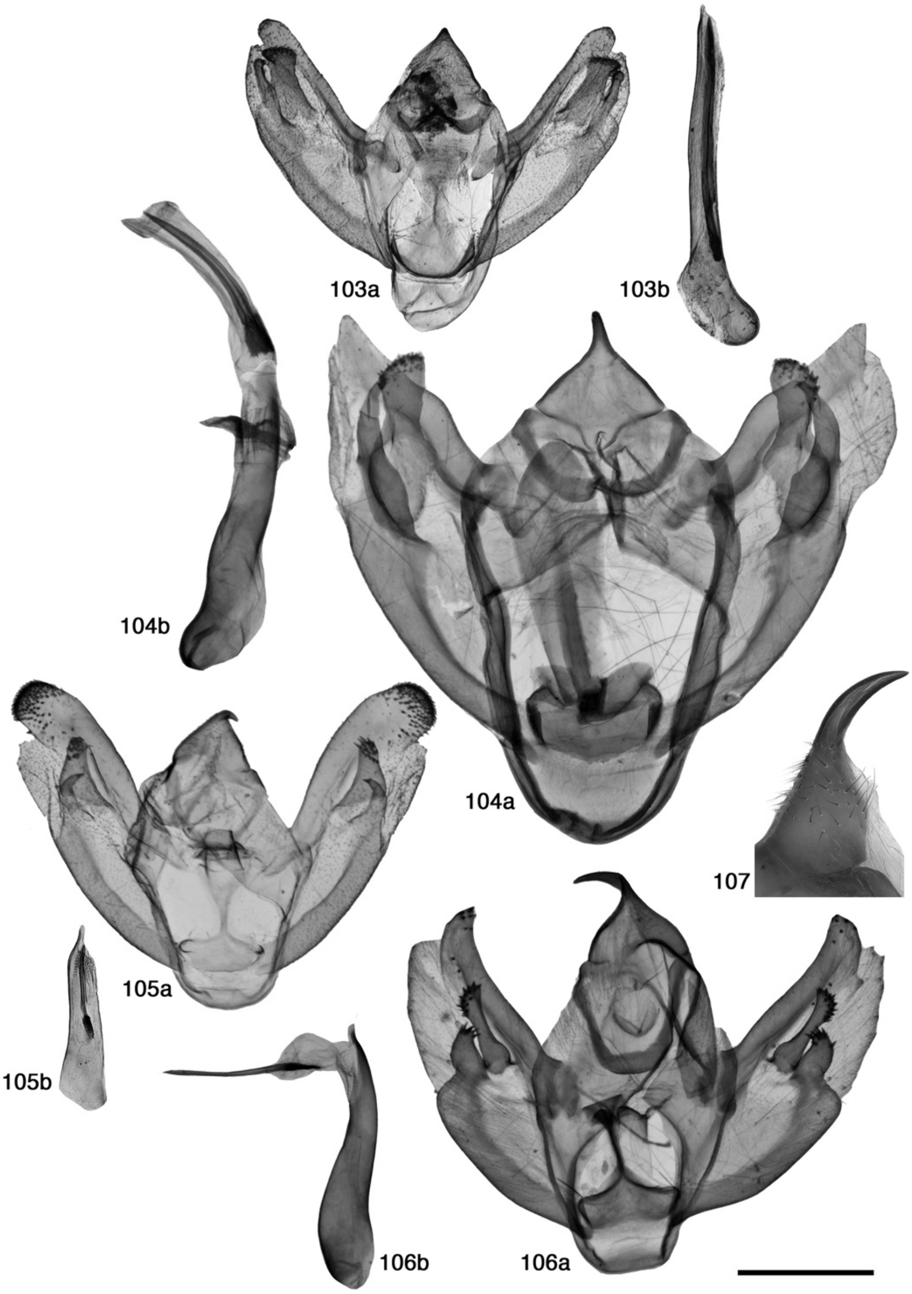
FIGURES 88-92. Male genitalia of *Nychiodes* species. 88: Lectotype of *N. mauretanica* (Algeria, Lambèse, g.prep. Fazekas I. No. 2593); 89: *N. waltheri* (Turkey, Kayseri, g.prep. 0453/2019 D. Wanke); 90: Uncus, lateral view, *N. waltheri* (Turkey, Aksehir, g.prep. 0409/2019 D. Wanke); 91: Lectotype of *N. palaestinensis* (Israel, Jerusalem, g.prep. 0225/2019 D. Wanke); 92: Uncus, lateral view, *N. palaestinensis* (Jordan, Ajlun, g.prep. 0392/2019 D. Wanke). a = genitalia capsule; b = aedeagus. Scale-bar 1 mm.



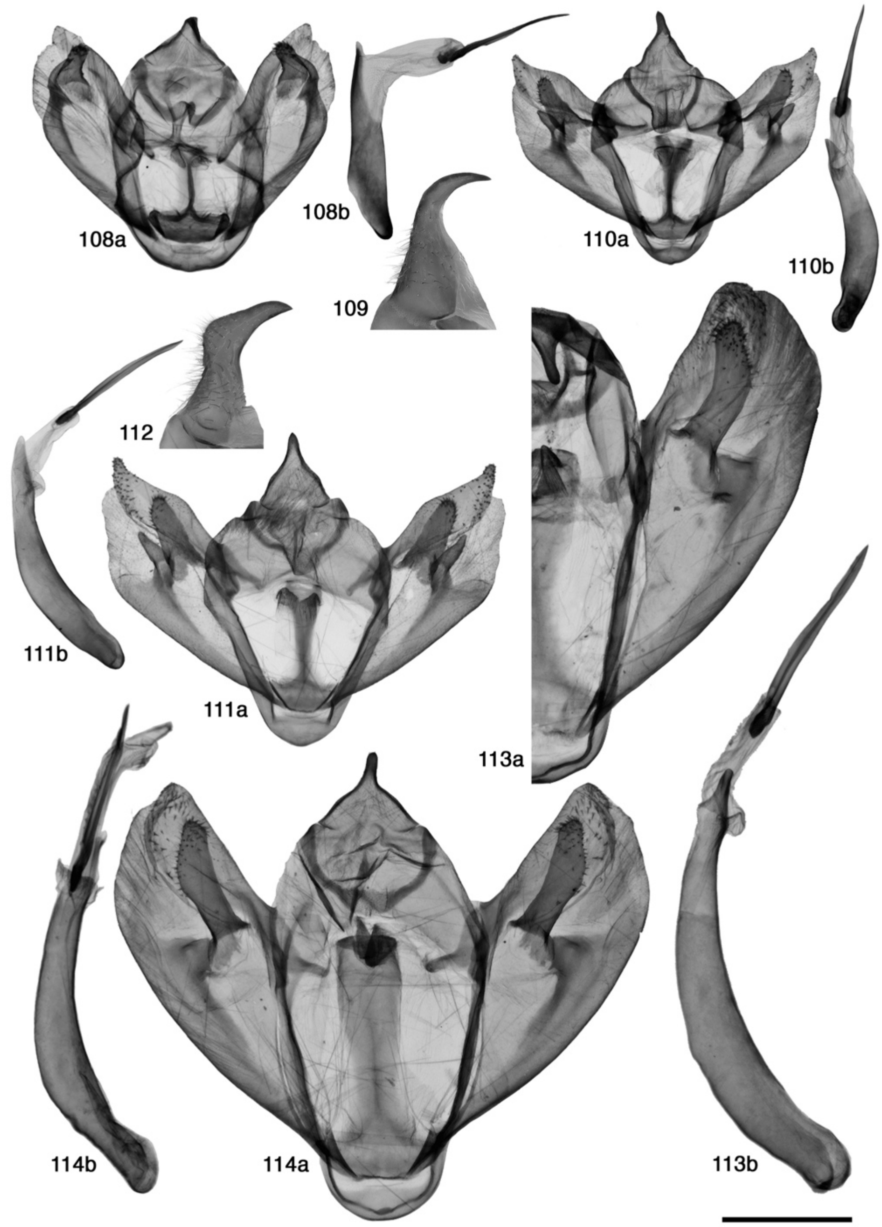
FIGURES 93-95. Male genitalia of *Nychiodes* species. 93: Lectotype of *N. persuavis* **syn. rev.** of *N. palaestinensis* (Lebanon, Beirut, g. prep. 4065; aedeagus in genitalia capsule); 94: Paratype of *N. muelleri* (Jordan, Shaubak, g.prep. 14416); 95: *N. aphrodite* (Cyprus, Paphos, g.prep. 2109/2017 H. Rajaei). a = genitalia capsule; b = aedeagus. Scale-bar 1 mm.



FIGURES 96-102. Male genitalia of *Nychiodes* species. 96: *N. amygdalaria* (Turkey, Aksehir, g.prep. 2089/2017 H. Rajaei); 97: Uncus, lateral view, *N. amygdalaria* (Turkey, Maras, g.prep. 0411/2019 D. Wanke); 98: Holotype of *N. farinosa* (Iran, Fars, g.prep. 10924); 99: Uncus, lateral view, *N. farinosa* (Iran, Hamadan, g.prep. 0414/2019 D. Wanke); 100: *N. antiquaria* (Tadjikistan, Kalaishum, g.prep. 0365/2019 D. Wanke); 101: Uncus, lateral view, *N. antiquaria* (Uzbekistan, Guzar, g.prep. 0408/2019 D. Wanke); 102: Holotype of *N. princeps* (Afghanistan, Band-i-Amir, g.prep. WW36). a = genitalia capsule; b = aedeagus. Scale-bar 1 mm.



FIGURES 103-107. Male genitalia of *Nychiodes* species. 103: Paratype of *N. quettensis* (Pakistan, Quetta, g.prep. WW223); 104: Paratype of *N. admirabila* (Iran, Fars, g.prep. 10920); 105: Holotype of *N. rayatica* (Iraq, Rayat, g.prep. 11019); 106: Paratype of *N. subfusca* (Iran, Komehr, g.prep. 10932); 107: Uncus, lateral view, *N. subfusca* (Iran, Dasht-e Arjan, g.prep. 0412/2019 D. Wanke). a = genitalia capsule; b = aedeagus. Scale-bar 1 mm.



FIGURES 108-114. Male genitalia of *Nychiodes* species. 108: Paratype of *N. leviata* (Iran, Fars, g.prep. 10926); 109: Uncus, lateral view, *N. leviata* (Iran, Isfahan, 0417/2019 D. Wanke); 110: *N. agatcha* **syn. nov.** of *N. subvirida* (Iran, Laristan, g.prep. 10922); 111: Paratype of *N. subvirida* (Iran, Fars, g.prep. 10934); 112: Uncus, lateral view, *N. subvirida* (Iran, Fars, g.prep. 0415/2019 D. Wanke); 113: Holotype of *N. variabila opulenta* **syn. nov.** of *N. divergaria* (Iran, Baloutchistan, g.prep. 10928); 114: Holotype of *N. variabila* **syn. nov.** of *N. divergaria* (Iran, Fars, g.prep. 10930); a = genitalia capsule; b = aedeagus. Scale-bar 1 mm.

Additional material studied: 35 ♂, 22 ♀ (see appendix).

Diagnosis. Wingspan ♂ 24–37 mm, ♀ 25–33 mm (forewing length ♂ 16–21 mm, ♀ 15–19 mm) (figs 47–51). Ground colour of wings yellow-brown sprinkled; postmedial line yellow. Reminiscent of *N. farinosa* (see diagnosis of *N. farinosa*) and some forms of the highly variable *N. divergaria* but differing from these species by the pattern of male and female genitalia. Male genitalia of *N. subvirida* with costa of valva medially humped, apex tapered (costa of valva not humped, apex rounded in *N. divergaria* and *N. farinosa*) (figs 110–112).

In female genitalia of *N. subvirida*, apophyses anteriores strongly reduced; sternite A9 conical, without any appendices (apophyses anteriores strongly reduced, sternite A9 with two strongly sclerotized spherical patches in *N. divergaria*; apophyses anteriores 1/3 length of apophyses posteriores, sternite A9 conical, without any appendices in *N. farinosa*) (figs 133, 138–142).

In southern Iran and on the most western border of its range *N. subvirida* is sympatric with *N. mirzayansi* **sp. nov.**, *N. farinosa*, *N. admirabila*, *N. subfusca* and *N. leviata*, but none of them can be externally confused with *N. subvirida* (see figs 26, 27, 38–40, 43–51).

Phenology. Examined specimens collected from March to November, with a gap from July to August, potentially indicating on two generations.

Biology. Unknown.

Habitat. In altitudes from 200 up to 2800 m.

Distribution. Distributed throughout southern Iran (see map 3).

DNA barcoding. COI data in a complex, overlapping and BIN-sharing cluster with *N. divergaria*, but morphologically showing clear diagnostic characters, which support the validity of both taxa. Nearest species (minimum pairwise distances): *N. mirzayansi* **sp. nov.** (1.6%) and *N. eberti* **sp. nov.** (3.1%) (fig. 145).

Nychiodes divergaria Staudinger, 1892

(figs 52–72, 113–119, 141, 142; maps 4, 5)

Nychiodes divergaria divergaria Staudinger, 1892. Deutsche Entomologische Zeitschrift Iris 5, 171. Syntypes ♂ (Mesopotamia [Turkey]: Mardin, Egin) (in MNHU, examined).

Nychiodes divergaria achtyca Wehrli, 1939. Entomologische Rundschau 56 (33), 365. Syntypes 3♂ ([Transcaucasus]: Rjabov) (in ZFMK, examined). Hereby regarded as a **new synonym** of *Nychiodes divergaria* based on morphological examination and sympatric occurrence of these forms.

Nychiodes divergaria elbursica Wehrli, 1937. Lambillionea 37 (8-9), 187. Syntypes 11♂ 4♀ ([Iran]: Elburs Mts.), (in NHRS, examined). Hereby regarded as a **new synonym** of *Nychiodes divergaria* based on morphological examination and sympatric occurrence of these forms.

Nychiodes divergaria fallax Wehrli, 1939. Entomologische Rundschau 56 (33), 366. Holotype ♂ (Transcaucasus), (in ZFMK, examined). Hereby regarded as a **new synonym** of *Nychiodes divergaria* based on morphological examination and sympatric occurrence of these forms.

Nychiodes variabila Brandt, 1938. Entomologische Rundschau, 55 (51), 37. Syntypes ♂, ♀ ([Iran]: Comèe, Fort Mian-Kotal, Fort Sine-Sefid), (in NHRS, examined). Hereby regarded as a **new synonym** of *Nychiodes divergaria* based on morphological and molecular examination.

Nychiodes variabila opulenta Brandt, 1941. Mitteilungen der Münchner Entomologischen Gesellschaft, 31, 878. Syntypes ♂, ♀ (Iran, Baloutchistan, Kouh i Taftan (Khach)), (in NHRS, examined). Hereby regarded as a **new synonym** of *Nychiodes divergaria* based on morphological examination and sympatric occurrence of these forms.

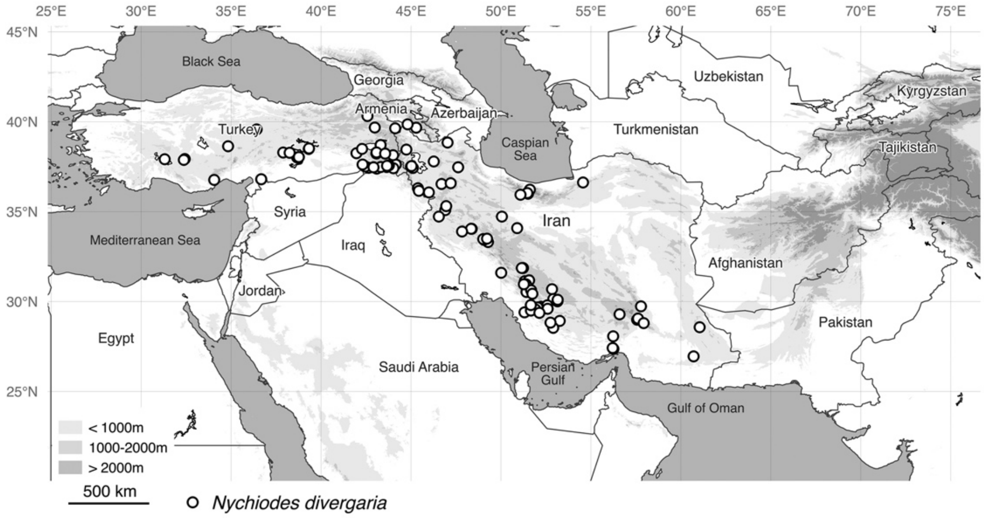
Nychiodes variabilis. Incorrect subsequent spelling of *Nychiodes variabila* **syn. nov.** of *Nychiodes divergaria* in Wiltshire, 1943. Journal of the Bombay Natural History Society, Bombay, 43, 630.

Nychiodes variabilis. Incorrect subsequent spelling of *Nychiodes variabila* **syn. nov.** of *Nychiodes divergaria* in Wiltshire, 1957. The Lepidoptera of Iraq. Government of Iraq (Ministry of Agriculture), 111.

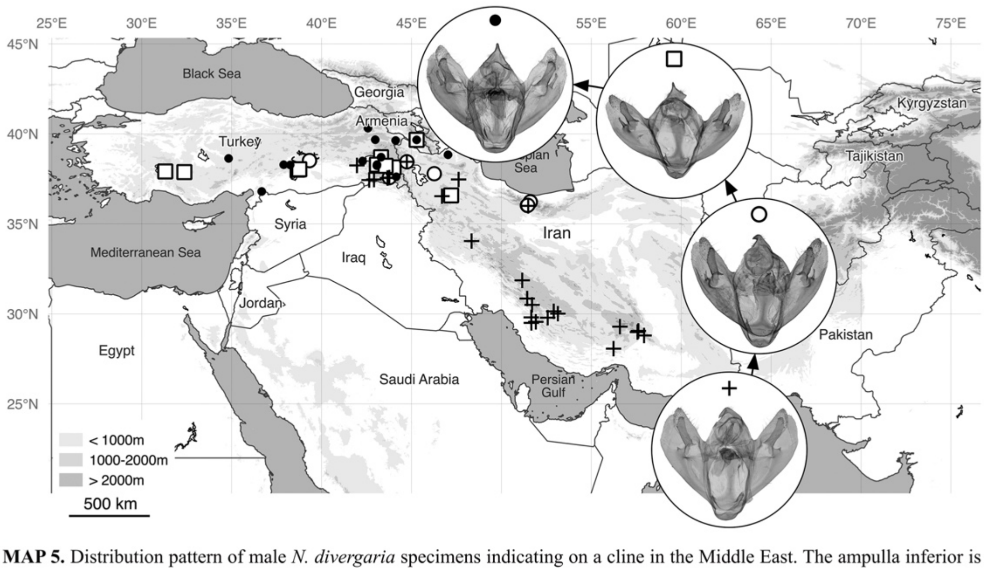
Type material examined. *Nychiodes divergaria*, Lectotype (herewith designated), ♂, Origin, [Turkey], Mardin, g.prep. 2106/2017 H. Rajaei; Paralectotype (herewith designated), 1 ♂, Origin, [Turkey], Egin, g.prep. 2107/2017 H. Rajaei; all in MNHU.

Nychiodes divergaria achtyca. Syntype, 1 ♂, Dagestan, Ackty, 28.vii.[19]33, M. Rjabov, g.prep. 7272; in ZFMK.

Nychiodes divergaria elbursica Holotype, ♂, Persia, Elbursgebirge, Rehne-Demavend, 2600 m, 21.-27.vii.[19]36, Schwingenschuss; in ZFMK.



MAP 4. Distribution pattern of *N. divergaria.* This species is widely distributed from Turkey to south-eastern Iran.



MAP 5. Distribution pattern of male *N. divergaria* specimens indicating on a cline in the Middle East. The ampulla inferior is highly variable from absent to present in this species. An increase in the development of this structure is visible from Southern Iran to Turkey.

Nychiodes divergaria fallax Holotype, ♂, Transcaucasus, Arax, Darasham, v. 1934, M. Rjabov g.prep. 7273; in ZFMK.

Nychiodes variabila Holotype, ♂, Iran, Fars, Straße Chiraz-Kazeroun, Fort Sine-Sefid, ca. 2200 m, 25.v.1937, coll. Brandt, g.prep. 10930; Paratypes, 1 ♀, same locality, ca. 2000 m, 8.-7.v.1937, coll. Brandt, (labeled as Allotype), g.prep. 10931; all in NHRS. 1 ♂, same locality, ca. 2200 m, Sept.1937, coll. Brandt; 1 ♀, same locality, 28.v.1937, coll. Brandt; 1 ♂, same locality, Mai.1937, coll. Brandt; 1 ♂, 1 ♀, same locality, 10.v.1937, coll. Brandt; all in ZFMK.

Nychiodes variabila opulenta Holotype ♂, Iran, Baloutchistan, Kouh i Taftan (Khach), 2500 m, 26.iv.1938, coll. Brandt, g.prep. 10928; Paratypes, 1 ♂, Iran, Baloutchistan, Kouh i Taftan (Khach), 2500 m, 3.v.1938, coll. Brandt, (labeled as Allotype) g.prep. 10929; NHRS. 1 ♂, same locality, 3000 m, 20.vi.1938, coll. Brandt; Paratype 1 ♂, same locality, 2500 m, 17.vi.1938, coll. Brandt; all in ZFMK.

Additional material studied: 232 ♂, 84 ♀ (see appendix).

Note. *Nychiodes divergaria* is the most variable species within this genus, in sense of wing pattern and male genitalia (see figs 52–72). This extreme variability caused the description of several species and subspecies, which are regarded as synonymous taxa based on the extensive morphological and molecular examinations in the current study. In male genitalia, the most variable structure is the ampulla inferior of the valva. Examination of 180 genitalia slides and plotting these on a geographic map reveals a clinous charater distribution of the size of the ampulla inferior, starting from southern Iran (without ampulla inferior) to south-western Turkey (with well-developed ampulla inferior) (see map 5). The female genitalia show stable diagnostic characters with little variation between populations. Another reliable differential character is the costa of valva in the male genitalia. Therefore, we strongly recommend dissection for secure species identification of *N. divergaria*.

Diagnosis. Wingspan ♂ 25–40 mm, ♀ 29–44 mm (forewing length ♂ 15–22 mm, ♀ 17–25 mm) (figs 52–72). Ground colour of wings highly variable, differing from sandy yellow and light brown to dark, almost black specimens. *N. divergaria* can be confused with most sympatric congeners (*N. farinosa*, *N. rayatica*, *N. subfusca*, *N. leviata*, *N. subvirida*, *N. eberti* **sp. nov.**). Diagnostic characters of male and female genitalia in comparison to the above mentioned sympatric species are presented below.

Male genitalia (figs 113–119) with costa of valva wide, strongly sclerotized, reaching the apex of valva (in rare cases exceeding apex, figs 119J–P) (costa of valva exceeding tip of valva, slightly curved in *N. farinosa*; apically extremely dilated, exceeding tip of valva in *N. rayatica*; curved towards uncus in *N. subfusca*; curved in *N. leviata*; medially humped in *N. subvirida*; costa of valva narrow, digitiform in *N. eberti* **sp. nov.**) (see figs 98, 105, 106, 108, 110, 111, 119, 120, 122). Ampulla superior long, broad, usually tubular; ampulla inferior highly variable, from absent state to thin and long in size, if present always much narrower than ampulla superior (see fig 119) (ampulla superior apically dilated, ampulla inferior slightly curved in *N. farinosa*; ampulla superior conical, broad, ampulla inferior strongly curved in *N. rayatica*; ampulla superior narrow, apically dilated, ampulla inferior short and broad in *N. subfusca*; ampulla superior broader than ampulla inferior, both with similar length and curved in *N. leviata*; both ampullae slightly conical in *N. subvirida*; both ampullae digitiform, characteristically located in the distal half of valva in *N. eberti* **sp. nov.**) (see figs 98, 105, 106, 108, 110, 111, 119, 120, 122).

Female genitalia *N. divergaria* with strongly reduced apophyses anteriores, and two strongly sclerotized spherical patches on sternite A9 which cannot be confused with any other species of the *amygdalaria* species-group (see figs 141, 142).

Phenology. Three generations (as mentioned also by Wiltshire 1957), flying from March to November.

Biology. In Iraq feeding observations on trees and shrubs of Rosaceae (*Prunus*, *Amygdalus* and cultivated apricot) (Wiltshire 1957).

Habitat. Occurring in the woodland zone of the mountains and in apricot orchards in lower plains; in the Zagros range inhabiting scrub woods (Wiltshire 1957). In altitudes from 400 up to 3000 m.

Distribution. Anatolian-Iranian, from southern Turkey, southern Armenia, to western, northern and south-eastern Iran (maps 4, 5).

DNA barcoding. Clustering with *N. subvirida* in a '*divergaria-subvirida*-complex', but showing diagnostic morphological characters, supporting the taxonomic validity of both taxa at species rank. Nearest species (minimum pairwise distances): *N. eberti* **sp. nov.** (3.1%) (fig. 145).

Nychiodes eberti sp. nov. Wanke, Hausmann & Rajaei

(figs 73–83, 120–122; map 3)

Type material examined. Holotype, ♂, Türkei, Prov. Erzurum, Kopdagi Pass, vic. Ascale, 2200 m, 27.-31.vii.1978, Lichtf., leg. W. Thomas, g.prep. 0267/2019 D. Wanke; in SMNS. Paratypes, 1 ♂, 1 ♀, NE Türkei, Prov. Erzurum, Dogu Karadeniz Daglari, Korga Dagi, Köprüköy, Umg. bei Ispir, 2000 m, w. 28.vii.2001, e.o. 3.xi.2001, leg. J. Gelbrecht, S. Beshkov, R. Busse, A. Kazanci & E. Schwabe, g.preps (♂) 0456/2019 D. Wanke, (♀) 0457/2019

D. Wanke; 1 ♂, NE Türkei, Dogu Karadeniz Daglari, Ovit Dagi, ca. 5 km südl. Ovit Dagi Gecidi, 2400-2500 m, 27.vii.2001, leg. J. Gelbrecht, S. Beshkov, R. Busse, A. Kazanci & E. Schwabe, g.prep. 0241/2019 D. Wanke; all in PCJG. 1 ♂, Turkey, St. 2108, Nigde, Bolkardaglari N Side, SW Maden, 1600 m, 3.viii.1995, leg. D.v.d. Poorten, W. De Prins, g.prep. 0341/2019 D. Wanke; 1 ♀, Turkiye, Konya, 38 km W Konya, 1550 m, 8.-9.vii.[19]88, leg. S. Wagener, g.prep. 0443/2019 D. Wanke; 1 ♂, 1 ♀, Turkey, Erzincan, Caglayan, 4 km S. Kalecik, 1600 m, 13.-15.vii.2000, leg. K. Larsen, g.prep. (♂) 0339/2019 D. Wanke, (♀) 0444/2019 D. Wanke; 2 ♂, Turkey, Konya, Toros Daglari, Adiller Taskent, 1700 m, 14.vii.1986, leg. Arne Moberg, g.prep. 0343/2019 D. Wanke; 1 ♂, Turkey, Ankara, 1150-1250 m, 10 km NW Kizilcahaman, 6.-7.viii.1989, leg. Fibiger, Esser; 1 ♂, Turkiye, St. 1711, Artvin, 8-10 km SW Yusufeli Coruh valley, 900-1000 m, 4.-9.vii.1991, leg. W. De Prins, D.v.d. Poorten, A. Riemis, g.prep. 0344/2019 D. Wanke; 3 ♂, Turkey, Nigde, Bolkar Daglari, N.s. Maden, 2100 m, 29.vii.1997, K. Larsen, g.prep. 0342/2019 D. Wanke; 1 ♂, Turkey, Sivas, Gökpinar, 10 km S Gürün, 1500 m, 1.viii.1997, leg. K. Larsen, g.prep. 0340/2019 D. Wanke; 1 ♂, Turkey, Sivas, Gökpinar, 12 km S Gürün, 1500 m, 25.vii.1998, leg. K. Larsen; 1 ♀, Turkey, Sivas, Gökpinar, 10 km S Gürün, 1500 m, 11.vii.2000, leg. K. Larsen, g.prep. 0445/2019 D. Wanke; 1 ♀, [Turkey], Maras, Binboga Daglari, Göksun Yalakköy, 1600 m, 17.vii.1986, leg. A. Moberg, g.prep. 0451/2019 D. Wanke; all in PCPS. 2 ♂, Türkei centr., Provinz Sivas, Gökpinar, 1,5 km westlich, N 38°39‘21“, O 37°17‘19“, 1600 m ü.NN, 02.vii.2008, LF, leg. Ralf & Sylvana Fiebig, g.prep. 2134/2017 H. Rajaei; 1 ♂, 1 ♀, Türkei centr., Provinz Nevsehir, Kappadokien, Göreme, N 38°39‘, O 34°50', 1080-1150 m ü.NN, 08.-11.vii.2011, LF, leg. R. Fiebig & S. Rothe, g.preps. (♂) 0398/2019 D. Wanke (♀) 0399/2019 D. Wanke; 1 ♂, Türkei centr., Prov. Nevsehir, Kappadokien, Aktepe 1 km SSO, N 38°40‘43“, O 34°52‘25“, 1070 m ü.NN, 26.-27.viii.2009 LF, leg. R. & S. Fiebig, g.prep. 0400/2019 D. Wanke; 1 ♂, Türkei centr, Provinz Nigde, Aladag West, 5 km SSO von Sulucaova, N 37°58‘13“, O 35°09‘58“, 2200-2500m ü.NN, 16.viii.2009, LF, leg. R. Fiebig & S. Rothe, g.prep. 0396/2019 D. Wanke; all in PCRF. 2 ♂, Türkei, Kopdagi, 4.viii.1978, 2100m, leg. Dittrich, Austria; in PCTM. 2 ♀, Türkei, Prov. Erzurum, Kopdagi Pass, vic. Ascale, 2200 m, 27.-31.vii.1978, Lichtf., leg. W. Thomas, g.preps 0263, 0435/2019 D. Wanke; 1 ♂, [Turkey], Kleinasien, Prov. Erzurum, 40 km NW Erzurum, vic. Egerti, 1850-2000 m, 30.vii.-01.viii.[19]80, g.prep. 0066/2018 D. Wanke; 5 ♂, [Turkey], Kleinasien, Prov. Kars, vic. Karakurt, Aras-Tal, 1500 m, 15.-16.vii.1978, leg. de Freina, g.preps 0076, 0077/2018 D. Wanke, 0260/2019 D. Wanke; 5 ♂, 1 ♀, [Turkey], Kleinasien, Prov. Kars, vic. Kagizman, Kötek, 1550 m, 29.-31.vii.[19]78, leg. de Freina, g.preps (♂) 0078, 0080/2018 D. Wanke, 0261, 0262, 0264/2019 D. Wanke, (♀) 0266/2019 D. Wanke; 2 ♂, [Turkey], Kleinasien, Prov. Erzurum, Umg. Ovacik, Camlika, 2100 m, 01.-02.viii.1980, leg. de Freina, g.prep. 0086/2018 D. Wanke; 1 ♂, [Turkey], Kleinasien, Prov. Kars, vic. Sarikamis, 2000-2300 m, 21-27.vii.[19]80, leg. de Freina, 0079/2018 D. Wanke; 1 ♀, Türkei, Anatolien, 25 km, südl. Sivas, 1500 m, 24.+25.vii.1978, leg. W. Thomas, g.prep. 0432/2019 D. Wanke; 2 ♀, [Turkey], Kleinasien, Prov. Artvin, 5 km SE Sarigöl, 750 m, 31.vii.-09.viii.[19]83, leg. de Freina, g.prep. 2090/2017 H. Rajaei, 0436/2019 D. Wanke; all in SMNS. 6 ♂, [Turkey], Anatolien, Ankara, 1000 m, vi.1934, leg. Herbert Noack, g.preps 0161, 0162/2018 D. Wanke, 0282, 0283, 0284/2019 D. Wanke; 1 ♀, Türk., Ostkurdistan, Van Gölü, ca. 1800 m, 1.-31.Vii.1965, leg. Herbert Noack, g.prep. (♀) 0292/2019 D. Wanke; all in SMNK. 1 ♂, Türkei, vii.[19]95, leg. Gelbrecht, g.prep. 0464/2019, D. Wanke; in ZSM.

Description. Wingspan ♂ 29–40 mm, ♀ 35–42 mm (forewing length ♂ 18–22 mm, ♀ 19–24 mm) (figs 73–83). Antennae bipectinate in both sexes. Frons flat, projecting about one quarter diameter of eye, smoothly scaled. Chaetosemata present as two small patches. Length of labial palpi about 1.0 times diameter of the eye, slightly exceeding frons. Proboscis absent. Ground colour of wings highly variable, varying from sandy grey-yellow and light brown to dark brown. Transverse lines faint or visible. Terminal line from light to dark brown, sometimes faint. Postmedial line of forewing, if present, curved between M1 and M2; antemedial line, if visible, curved outwards. Postmedial line of hindwing absent or slightly visible. Antemedial line often faint or slightly visible as a shadow. Underside of wings variable, from unicolorous to vaguely showing the pattern of the upper side. Discal spots present only on underside.

In male genitalia (figs 120–122) uncus tapered and curved, basally broad (fig. 121). Gnathos well developed, strongly sclerotized, medially tongue-shaped. Saccus wide. Costa of valva narrow, strongly sclerotized, apically spinose, digitiform and slightly exceeding apex of valva. Both ampullae located in the distal half of valva, apically spinose; ampulla superior long, basally wide, medially narower; ampulla inferior well developed, of similar length like ampulla superior and narrower than the latter. Juxta anchor-shaped, stalk broad. Aedeagus broad (width-length ratio, 1:9), medially curved; cornutus half length of aedeagus.

In female genitalia ovipositor broad, Apophyses anteriores one fifth length of apophyses posteriores (fig. 143).

Sternite A9 conical. Lamella postvaginalis antero-posteriorly extended. Ductus bursae sclerotized. Corpus bursae membranous, pear-shaped, signum stellate.

Note. *Nychiodes eberti* **sp. nov.** is highly variable in wing pattern, similar to the large variability in *N. divergaria* (see figs 52–83). Therefore, wing pattern and coloration are absolutely unreliable characters for a secure diagnosis of these two species and examination of male and female genitalia is mandatory.

Diagnosis. In the distribution range of *N. eberti* **sp. nov.** the sympatrically occurring *N. rayatica* and *N. divergaria* can be confused when comparing wing pattern only (see figs 41, 42, 52–83). Furthermore, the wing pattern and coloration of *N. eberti* **sp. nov.** overlaps with that of *N. convergata* **sp. nov.**, which is so far only known from Israel (figs 84, 85).

Male genitalia of *N. eberti* **sp. nov.** with costa of valva characteristically narrow, digitiform at apex, slightly exceeding apex of valva (costa of valva apically very large and broad, clearly exceeding apex of valva in *N. rayatica*; costa of valva wide, not exceeding apex of valva in *N. divergaria*; costa of valva basally narrow, apically widely clubbed, clearly exceeding apex of valva in *N. convergata* **sp. nov.**) (see figs 105, 113–123). In *N. eberti* **sp. nov.** ampulla superior twice as broad as ampulla inferior, both ampullae not curved, located in the distal half of valva (ampulla superior conical, ampulla inferior strongly curved, both ampullae located at the centre of valva in *N. rayatica*; ampulla superior very long and broad, ampulla inferior highly variable, both ampullae located at the centre of valva in *N. divergaria*; ampulla superior digitiform, three times as broad as ampulla inferior, both ampullae located at the centre of valva in *N. convergata* **sp. nov.**) (see figs 105, 113–123). In *N. eberti* **sp. nov.** aedeagus thick and slightly curved, cornutus-aedeagus ratio 1/2 (aedeagus very small and short, cornutus-aedeagus ratio 1/2 in *N. rayatica*; aedeagus thick and strongly curved, cornutus-aedeagus ratio 2/3 in *N. divergaria*; aedeagus narrow and long; cornutus-aedeagus ratio 1/3 in *N. convergata* **sp. nov.**) (see figs 105b, 113b–118b, 123b). Female genitalia of *N. eberti* **sp. nov.** with apophyses anteriores one fifth length of apophyses posteriores (strongly reduced apophyses anteriores, two strongly sclerotized spherical patches on sternite A9 in *N. divergaria*; female of *N. rayatica* and *N. convergata* **sp. nov.** unknown) (see figs 141–143).

Phenology. Flying from May to August.

Biology. Unknown.

Habitat. In altitudes from 50 up to 2500m.

Distribution. Distributed in Turkey (map 3).

DNA barcoding. Diverging by 3.1% (minimum pairwise distance) from the *N. divergaria-subvirida* complex. Nearest species (minimum pairwise distances): *N. mirzayansi* sp. nov. (3.1%) and *N. convergata* sp. nov. (3.4%) (fig. 145).

Etymology. The name of this species is dedicated to Günter Ebert (born in 1935), former curator of the Lepidoptera collection in Karlsruhe State Museum of Natural History and editor in chief of the masterpiece "Die Schmetterlinge Baden-Württenbergs" in 10 volumes. During his many expeditions in Iran and Afghanistan, Günter Ebert collected the most important reference collection for these countries, deposited in SMNK (and parts in ZSM). All *Nychiodes* specimens, which were collected by Ebert are examined in this paper.

***Nychiodes convergata* sp. nov. Hausmann, Wanke & Rajaei**

(figs 84, 85, 123, 124; map 1)

Material examined. Holotype, ♂, N. Israel, Mt. Hermon, Upper Cable Station, 2200 m, 8.-10.vi.2000, leg. Müller, g.prep. 0463/2019 D. Wanke; in ZSM.

Paratypes, 1 ♂, N. Israel, Mt. Hermon, Upper Cable Station, 2200 m, 8.-10.vi.2000, leg. Müller; 1 ♂, N. Israel, South Golan, 500 m, v.2003, leg. Müller & Kravchenko, g.prep. ZSM G 13237; both in ZSM. 1 ♂, N. Israel, Mt. Hermon, Upper Cable Station, 2200 m, 8.-10.vi.2000, leg. Müller, g.prep. 0243/2019 D. Wanke; in SMNS.

Description. Wingspan ♂ 37 mm, (forewing length ♂ 17–20 mm) (figs 84, 85). Antennae bipectinate in males (female unknown). Frons rather flat, projecting about one quarter diameter of eye, smoothly scaled. Chaetosemata present as two small patches. Labial palpi about the size of eye diameter. Proboscis absent. Ground colour of wings brown, intermixed with dark brown scales, basal and medial areas slightly darker. On both wings antemedial line faint; postmedial line dark brown; postmedial line on forewing slightly angled outwards between M1-M2. Underside of wings unicolorous, light to dark brown, postmedial line partially visible. Terminal line dark brown. Discal spot black, more prominent on hindwing.

In male genitalia (figs 123, 124) uncus long, basally broad, medially curved, apically pointed. Gnathos strongly sclerotized, tongue-shaped. Saccus wide,anteriorly flat. Costa of valva strongly sclerotized, straight, apically broad and spinose, exceeding apex of valva. Ampulla superior broad, slightly curved, apically spinose; ampulla inferior narrow, half length of ampulla superior. Juxta anchor-shaped, stalk very thin, apical part extended. Aedeagus long and narrow (width-length ratio 1:11), cornutus one third length of aedeagus.

Female genitalia. Unknown.

Diagnosis. The type locality of the new species is in Israel, where only *N. amygdalaria* is (co-)distributed, but due to their wing pattern and colour these species cannot be confused. The wing pattern and coloration of *N. convergata* **sp. nov.** overlaps with that of *N. divergaria* and *N. eberti* **sp. nov.** (figs 52–85). Although the last two species are not yet reported from Israel, here we present a differential diagnosis for their male genitalia: In *N. convergata* **sp. nov.** costa of valva basally narrow, apically clubbed, exceeding apex of valva (costa of valva basally and apically narrow, digitiform, reaching slightly over apex of valva in *N. eberti* **sp. nov.**; costa of valva basally and apically wide, reaching apex of valva in *N. divergaria*) (see figs 113–123). *N. convergata* **sp. nov.** with ampulla superior digitiform, twice as broad as ampulla inferior, both ampullae located at the centre of valva (ampulla superior twice as broad as ampulla inferior, both ampullae located in the distal half of valva in *N. eberti* **sp. nov.**; ampulla superior very long and broad, ampulla inferior highly variable, both ampullae located at the centre of valva in *N. divergaria*) (see figs 113–123). *N. convergata* **sp. nov.** with long and narrow aedeagus; cornutus-aedeagus ratio 1/3 (aedeagus thick and strongly curved, cornutus-aedeagus ratio 2/3 in *N. divergaria*; aedeagus thick and slightly curved, cornutus-aedeagus ratio 1/2 in *N. eberti* **sp. nov.**) (see figs 113–123).

Phenology. Univoltine late spring species. From May to early June.

Biology. Unknown.

Habitat. Montane. Dry rocky or stony slopes with scattered steppe vegetation. From 500 up to 2200 m (Mt. Hermon, upper cable station).

Distribution. So far only collected on Mt. Hermon and on Golan heights (map 1). The unclear record of '*Nychiodes* (?) *divergaria*' in Wehrli (1934) for 'Haifa', may belong here, too, but the occurrence in the Carmel requires further confirmation.

DNA barcoding. Genetically homogeneous in the Levant (n=2 from Israel). Nearest species (minimum pairwise distances): *N. eberti* **sp. nov.** (3.3%) (fig. 145).

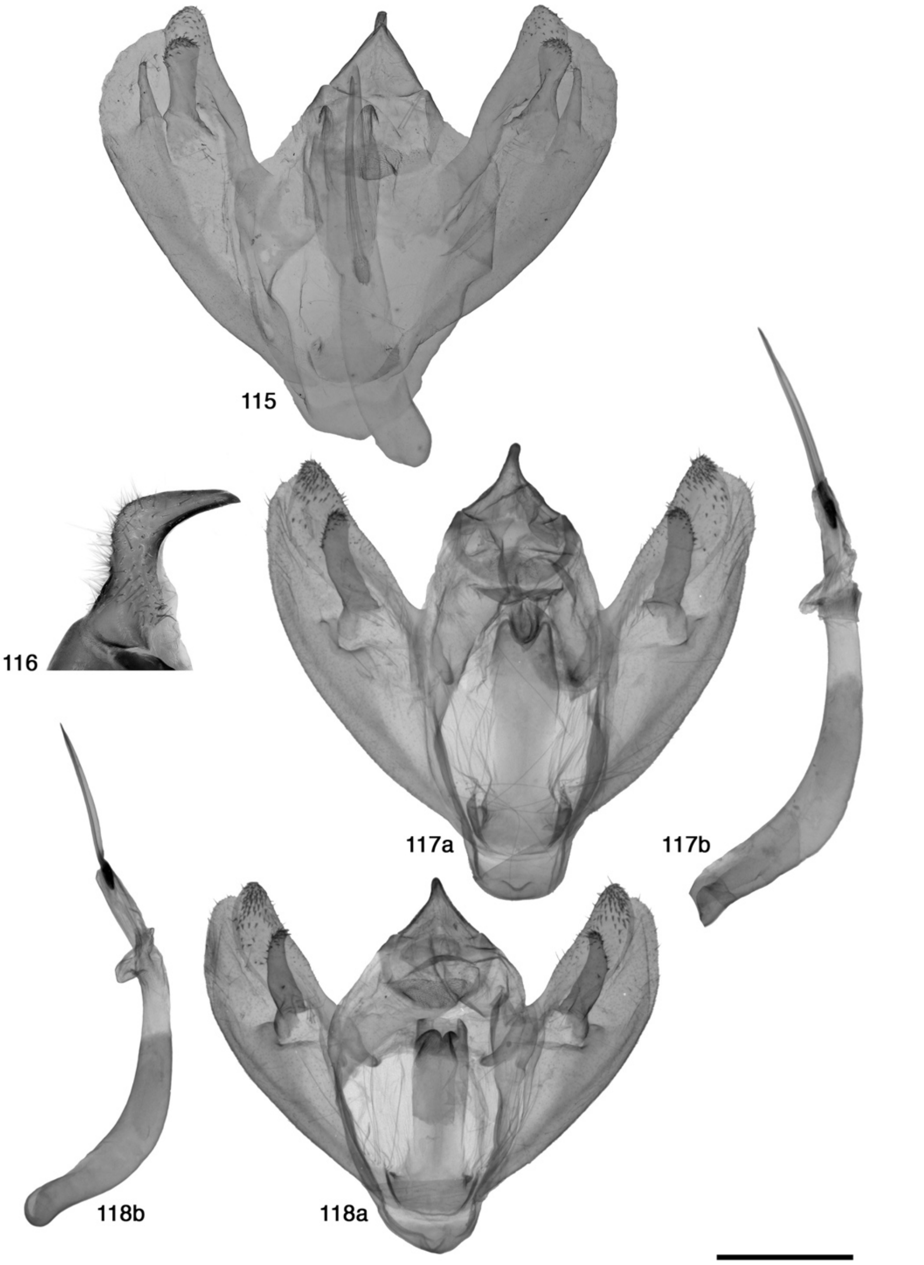
Etymology. The name alludes to the species name of its sister species *N. divergaria*, and to the latin verb convergere = to agree with.

Nychiodes mirzayansi **sp. nov. Wanke, Hausmann & Rajaei**

(figs 86, 87, 125, 126, 144; map 2)

Material examined. Holotype, ♂, Iran, Kerman, Jiroft NW, Gardaneh, Sarbishan, Shingara vic., 2700-2900 m, 3./4. vi.2002, leg. J.-U. Meineke, A. Hofmann, A. Kallies *et al.*; in SMNK.

Paratypes, 5 ♂, same as before, g.preps 0314, 0315, 0320/2019 D. Wanke; 1 ♀, Iran, Kerman, Bam SW, Deh Bakri, 2000-2200 m, 18.-21.v.2004, leg. A. Hofmann, J.-U. Meineke, G. Tremewan, g.prep. 0420/2019 D. Wanke; 1 ♀, Iran, Prov. Kerman, Baft N, Kherin N, 2600-2700 m, 12.vi.1998, leg. A. Hofmann, J.-U. Meineke, B. Mollet, g.prep. 0316/2019 D. Wanke; 1 ♀, [Iran, Kerman prov.], Djebal-Barez, Abtorsch, 12.vi.1971, leg. Neim.[i], Hasch.[emi], g.prep. 0186/2018 D. Wanke; 1 ♂, same data, 12.vi.1971; all in SMNK. 1 ♂, Iran, Kerman, Jiroft NW, Gardaneh, Sarbishan, Shingara vic., 2700-2900 m, 3./4.vi.2002, leg. J.-U. Meineke, A. Hofmann, A. Kallies *et al.*; in HMIM (Hayk Mirzayans Insect Museum, Tehran). 3 ♂, Iran, Kerman, Jiroft NW, Gardaneh, Sarbishan, Shingara vic., 2700-2900 m, 3./4.vi.2002, leg. J.-U. Meineke, A. Hofmann, A. Kallies *et al.*; 1 ♀, Iran, Kerman, Bam SW, Deh Bakri, 2000-2200 m, 18.-21.v.2004, leg. A. Hofmann, J.-U. Meineke, G. Tremewan, g.prep. 2252/2019 H. Rajaei; all in PCJG. 1 ♂, Iran, Kerman, Jiroft NW, Gardaneh, Sarbishan, Shingara vic., 2700-2900 m, 3./4.vi.2002, leg. J.-U. Meineke, A. Hofmann, A. Kallies *et al.*; in PCPS. 2 ♂, Iran, Kerman, Jiroft NW, Gardaneh, Sarbishan, Shingara vic., 2700–2900 m, 3./4.vi.2002, leg. J.-U. Meineke, A. Hofmann, A. Kallies *et al.*, g.preps 0222, 0419/2019 D. Wanke; 1 ♀, Iran, prov. Kerman, 5 km to Dehbakri from Bam, near Kuh-e Shir, N 29°04'01" E057°28'03", Alt. 1940 m, 18.–19.v.2009, *Amygdalus* community, leg. Hossein Rajaei, g.prep 0304/2019 D. Wanke; all in SMNS. 1 ♂, Iran, Kerman, Jiroft NW, Gardaneh, Sarbishan, Shingara vic., 2700–2900 m, 3./4.vi.2002, leg. J.-U. Meineke, A. Hofmann, A. Kallies *et al.*; in ZSM.



FIGURES 115-118. Male genitalia of *Nychiodes* species. 115: Syntype of *N. divergaria achtyca* **syn. nov.** of *N. divergaria* (Dagestan, Ackty, g.prep. 7272); 116: Uncus, lateral view, *N. divergaria* (Turkey, Hakkari, g.prep. 0395/2019 D. Wanke); 117: Lectotype (herewith designated) of *N. divergaria* (Turkey, Mardin, g.prep. 2106/2017 H. Rajaei); 118: Paralectotype (herewith designated) of *N. divergaria* (Turkey, Egin, g.prep. 2107/2017 H. Rajaei); a = genitalia capsule; b = aedeagus. Scale-bar 1 mm.

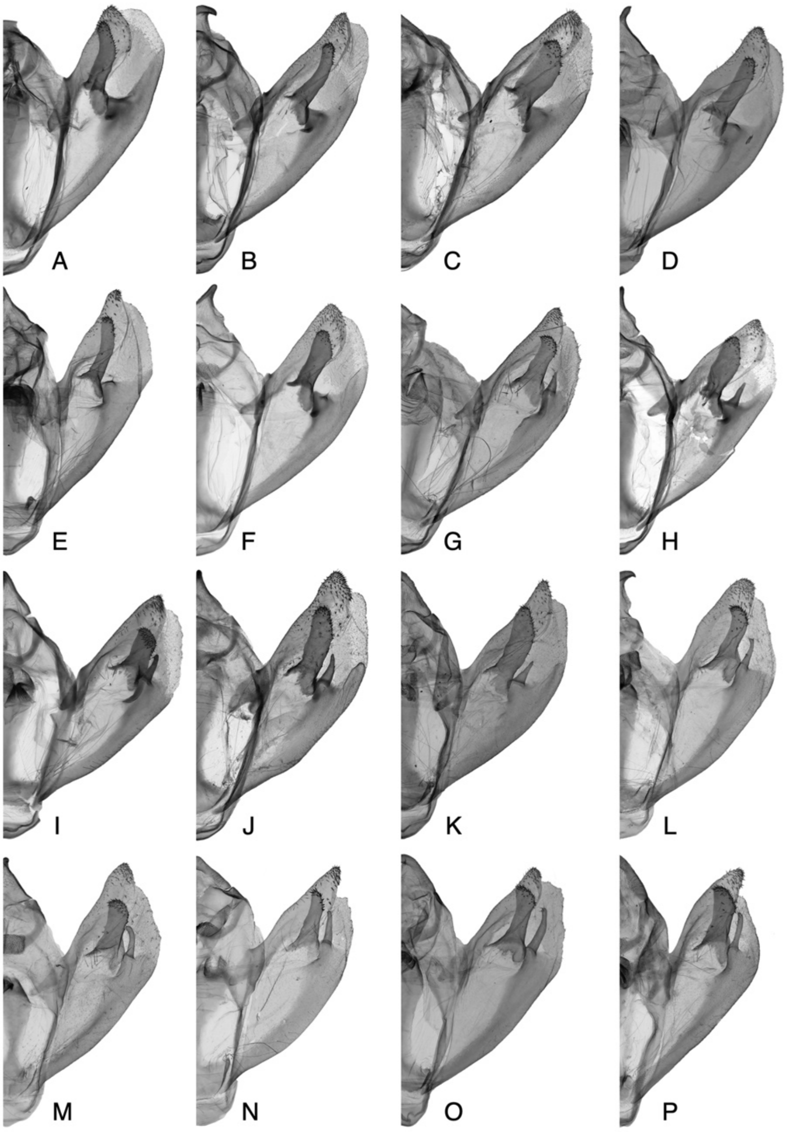
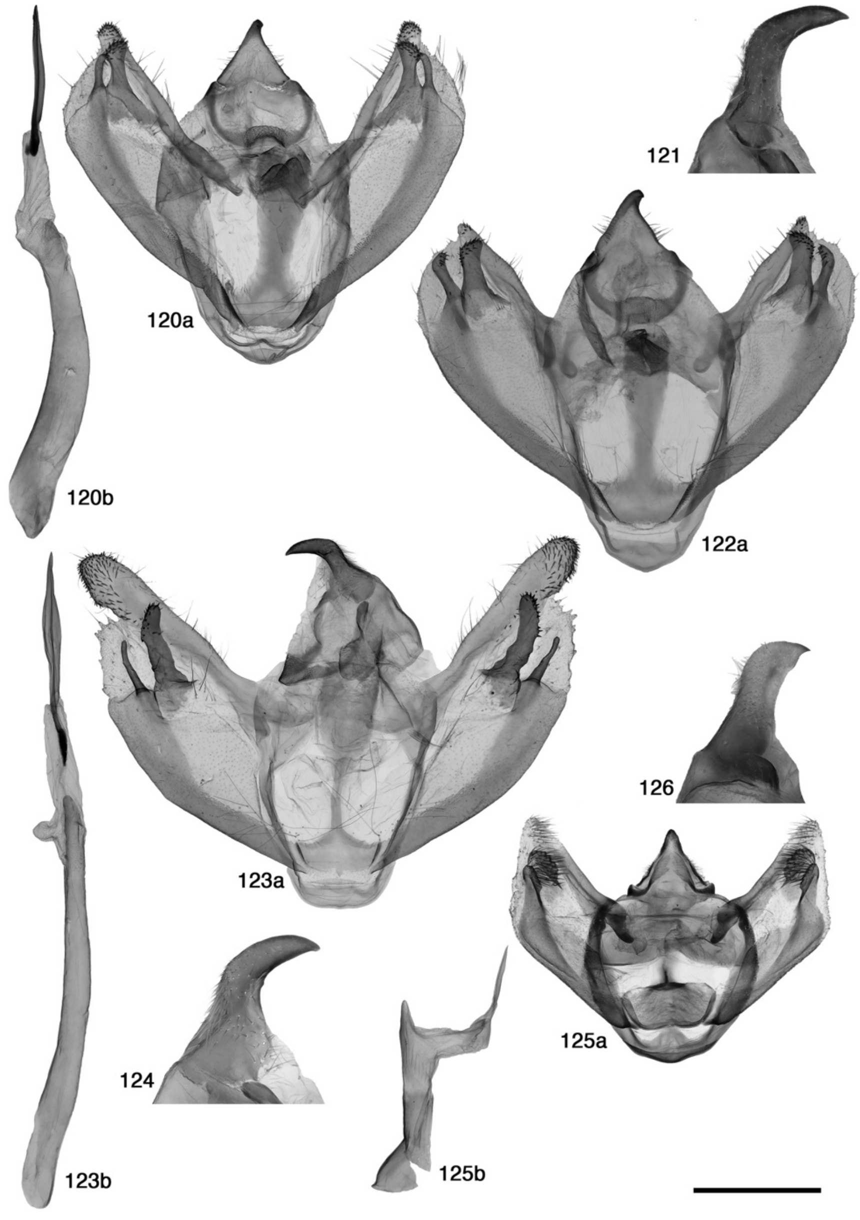


FIGURE 119. Variations in the genitalia capsule of *N. divergaria*. Differences occur in the shape of the costa of the valva, the shape of the ampulla superior and the presence versus absence of the ampulla inferior. Genitalia capsules sorted from no ampulla inferior (A) to a fully developed one (P). A: Iran, Kermanschah, g.prep. 0189/2018 D. Wanke; B: Iran, Rezaiyeh, g.prep. 0201/2018 D. Wanke; C: Iran, Azerbaijan, g.prep. 0204/2018 D. Wanke; D: g.prep. 0064/2018 D. Wanke; E: Iran, Azerbaijan-e Gharbi, g.prep. 0131/2018 D. Wanke; F: Iran, Miyan Kotal, g.prep. 0177/2018 D. Wanke; G: Turkey, Van, g.prep. 0258/2019 D. Wanke; H: Iran, prov. Kerman, g.prep. 0170/2018 D. Wanke; I: Turkey, Van, g.prep. 0257/2019 D. Wanke; J: Iran, Kendevan, g.prep. 0256/2019 D. Wanke; K: Iran, Mazandaran, g.prep. 2187/2018 H. Rajaei; L: Armenia, Yeghegnadzor suburbs, g.prep. 0375/2019 D. Wanke; M: Armenia, Yeghegnadzor suburbs, g.prep. 0376/2019 D. Wanke; N: Turkey, Malatya, g.prep. 0452/2019 D. Wanke; O: Turkey, Van, g.prep. 0062/2018 D. Wanke; P: Armenia, Yeghegnadzor suburbs, g.prep. 0374/2019 D. Wanke.



FIGURES 120-126. 120: Paratype of *N. eberti* **sp. nov.** (Turkey, g.prep 0464/2019 D. Wanke); 121: Uncus, lateral view, *N. eberti* **sp. nov.** (Turkey, Sulucaova, g.prep 0396/2019 D. Wanke); 122: Paratype of *N. eberti* **sp. nov.** (Turkey, Kötek, g.prep 0264/2019 D. Wanke); 123: Holotype of *N. convergata* **sp. nov.** (Israel, Mt. Hermon, g.prep. 463/2019 D. Wanke); 124: Uncus, lateral view, *N. convergata* **sp. nov.** (Israel, Mt. Hermon, g.prep. 463/2019 D. Wanke); 125: Paratype of *N. mirzayansi* **sp. nov.** (a: Iran, Kerman, g.prep. 0222/2019 D. Wanke; b: Iran, Kerman, 0315/2019 D. Wanke); 126: Uncus, lateral view, *N. mirzayansi* **sp. nov.** (Iran, Kerman, g.prep. 0419/2019 D. Wanke). a = genitalia capsule; b = aedeagus. Scale-bar 1 mm.

Description. Wingspan ♂ 34–39 mm, ♀ 37–40 mm (forewing length ♂ 17–20 mm, ♀ 19–21 mm) (figs 86, 87). Antennae bipectinate in both male and female. Frons rather flat, projecting about one quarter diameter of eye, smoothly scaled. Chaetosemata present as two small spots. Labial palpi very short, not exceeding frons. Proboscis absent. Ground colour of wings beige, olive-grey intermixed with dark brown scales. Terminal line black, discontinuous at veins, its margin yellow highlighted. Antemedial line of forewing characteristically curved outwards twice. Postmedial line nearly parallel to termen, curved inwards at vein M1. Hindwing slightly lighter than forewing, only postmedial line visible, subcostally curved outwards, at costa curved inwards. Underside of wings lighter than upperside, without clear pattern, only postmedial line on hindwing partially visible. Terminal line uninterrupted. Discal spots present on the hindwings.

Male genitalia (figs 125, 126). Genital capsule small. Uncus broad, slightly constricted at centre, apex bent and tapered. Gnathos well developed, medially tongue-shaped. Saccus broad. Costa of valva sclerotized, narrow, not humped at centre, apically merged with apex of valva, poorly sclerotized. Ampulla superior short, twice as broad as ampulla inferior, spinose over the whole length; length of ampulla inferior similar to that of ampulla superior, apically spinose. Sacculus dilated. Juxta anchor-shaped, stalk very thin and short, basal part large and extremely wide. Aedeagus short, straight, apically tapered; cornutus weakly sclerotized, one third length of aedeagus.

Female genitalia (fig. 144). Generally short in size, with broad ovipositor. Length of apophyses anteriores almost reaching length of apophyses posteriores (diagnostic within the genus *Nychiodes*). Lamella postvaginalis without strong sclerotization and extension. Ductus bursae narrow, posteriorly sclerotized. Corpus bursae small, membranous, signum absent.

Diagnosis. Endemic species in southern Iran with very characteristic wing colour and pattern, confusion with any other *Nychiodes* species excluded (see figs 86, 87).

N. mirzayansi **sp. nov.** is co-distributed with *N. subvirida* and *N. divergaria*. Ground colour and wing pattern of *N. mirzayansi* **sp. nov.** diagnostic, beige or olive grey intermixed with dark brown scales (wing pattern yellow-brown sprinkled, postmedial line yellow in *N. subvirida*; wing pattern highly variable in *N. divergaria*) (see figs 47–72). In male genitalia of *N. mirzayansi* **sp. nov.**, apex of uncus short and tapered in lateral view (apex long and curved in *N. subvirida* and *N. divergaria*) (see figs 112, 116, 126). In *N. mirzayansi* **sp. nov.** costa of valva medially not humped, apically merged with apex of valva (costa of valva medially humped, apex tapered in *N. subvirida*; costa of valva wide, medially not humped, not exceeding apex of valva in *N. divergaria*) (see figs 110, 111, 113–119, 125). Both ampullae of *N. mirzayansi* **sp. nov.** broad, short and strongly spinose; basal part of juxta large and broad (both ampullae straight, slightly spinose; basal part of juxta very thin in *N. subvirida*; ampulla superior long, broad, usually tubular, ampulla inferior highly variable, basal part of juxta not wide in *N. divergaria*) (see figs 110, 111, 113–119, 125).

The female genitalia of *N. mirzayansi* **sp. nov.** cannot be confused with any other *Nychiodes* species, because the apophyses anteriores have (almost) the same length as apophyses posteriores; lamella postvaginalis without strong sclerotization and extension (apophyses anteriores strongly reduced; lamella postvaginalis antero-posteriorly extended in *N. subvirida* and *N. divergaria*) (see figs 138–142, 144).

Phenology. Flying in May, June.

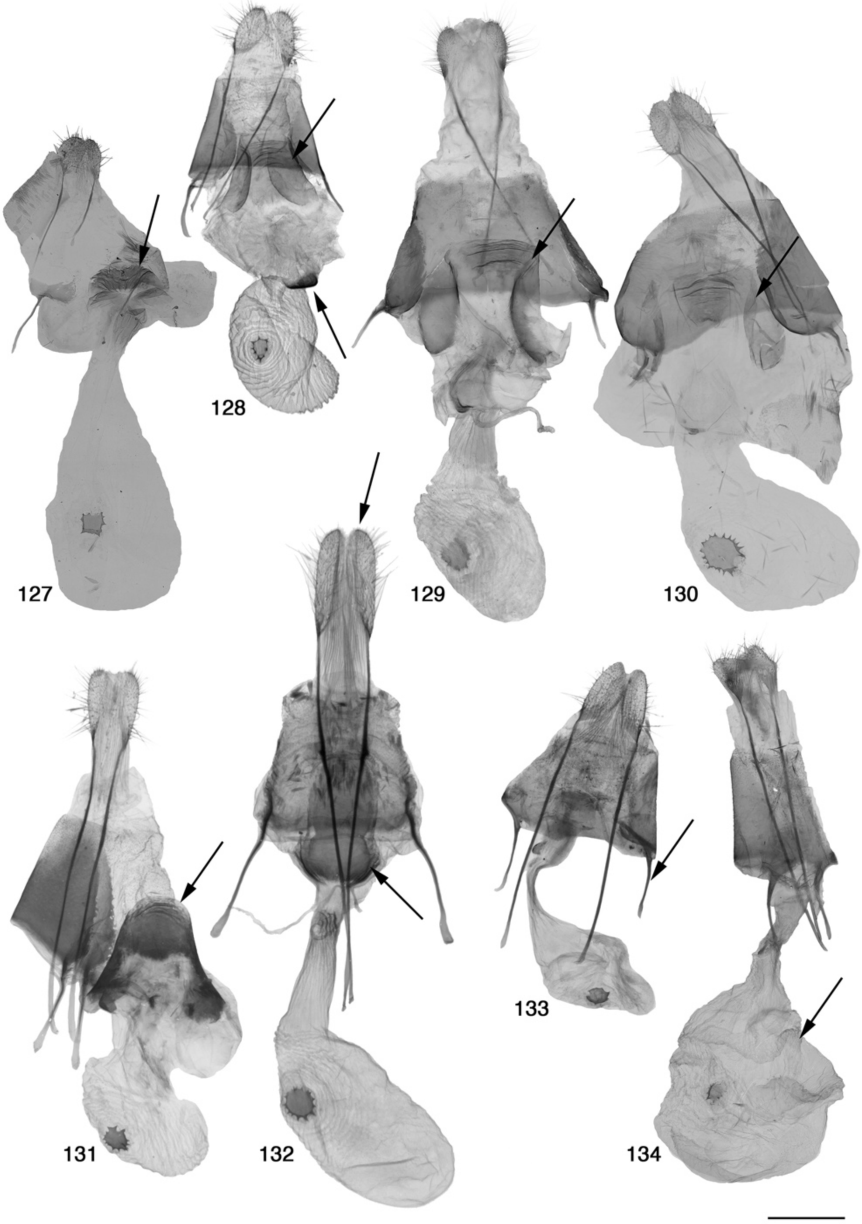
Biology. Unknown.

Habitat. In altitudes from 2000 up to 2900m

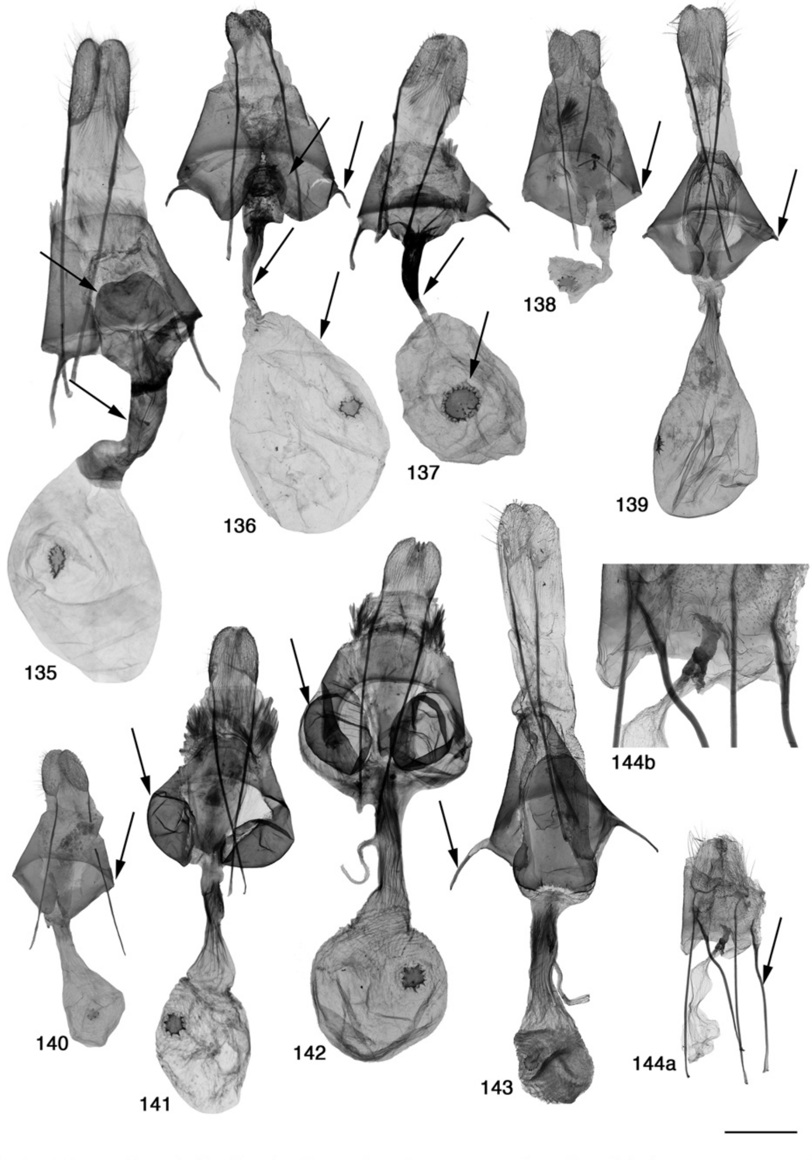
Distribution. Endemic species in Kerman (map 2).

DNA barcoding. Slightly diverging by 1.6% from the '*divergaria-subvirida*-complex' (see above), but showing strong morphological differences from both species (fig. 145).

Etymology. The name of this species is dedicated to Hayk Mirzayans (1920–1999), well-known Iranian entomologist, founder of Hayk Mirzayans Insect Museum, (Iranian Research Institute of Plant Protection, Tehran) and founding member of the Entomological Society of Iran. He was a communicative researcher, who was open-minded to cooperate with any enthusiastic entomologist around the world. During his life, he collected intensively in all corners of Iran and extensively improved the quantity and quality of the collection. Hayk Mirzayans was a close friend of Günter Ebert, to whom another new species is dedicated in this paper.



FIGURES 127-134. Female genitalia of *Nychiodes* species. 127: *N. mauretanica* (Algeria, Lambèse, g.prep. G2365); 128: *N. waltheri* (Bulgaria, Sozopol, g.prep. BMB386); 129: Paralectotype (herewith designated) of *N. palaestinensis* (Israel, Jerusalem, g.prep. 0226/2019 D. Wanke); 130: Paratype of *N. muelleri* (Jordan, Shoubak, G6437); 131: *N. aphrodite* (Cyprus, Moniatis, 2108/2017 H. Rajaei); 132: *N. amygdalaria* (Turkey, Artvin, g.prep. 2088/2017 H. Rajaei); 133: *N. farinosa* (Iran, Fars, g.prep. 10925); 134: Lectotype (herewith designated) of *N. antiquaria* (Uzbekistan, Margelan, g.prep. 0227/2019 D. Wanke). Scale-bar 1 mm.



FIGURES 135-144. Female genitalia of *Nychiodes* species. 135: Paratype of *N. admirabila* (Iran, Fars, g.prep. 10921); 136: Paratype of *N. subfusca* (Iran, Fars, g.prep. 10933); 137: Paratype (labeled as Allotype) of *N. leviata* (Iran, Fars, g.prep. 10927); 138: Paratype (labeled as Allotype) of *N. subvirida* (Iran, Fars, g.prep. 10935); 139: *N. subvirida* (Iran, Fars, g.prep. 0169/2018 D. Wanke); 140: Paratype (labeled as Allotype) of *N. agatcha* **syn. nov.** of *N. subvirida* (Iran, Laristan, g.prep. 10923); 141: Paratype (labeled as Allotype) of *N. variabila* **syn. nov.** of *N. divergaria* (Iran, Fars, g.prep. 10931; according to morphological examination this specimen belongs to *N. divergaria*); 142: Paratype (labeled as Allotype) of *N. variabila opulenta* **syn. nov.** of *N. divergaria* (Iran, Baloutchistan, g.prep. 10929), 143: Paratype of *N. eberti* **sp. nov.** (Turkey, Ascale, g.prep. 0263/2019 D. Wanke); 144: Paratype of *N. mirzayansi* **sp. nov.** (Iran, Kerman, a: whole genitalia; b: close up; g.prep. 2252/2019 H. Rajaei). Scale-bar 1 mm.

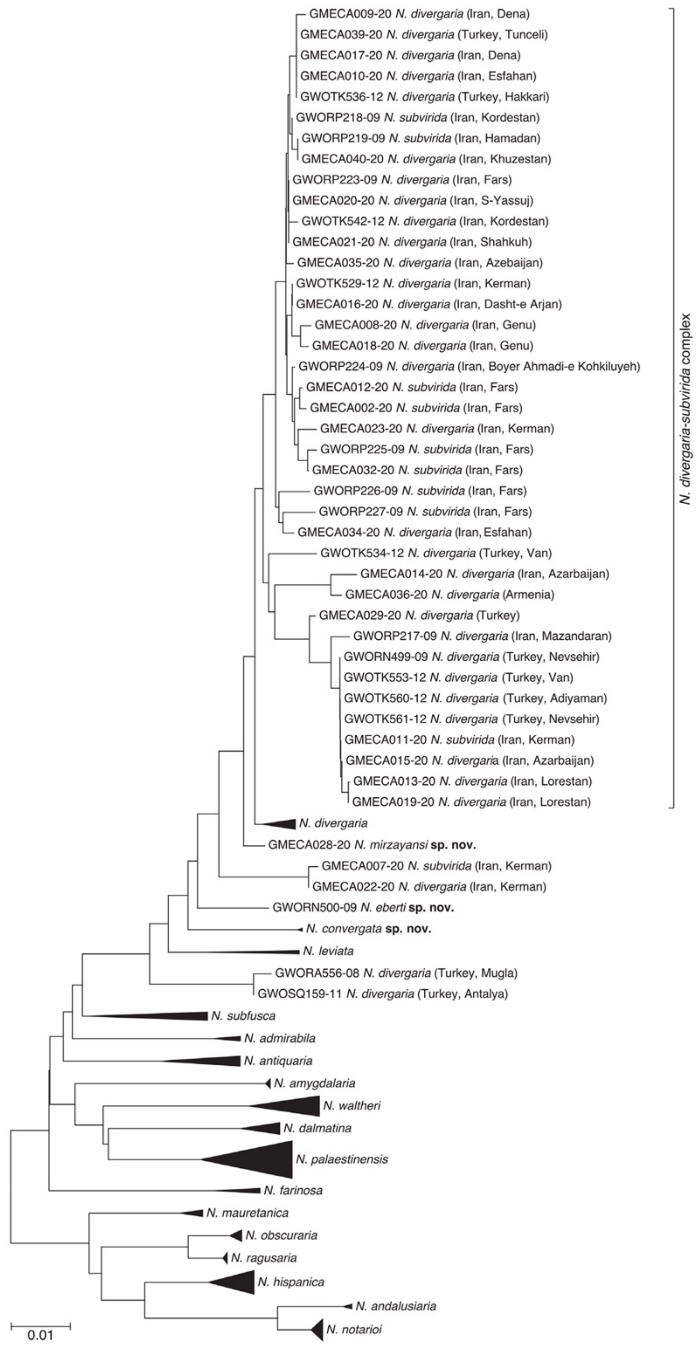


FIGURE 145. Un-rooted neighbour joining tree (Saitou & Nei 1987) based on 20 species of the genus *Nychiodes* (calculated using K2P model: Kimura 1980 with MEGA X (Kumar *et al.* 2018).

Taxonomic remark to the systematic position of *Nychiodes tyttha* Prout, 1915.

Prout (1915) described *Nychiodes tyttha* based on one male and one female specimen from Eritrea (Caraiai) as the only *Nychiodes* species south of North Africa. Thereby Prout mentioned the slightly different venation from *Nychiodes* species and the much smaller size. In fact, even the smallest known *Nychiodes* species are much larger than *N. tyttha*. Furthermore, the strongly differing morphological characters of the genitalia of *N. tyttha* show that this taxon cannot be a *Nychiodes* species, confirmed by the DNA barcode (n=3 from Ethiopia and Eritrea, including the holotype). Herewith, we propose that this species should be excluded from the genus *Nychiodes*, as the genitalia characters of *N. tyttha* could assign it to several other genera in the subfamily Ennominae. We recommend further investigation on this taxon for a convincing classification.

Complete checklist of the species of *Nychiodes* with taxonomic changes in this paper

(Distribution data for European species taken from Müller *et al.* 2019):

***N. obscuraria* (Villers, 1789)** (eastern France, Italy, southern Switzerland, Slovenia, Croatia)
***N. ragusaria* Millière, 1884** (endemic in Sicily and southern Italy)
***N. andalusiaria* Millière, 1865** (endemic in western Iberian Peninsula)
***N. notarioi* Expósito, 2005** (eastern Spain to south-western France)
***N. hispanica* Wehrli, 1929** (southern Spain, Morocco to northern Algeria)
 ***hispanica torrevinagrensis* Expósito, 1984** (valid at subspecific rank)
 ***hispanica atlanticaria* Schwingenschuss, 1936** (valid at subspecific rank)
***N. mauretanica* Wehrli, 1929** (Algeria, Tunisia)
***N. waltheri* Wagner, 1919** (from Bulgaria, Greece, Turkey to northern Iran)
 waltheri saerdabica Wehrli, 1938 **syn. nov.**
 ***waltheri transcaspia* Wehrli, 1938** (valid at subspecific rank)
***N. palaestinensis* Wagner, 1919** (Israel, Palestine, northern Jordan, Lebanon and south- western Syria)
 palaestinensis libanotica Zerny, 1933 **syn. nov.**
 persuavis Wehrli, 1929 **syn. rev.**
***N. muelleri* Hausmann, 1991** (endemic in southern Jordan)
***N. aphrodite* Hausmann & Wimmer, 1994** (endemic in Cyprus)
***N. amygdalaria* (Herrich-Schäffer, 1848)** (Balkan Peninsula, Levant, Transcaucasia, western Iran)
***N. dalmatina* Wagner, 1909** (from north-easternmost Italy to Balkan Peninsula)
***N. farinosa* Brandt, 1938** (endemic in western Iran)
***N. antiquaria* Staudinger, 1892** (in south-eastern Uzbekistan, western Tajikistan, western Kyrgyzstan, south-eastern Kazakhstan, eastern Afghanistan and northern Pakistan)
***N. princeps* Wiltshire, 1966** (endemic in central Afghanistan)
***N. quettensis* Wiltshire, 1966** (endemic in Pakistan)
***N. admirabila* Brandt, 1938** (endemic in south-western Iran)
 admirabila safidaria Wiltshire, 1943 **syn. nov.**
***N. rayatica* Wiltshire, 1957** (Iraq, eastern Turkey, north-western Iran)
***N. subfusca* Brandt, 1938** (endemic in south-western Iran)
***N. leviata* Brandt, 1938** (endemic in western Iran)
***N. subvirida* Brandt, 1938** (endemic in southern Iran)
 agatcha Brandt, 1938 **syn. nov.**
 subvirida disjuncta Wehrli, 1941 **syn. nov.**
 subvirida taftana Brandt, 1941 **syn. nov.**
***N. divergaria* Staudinger, 1892** (from southern Turkey and Armenia to Iran)
 variabila Brandt, 1938 **syn. nov.**
 variabila opulenta Brandt, 1941 **syn. nov.**
 divergaria elbursica Wehrli, 1937 **syn. nov.**

divergaria fallax Wehrli, 1939 **syn. nov.**
divergaria achtyca Wehrli, 1939 **syn. nov.**
N. eberti **sp. nov. Wanke, Hausmann, Rajaei** (Turkey)
N. convergata **sp. nov. Hausmann, Wanke, Rajaei** (endemic in Israel)
N. mirzayansi **sp. nov. Wanke, Hausmann, Rajaei** (endemic in Kerman, Iran)

Conclusion

This study provides the first comprehensive integrative taxonomic revision of the genus *Nychiodes*, covering mainly the Middle East. This region can be defined as a hotspot of biodiversity for the genus *Nychiodes*, as 16 out of 25 known species occur there. Within this region, our results revealed a high intraspecific variation in external and internal characters of some species (e.g., *N. divergaria*, *N. antiquaria*, *N. eberti* **sp. nov.**). This has led to misidentifications and descriptions of a number of taxa in the past. Under the most problematic species, *N. divergaria*, several described taxa had to be synonymized here. For this reason, in any future taxonomic description in *Nychiodes*, a large number of specimens should be carefully examined using an integrative approach (at least combination of genetic and morphologic data). Additionally, it should be considered that some geometrid species in the Middle East may show a clinal character distribution (e.g., *N. divergaria* and *Gnopharmia rubraria* Staudinger, 1892 (see Rajaei *et al.* 2011)), and this may lead to taxonomic misinterpretations.

Acknowledgements

We are very grateful to Robert Trusch (Staatliches Museum für Naturkunde Karlsruhe, Germany), Marianne Espeland (Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany), Mehdi Esfandiari (Insect and Mite Collection Ahvaz), Bernd Müller (Berlin, Germany), Théo Léger (Museum für Naturkunde der Humboldt-Universität, Berlin, Germany), Dirk Stadie (Eisleben, Germany), Jörg Gelbrecht (Königs Wusterhausen, Germany) and Peder Skou (Vester Skerninge, Denmark) for the loan of valuable specimens from their collections. Many thanks to David Lees and Geoff Martin (both Natural History Museum London, UK) and Sabine Gaal-Haszler (Natural History Museum Vienna) for the loan of material and the photography of some type specimens and genitalia slides. We thank Paul Hebert (CCBD, University of Guelph, Canada) and his team for their support in generating and analyzing the DNA barcodes. Thanks to Antonio S. Ortiz, Bernd Müller, Dirk Stadie, Feza Can, Gabriele Fiumi, Iva Mihoci, Jörg Gelbrecht, Marco Infusio, Muhammad Ashfaq and Norbert Pöll for sharing information on DNA barcodes. Many thanks to Michael Falkenberg for his help and constant support in the collection of SMNK. Furthermore, we thank Anne-Kristin Schilling, Daniel Bartsch and Arnaud Faille for their support to the first author during his research at SMNS. We appreciate Zoltan Varga, Erki Õunap and a third anonymous reviewer for their critical review, constructive comments and valuable suggestions to this paper. This project was partially supported by a Research Incentive Grant from the State Museum of Natural History, Stuttgart, Germany. This paper is part of the PhD project of Dominic Wanke at the University of Hohenheim.

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Appendix

Additional material examined.

Nychiodes waltheri Wagner, 1919

2 ♂, Türkei, Katrancik Dagi, Str. Korkuteli-Tefenni, 1300 m, Lichtfang, 30.vi.1998, 37°13‘N, 29°58‘O, leg. Bartsch, Salmen; 1 ♀, Türkei, Anatolien, Capadocia, Develi Ovasi, Seyhsaban, 1150 m, 18.vi.1998, Lichtfang, 38°28‘N, 35°18‘O, leg. Bartsch, Salmen; all in SMNS.

1 ♂, Türkei centr., Prov. Tunceli, 9,5 km NO von Ovacik, 1400 m ü. NN, N 39°25‘27‘, / O 39°16‘52“, 24.viii.2009, LF, leg. R. & S. Fiebig; in PCRF.

1 ♂, 1 ♀, Türkei, Prov. Mugla, Taurus, Boncuk Daglari, 15 km südl. Cavdir, Kozdag Pass, 1440 m, EL, 27.v.1998, leg. Leipnitz, g.prep. (♂) 0329/2019 D. Wanke; in PCML.

1 ♂, Turkey, Konya, Taskent, 1500 m, 20.-21.vii.1994, leg. K. Larsen; 1 ♂, Turkey, Kayseri, Ala Daglar, Ulupinar, 1600 m, 30.vii.1998, leg. K. Larsen, g.prep. 0453/2019 D. Wanke; 1 ♂, Turkey, Malatya, Gündüzbey, 1200 m, 4.-5.viii.1997, leg. K. Larsen; 1 ♂, Turkey, Nigde, Bolkar Daglari, N.s. Maden, 2100 m, 29.vii.1997, K. Larsen, g.prep. 0447/2019 D. Wanke; all in PCPS.

5 ♂, [Turkey], Kleinasien, Prov. Hakkari, Sat-Daglari, vic. Varagöz, 1850-2000 m, 21.-24.vii.[19]83, leg. de Freina, g.prep. 2156/2017 H. Rajaei; 1 ♂, [Turkey], Kleinasien, Prov. Kastamonu, 20 km SW Kastamonu, 1300 m, 14.viii.[19]83, leg. de Freina; 1 ♀, [Turkey], Kleinasien, Prov. Maras, Umg. Maras, vic. Agabeyli, 700-1200 m, 27.-28.v.[19]81, leg. de Freina; 1 ♀, [Turkey], Kleinasien, Prov. Maras, Umg. Maras, vic. Agabeyli, 700-1200 m, 25.-28.v.[19]78, leg. de Freina; 1 ♀, [Turkey], Kleinasien, Prov. Kars, Aras Tal, vic. Karakurt, 1500 m, 24.vi.[19]81, leg. de Freina; 2 ♂, [Turkey], Aksehir, Asia Minor, 1000 m, 20.vii.-5.viii.1966, leg. Czipka, g.prep. 0409/2019 D. Wanke; 2 ♂, Turkey, Izmir, 1 km N. Bayindir, 600 m, 17.viii.1987, leg. M. Fibiger, g.prep. 0428/2019 D. Wanke; 1 ♂, [Turkey], Asia Minor, Izmir, S Darutsav, Hotel Jetis, 5 m, 28.viii.-2.ix.1984, leg. St. Reiss; all in SMNS.

4 ♂, [Turkey], Anatolien, Akshehir, ca. 1000 m, 1.-30.viii.[19]64, leg. Herbert Noack; 6 ♂, 3 ♀, Türk. Ostkurdistan, van Gölü, ca 1800 m, 1.-31.vii.1965, leg. Herbert Noack, g.prep. (♂) 0166/2018 D. Wanke; 2 ♂, Türk. Ostkurdistan, van Gölü, ca 1800 m, 1.-8.viii.1965, leg. Herbert Noack; 4 ♂, Ostanatolien, van Gölü, ca 1800 m, 1.-31.vii.1965, leg. Herbert Noack; 3 ♂, Ostanatolien, van Gölü, ca 1800 m, 6.-31.vii.1965, leg. Herbert Noack; 1 ♂, Iran N, E Alborz, Prov. Mazanderan, E Gorgan, S Aliabad, oberh. Shirinabad, N 36°47‘21“, E 055°01‘25“, 1100mNN, 21.v.2005, leg. Trusch, Petschenka, Müller, g.prep. 0207/2018 D. Wanke; 1 ♀, [Iran], Gorgan, Paz. Abai, 24.ix.1972, g.prep. 0208/2018 D. Wanke; 1 ♀, N-Iran, Masandaran, Schasavar envir., 0m Zone, 27.ix.1972, leg. Ebert; 1 ♀, N-Iran, Bandar Phalavi, -20 m, 28.ix.1970, leg. G. Ebert; all in SMNK.

1 ♂, 1 ♀, West Türkei, Koru Dagi, 30.v.1986, 350 m, leg. P. Kuhna; 1 ♀, SO-Türkei, 20 km nördlich Cölbasi, 17.vi.1977, leg. P. Kuhna; 2 ♂, O-Türkei, Euphrat, Kale, 12.vi.1977, leg. P. Kuhna; 1 ♂, Ost-Türkei, 47 km Malatya, Kale Euphrat, 700 m, 28.vi.1979, leg. P. Kuhna; all in ZFMK.

2 ♂, [Iran], Persia sept., Elburs mts.c.s. Särdab Tal, Vandarban, 19-2200 m, 10.-14.vii. [19]37, leg. E. Pfeiffer & W. Forster, g.prep. 0239/2019 D. Wanke; 2 ♂, [Iran], Persia sept., Elburs mts.c.s., Tacht i Suleiman, Särdab Tal, Vanderban, 25-2700 m, 14.-18.vii. [19]37, leg. E. Pfeiffer & W. Forster, g.prep. 0240/2019 D. Wanke; all in ZSM.

Nychiodes palaestinensis Wagner, 1919

1 ♂, Jordanien, Gouvern. At Tafila, Dhana Nature Reserve, N 30°37‘11“, E 35°37‘37“, 1300 m ü.NN, 12.-15.v.2010 LF, leg. R. & S. Fiebig; 2 ♂, 1 ♀, Jordanien, Gouvern. At Tafila, Dhana Nature Reserve, N 30°37‘11“, E 35°37‘37“, 1300 m ü.NN, ♀ 14.-24.v.2010 LF e.o., leg. R. & S. Fiebig, g.preps (♂) 2136/2017 H. Rajaei, 0232/2019 D. Wanke (♀) 0389/2019 D. Wanke; 1 ♀, Jordanien, Gouvern. At Tafila, Dhana Nature Reserve, N 30°37'11", E 35°37'37", 1300 m ü.NN, 22.-24.v.2010 LF, leg. R. & S. Fiebig; 1 ♂, 1 ♀, Jordanien, Gouvern. At Tafila, Dhana Nature Reserve, N 30°38'39", E 35°36'48", 1150 m ü.NN, 19.v.2010, LF, leg. R. & S. Fiebig, g.prep. (♂) 0390/2019 D. Wanke; 2 ♂, 2 ♀, Jordanien centr., Dana, Nature Reservation, N 30°37'27", E 35°36'44", 1000-1100 m ü.NN, ♀ LF 19.-21.v.2010 e.o., leg. R. & S. Fiebig, g.preps (♂) 0234/2019 D. Wanke (♀) 0391/2019 D. Wanke; 1 ♀, Jordanien, Gouvernement Ma'an, 7 km N von Petra, N 30°22‘47“, E 35°29‘41“, 1660 m ü.NN, 13.v.2010 LF, leg. R. & S. Fiebig; 1 ♂, 1 ♀, Jordanien, Ajlun vic, 900 m, 04.v.2010, N32°21‘33“, E035°43‘40“, ex. ovo. (♂) 14.ix.2010 (♀) 20.ix.2010, leg. S. Schellhorn, Schnitter, Zucht Bernd Müller; in PCPS.

5 ♂, 6 ♀, Jordanien, Gouvernement Ajlun, Ajlun Nature Reserve, N32°23‘29“, E 35°46‘19“, 860 m ü. NN, ♀ LF 09.-10.v.2010 e.o., leg. R. & S. Fiebig, g.preps (♂) 2135/2017 H. Rajaei, 0233, 0392/2019 D. Wanke (♀) 0393/2019 D. Wanke; 1 ♂, Jordanien, Gouvernement Ajlun, Umg. Ajlun 2 km Nördlich, N32°20‘47“, E 35°44‘45“, 920 m ü. NN, LF 08.-10.v.2010 e.o., leg. R. & S. Fiebig; all in PCRF.

2 ♂, 1 ♀, Jordanien, Umg. Ajlun, 900 m NN, Mitte 06.2011, Ex ovo Zucht Wauer, g.prep 0401/2019 D. Wanke; 1 ♂, 1 ♀, Syrien, Safita, ca. 500 m, LF 15.5.98, leg. Löbel & Drechsel, Nachzucht M. Leipnitz, g.prep. 2194/2018 H. Rajaei; all in SMNS.

1 ♂, N. Jordan, Badran, 20 km N Amman, 1000 m, 15.v.1999, leg. Li/Müller; 2 ♂, Asia, Lybanon, Batha Harissa, 800 m, 26.iv.1950, leg. Fabigan; 2 ♂, N. Israel, Mt. Hermon, Upper Cabel Station, 2200 m, 8.-10.vi.2000, leg. Müller, g.preps 0242, 0422/2019 D. Wanke; all in ZSM.

Nychiodes aphrodite Hausmann & Wimmer, 1994

1 ♂, 1 ♀, Cyprus, occ., NE Pafos, NW Filousa, 390 m, 34°51‘N 32°43‘E, ♀: 12.v.20015, ex ovo, leg. Friedrich & Peuker, g.prep. 200§/2016 H. Rajaei; in PCBM.

1 ♀, Cyprus, Moniatis, N. Limassol, 850 m, 23-29.vi.1997, leg. D. Nilsson, A. Madsen, M. Fibiger, P. Svendsen, g.prep. 2108/2017 H. Rajaei; 1 ♂, Cyprus, Southern part, Panagia Valana, 720 m, 1,2 km, NE Laneia, 4.vi.2017, leg. B. Skule; g.prep. 2109/2017 H. Rajaei; all in PCPS.

1 ♀, GR, Cyprus, occ. n/e Pafos, n/w Filousa, 390 m, 34°51‘N 32°43‘E, LF 12.v.15, E. Friedrich, 1. NZ Leipnitz, e.o. 9/2015 Thomas Müller; in SMNS.

Nychiodes amygdalaria **(Herrich-Schäffer, 1848)**

1 ♂, Türkei, Capadocia, Ürgüp, Umg. 5 km Est., 1300 m, Lichtfang, 17.vi.1998, 38°40‘ N 35°01‘ O, leg. D. Bartsch & Salmen; 1 ♂, Türkei, Kapadocia, Göreme Umg. 3 km O., 1000 m, Lichtfang, 16.vi.1998, 38°40‘ N 34°52‘ O, leg. D. Bartsch & Salmen; all in SMNS.

1 ♂, Griechenland, (NE) Thrakien, 1 km südlich Esimi bei Alexandroupoli, 320 m, N 41°00‘40“, E 25°56‘33“, 20.ix.2017, leg. J. Gelbrecht & E. Schwabe; in PCJG.

2 ♂, Türkei centr., Prov. Tunceli, Munzur Tal, 16 km NW von Tunceli, 1100 m ü. NN, N 39°14‘, O 39°28‘, 06.vii.2011, LF, leg. R. Fiebig & S. Rothe; in PCRF.

1 ♂, Anatolien, Aksehir, ca. 1000 m, 1.-31.vii.[19]64, leg. Herbert Noack g.prep. 0168/2018 D. Wanke; 1 ♂, Türk. -Ostkurdistan, Van Gölü, ca. 1800 m, 1.-8.viii.1965, leg. Herbert Noack; 3 ♂, Anatolien, Aksehir, ca. 1000 m, 1.-30.viii.[19]64, leg. Herbert Noack; 1 ♂, W-Iran, Kordestan, 36 km, NE Marivan, Straße nach Baneh, 1550 m, 8.-9.vii.1975, leg. Ebert & Falkner g.prep 0153/2018 D. Wanke; all in SMNK.

2 ♀, Kleinasien, Prov. Artvin, NO-Anatolisches Randgebirge-SE-Seite, Barhal Tal, 4 km NE Altiparmak, 1100 m, 31.vii.-03.viii.[19]83, leg. de Freina, g.prep. 2088/2017 H. Rajaei; 3 ♂, Aksehir, Asia minor, 1000 m, 20.vii.-23.viii.[19]67, leg. Czipka, 2089/2017 H. Rajaei; 1 ♂, Kleinasien, Prov. Maras, Umg. Maras, Agabeyli, 700-1200 m, 25.v.-28.5.[19]78, leg. de Freina, g.prep. 0411/2019 D. Wanke; 1 ♂, Kleinasien, Prov. Erzurum, Soganli-Daglari, Ovit-Paß, 20 km NW Ispir, 1600 m, 20.vii.1986, leg, de Freina; 1 ♂, Türkei, Zelve, Kapadocien, 23.vii.1978, leg. W. Thomas; 1 ♂, Kleinasien, Prov. Baliksehir, Gönen, 15 m, 22.viii.[19]78, leg. de Freina; all in SMNS.

1 ♂, Türkei, Hazar-See, NW-Ufer, 13.vi.[19]77, leg. P. Kuhna; 1 ♂, Türkei,Thermessos, 15.viii.[19]85, leg. Dittrich; all in ZFMK.

Nychiodes farinosa Brandt, 1938

2 ♂, 2 ♀, Iran Prov. Hamadan, Nehavand, 1851 m, N 34°02.756‘, E 048°22, 614‘, 26.vi.2005, leg. G. Petranyi, g.preps (♂) 2182/2018 H. Rajaei, 0414/2019 D. Wanke (♀) 0416/2019 D. Wanke; all in PCGP.

7 ♂, Iran, Fars prov., Shiraz-Kazeroun road, Dasht-e Arjan, 2090 m, N 29°38‘38“, E 52°00‘59“, 12.vi.2010, leg. H. Rajaei, g.prep. 0108/2018 D. Wanke; 1 ♂, Iran, prov. Kohkiluye va Boyerahmad, 30 km S Yassuj, road Abshare-Tange-Tamoradi, 8 km before Abshar, N30°31‘53“, E51°25‘11“, Alt. 2254 m, 24.v.2009, leg. Hossein Rajaei, g.prep. 0120/2018 D. Wanke; all in SMNS.

1 ♂, Iran, Prov. Chahar Mahal, Zagros mts., NW Samsami, 2800 m NN, N 32°09‘, E050°11‘, 13.vii.2003, (lux), leg. G. Ebert & R. Trusch, g.prep. 0180/2018 D. Wanke; in SMNK.

Nychiodes antiquaria Staudinger, 1892

1 ♂, Kyrgyzstan, Jalal Abad, Chatkal Valley 2 km NE Jany Bazar, 1522 m, ALF, 41°41‘18“N, 70°52‘41“E, 26.vi.2016, leg. D. Bartsch, g.prep. 0228/2019 D. Wanke; 1 ♂, Kyrgyzstan, Naryn Slopes 1 km S Kyzyl-Oi, 41°55’52”N, 74°09’03”E, 1780 m, 4.vii.2015, at light, leg. D. Bartsch, g.prep. 0326/2019 D. Wanke; 1 ♂, Kyrgyzstan, Naryn Slopes 1 km S Kyzyl-Oi, 41°55’52”N, 74°09’03”E, 1780 m, 5.vii.2015, at light, leg. D. Bartsch, g.prep. 0229/2019 D. Wanke; all in SMNS.

1 ♂, 1 ♀, Kyrgyzstan, Ferganskiy Mts., 1450 m, LF, Tschitschkan river valley, 1.vii.[20]01, leg. Drechsel, Kallies, NZ Leipnitz, g. prep. (♂) 0330/2019 D. Wanke; in PCML.

2 ♂, Tadjikistan, Gissar Gebirge, Guschary, 1300 m, 11.-12.vi.1999, g.prep. 0360/2019 D. Wanke; 7 ♂, same locality, 13.-15.viii.1999, g.preps 0345, 0346/2019 D. Wanke; 1 ♂, same locality, 13.-14.viii.1999; 3 ♂, Tadjikistan, Gissar Gebirge, Takob Umgebung, Dorf Peschanbe, 1800 m, 19.-20.viii.1999, g.prep. 0347/2019 D. Wanke; 4 ♂, same locality, 21.-22.viii.1999, g.prep. 0348/2019 D. Wanke; 2 ♂, same locality, 16.viii.1999, g.prep. 0351/2019 D. Wanke; 5 ♂, Tadjikistan, Gissar Gebirge, Takob Umgebung, Dorf Porut, 1750 m, 15.-16.viii.1999, g.preps 0350, 0421/2019 D. Wanke; 6 ♂, Tadjikistan, Chosratischo Gebirge, Schuroabad Umgebung bei Nikolaj Pass, 2000 m, 14.-15.viii.1999, g.preps 0352, 0353, 0354, 0355/2019 D. Wanke; 1 ♀, same locality, 19.-20.vii.1999; 10 ♂, Tadjikistan, Chosratischo Gebirge bei Daschtidjum, Schlucht Yoschdara, 1080 m, 9.-10.ix.1999, g.preps 0356, 0357/2019 D. Wanke; 2 ♂, 4 ♀, Tadjikistan, Gissar Gebirge, Kondara, 1100 m, 1.-3.vi.1999, g.prep. 0358/2019 D. Wanke; 1 ♀, same locality, 7.-8.viii.1999; 2 ♂, Tadjikistan, Gissar Gebirge, Fluss Ansob, 2250 m, 8.vii.1999; 2 ♂, 1 ♀, same locality, 9.-10.vii.1999, g.prep. (♂) 0359/2019 D. Wanke; 1 ♂, 1 ♀, Tadjikistan, Wachsch-Gebiet, Sarychosor, 1300 m, 1.-2.vii.1999, g.prep. (♂) 0361/2019 D. Wanke; 2 ♂, Tadjikistan, Baldjuan-Umgebung, Wachsch Gebiet, Sarychosor, 1300 m, 16.-18.vii.1999, g.prep. 0363/2019 D. Wanke; 1 ♂, [Tadjikistan], Pamir, Chorog [Chorugh], 2300 m, 29.-31.vii.1999, g.prep. 0364/2019 D. Wanke; 1 ♀, Tadjikistan, Gebiet Peter I, Ganichou, 2110 m, 20.-21.vi.1999, g.prep. 0366/2019 D. Wanke; 1 ♂, 1 ♀, Tadjikistan, Darvaz mts., Kugireui range, Host vill, Kalaishum city environs, 1500 m, 4.vii.2014, leg. Valentina Zurilina, g.prep. (♂) 0365/2019 D. Wanke; 1 ♂, 7 ♀, Kasakhstan, Dzhambul Region, Kirgizsky Mountains, Merke, 1100 m, 13.vi.2000, leg. A. Lukhtanov, g.preps (♂) 0379/2019 D. Wanke, (♀) 0380/2019 D. Wanke; 1 ♀, Kasakhstan, Dzhambul Region, Kurdai Pass, 950 m, 11.vi.2000, leg. A. Lukhtanov, g.prep. 0378/2019 D. Wanke; 1 ♂, Kirghisien, Talasskij, Chrebet, Sosnovka, 1600 m, 6.viii.1999, leg. I. Pljushtch, g.prep. 0413/2019 D. Wanke; 1 ♂, Kirgizstan, Ferganskij Mt., Alasch, 7.-8.vii.1998, 1800 m, leg. V. Dolin; all in PCPS.

5 ♂, 8 ♀, Uzbekistan, 20 km, SW Guzar, 38°30'N, 66°21'E, 3.vi.1995, 750 m, leg. Z. Weidenhoffer, g.preps (♂) 0099/2018, 0408/2019 D. Wanke, (♀) 0137, 0138/2018 D. Wanke; 1 ♂ Uzbekistan, Kugitangtau Mts., Shalkan Valley, 37°51'N, 66°39'E, 1.vi.1995, 1500 m, leg. Z. Weidenhoffer; 1 ♂ Uzbekistan, Kugitangtau Mts., Shalkan Valley, Vandob, 37°44'N, 66°34'E, 30.v.1995, 1500 m, leg. Z. Weidenhoffer, g.prep. 0098/2018 D. Wanke; 2 ♂ Uzbekistan, Sherabad Region, Maydan, 37°45'N, 66°54'E, 29.v.1995, 1500 m, leg. Z. Weidenhoffer, g.preps 0096, 0097/2018 D. Wanke; 1 ♂ Kyrgyzstan, Jalal Abad, road Toktogul-Kara-Kul, SW Kebbel Pass, 1120 m, 41°41'25"N, 072°53'46"E, 29.v.2014, lighttrap, leg. D. Bartsch, g. prep. 0100/2018 D. Wanke; 3 ♂ Kyrgyzstan, Jalal Abad, road Toktogul-Kara-Kul, Kebbel Pass, 1220 m, at light, 41°41'39"N, 072°53'48"E, 30.v.2014, leg. D. Bartsch, g. preps 0139/2018, 0410/2019 D. Wanke; 3 ♂ Kyrgyzstan, Jalal Abad, road Tash-Kumyr-Alcha, 770 m, lighttrap, 41°26'52"N, 072°12'46"E, 3.vi.2014, leg. D. Bartsch, g. prep. 0101/2018 D. Wanke; 1 ♂ Kyrgyzstan, Talas, S Talas, S Kozuchak, Besh-Tash NR, 1640 m, 42°36'04"N, 071°34'17"E, 19.vi.2014, leg. D. Bartsch, g. prep. 0102/2018 D. Wanke; 5 ♂ Afghanistan, Kabul Fluß, Tang i Gharu Schlucht 22.-23.v.1977, 1600 m, leg. de Freina, g.preps. 0094, 0135, 0136/2018 D. Wanke, 0407/2019 D. Wanke; 1 ♂ Afghanistan, Kabul Fluß, Tang i Gharu Schlucht, 11.viii.1977, 1600 m, leg. de Freina; all in SMNS.

2 ♂, 2 ♀, Tajikistan, S. Darvaz mts. Pianj river, Ravnob river valley, 1.5 km N of Zhag village, N38°14'316", E70°31'753", 1057 m, 23.v.2017, leg. B. Benedek & S. Ilniczky, g.prep. (♂) 0429/2019 D. Wanke; 1 ♂, SO-Afghanistan, Safed Koh, Südseite, Kotkai, 2350 m, 21.vi.-1.vii.1969, leg. Vartian, g.prep. 0156/2018 D. Wanke; 3 ♂, same locality, 21.vi.-1.vii.1969, leg. G. Ebert, g.preps 0157, 0158, 0159/2018 D. Wanke; 2 ♀, same locality, 28.vii.1968, leg. M. Müller; 1 ♂, same locality, 4.viii.1967, leg. M. Müller; 1 ♀, same locality, 9.vii.1968, leg. M. Müller; 2 ♂, 1 ♀, same locality, 20.vii.1968, leg. M. Müller, g.prep. (♂) 0160/2019 D. Wanke; 4 ♂, 1 ♀, W-Pakistan, Swat, N.v. Kalam, Gabral Tal, 2100 m, 6.-9.vii.1969, g.preps (♂) 0154/2019 D. Wanke, (♀) 0430/2019 D. Wanke; all in SMNK.

1 ♂, Afghanistan, Pagman-Gebirge (Kabul), ca. 3000 m, vi.-vii.1942, coll. Brandt; 1 ♂, NW-Pakistan, 20 km W of Besham, Karaora, 1200 m, N34°53', E72°47', 27.v.1992, leg. M. Hreblay & G. Csorba; 2 ♂, 2 ♀, Pakistan, Kohistan, Swat prov., N35°10', E72°32', Miandam, 1800 m, 25.vi.-5.vii.1992, leg. Z. Waldenhoffer; 5 ♂, NW-Pakistan, Kalam, 2200 m, 35°31'N, 72°36'E, 25-26.v.1992, leg. M. Hreblay & G. Csorba; 2 ♂, 1 ♀, NW-Pakistan, Khwazakheia, 1100 m, 34°55'N, 72°21'E, 24.v.1992, leg. M. Hreblay & G. Csorba; 1 ♂, N-Pakistan, 20 km E of Gupis, 2500 m, 36°15'N, 73°36'E, 20.vi.1992, leg. M. Hreblay & G. Csorba; 1 ♂, 1 ♀, Tadjikistan, Gissar Gebirge, Kandara, 1100 m, 29.-30.vii.1998, leg. local Coll; 3 ♂, Tadjikistan, Karategin-Gebirge, Schlucht Sangikar, 7.vii.[19]69, 1700 m, leg. Stschetkin; all in ZFMK.

***Nychiodes admirabila* Brandt, 1938**

2 ♂, Iran, Kohkiluye va Boyerahmad, yasuj, Sisakht, Dena, 2799 m, 30°57'23.6"N, 51°23'28.9"E, 30.vii.2016, leg. Sh. Feizpour, g.preps 0301, 0302/2019 D. Wanke; in SMNS.

1 ♂, Iran, Fars, Straße Ardekan-Talochosroe, Comè, 2600 m, vii.1937, g.prep. 0174/2018 D. Wanke; in SMNK.

***Nychiodes rayatica* Wiltshire, 1957**

1 ♂, [Turkey], Kleinasien, Prov. Hakkari, Hakkari-Daglari, 10 km, östl. Gecitli, 2100-2300 m, 13.vii.-14.vii.[19]80, leg. de Freina, g.prep. 0254/2019 D. Wanke; in SMNS.

1 ♂, W-Iran, Kordestan, Straße Baneh-Marivan, 25 km E Baneh, 1950 m, 4.vii.1975, leg. Ebert & Falkner, g.prep. 0197/2018 D. Wanke; in SMNK.

***Nychiodes subfusca* Brandt, 1938**

2 ♂, 3 ♀, Iran, Prov. Fars, Komehr, 2892 m, N 30°20.505', E 051°57.324', 29.vi.2005, leg. Petrányi G., g.prep. (♂) 2189/2018 H. Rajaei; 2 ♂, 2 ♀, Iran, Prov. Buyer Ahmad, Kuh-E-Dinar, 15 km N from Vazag, N 30°30,140', E 51°42,376', 2350 m, 12.vi.2007, leg. T. Hacz, L. Nadai, g.preps. (♂) 2190, 2191/2018 H. Rajaei; all in PCGP.

3 ♂, Iran, Fars prov., Shiraz-Kazeroun road, Dasht-e Arjan, 2090 m, N 29°38'38", E 52°00'59", 12.vi.2010, leg. H. Rajaei, g.preps 0367, 0412/2019 D. Wanke; 1 ♂, Iran, Prov. Esfahan, Zagros Mts., Fereidun Shar, 3000 m, 15.-17.vi.2010, leg. B. Benedek & T. Hácz, g.prep. 0368/2019 D. Wanke; 2 ♂, 1 ♀, [Iran], Esfahan, Smeirom Padena, Tange Bijan, 2930 m, 13.viii.1978, leg. Paz./Brou., g.preps (♂) 0369/2019 D. Wanke, (♀) 0442/2019 D. Wanke; all in PCPS.

1 ♂, Iran, Fars prov., Shiraz-Kazeroun road, Dasht-e Arjan, 2090 m, N 29°38'38", E 52°00'59", 12.vi.2010, leg. H. Rajaei, g.prep. 0107/2018 D. Wanke; in SMNS.

1 ♂, Iran, Fars, Straße Ardekan-Talochosroe, Comé, 2600 m, vii.1937, Brandt, g.prep. 0171/2018 D. Wanke; 1 ♂, S-Iran, Fars, Daschte Ardjan, Kotal-Pirehsan, 2000 m, 18.vi.1972, leg. Ebert & Falkner; all in SMNK.

***Nychiodes leviata* Brandt, 1938**

1 ♂, Iran, Lorestan, Kuh-e Garin, Gard ye Gema-Siab O [Gardaneh-e Gamasiab East], 2200 m, 25.vi.2009, leg. A. Hofmann, J.-U. Meineke, H. Rajaei, g.prep. 0214/2019 D. Wanke; 4 ♂, Iran, Boyerahmad-va-Kohgiluyeh, Gardaneh, Meymand, 2450-2800 m, 14./15.vi.2001, leg. A. Hofmann, J.-U. Meineke, W.G. Tremewan, g.preps 0219, 0221/2019 D. Wanke; all in PCJM.

1 ♂, same locality as before; in PCPS.

9 ♂, Iran, Isfahan prov. Hanna protected area, Hanna-Komee [Komehr] road, 15 km after Hanna, Baghak Mt., 2355 m, N 31°10'44", E 51°33'51", 10.vi.2010, leg. H. Rajaei, g.preps 0111, 0112, 0113/2018 D. Wanke, 0417/2019 D. Wanke; 1 ♂, Iran, Fars prov., Shiraz-Kazeroun road, Dasht-e Arjan, 2090 m, N 29°38'38", E 52°00'59", 12.vi.2010, leg. H. Rajaei, g.prep. 0109/2018 D. Wanke; 1 ♂, Iran, Lorestan, Dorud, Gahar lake, 2309 m, 33°18'40.8"N, 49°16'43"E, 28.vii.2016, leg. Sh. Feizpour, g.prep. 0122/2018 D. Wanke; all in SMNS.

1 ♂, Iran, Chaharmahal-va-Bakhtiyari, Borujen S Dorahun 6 km S, 1850-2100 m, 1.vi.2005, leg. A. Hofmann & J.-U. Meineke, g.prep. 0181/2018 D. Wanke; 1 ♂, S-Iran, Prov. Fars, Tange Surkh, 50 km NW Ardekan, 2250 m NN, 12.-15.vi.1975, leg. Ebert, Falkner, g.prep. 0280/2019 D. Wanke; all in SMNK.

Nychiodes subvirida **Brandt, 1938**

1 ♂, Iran, Baloutchistan, Kouh i Taftan (Khach), 2500 m, 15.v.1938, coll. Brandt, gpprep 10937; 1 ♀, Iran Laristan, Straße Bender-Abbas-Saidabad, Sardze Umgebung, ca. 200 m, Mitte Nomvember 1937, gpprep 10936; all in NHRS.

2 ♂, Iran, Prov. Fars, Ghir, 1500 m, 11.iv.2004, leg. T. Hacz, B. Benedek, g.prep. 0415/2019 D. Wanke; 10 ♂, 2 ♀, Iran, Prov. Fars, Lar, 30.iii.-04.iv.2009, leg. G. Petranyi, g.preps (♂) 2179, 2181/2018 H. Rajaei (♀) 2180/2018 H. Rajaei; all in PCGP.

1 ♂, Iran, Kerman, Jiroft NW, Gardaneh, Sarbishan, Shingara vic., 2700-2900 m, 3./4.vi.2002, leg. J.-U. Meineke, A. Hofmann, A. Kallies *et al.*, g.prep. 0224/2019 D. Wanke; 1 ♂, Iran, Kerman, Jiroft W, Shingera, 2800 m, 26./27.5.2004, leg. A. Hofmann, J.-U. Meineke, G. Tremewan, g.prep. 0305/2019 D. Wanke; 1 ♀, Iran, Balucestan, Kuh-e Taftan, Jam Chin, 2500 m, 16.-18.v.2004, leg. A. Hofmann, J.-U. Meineke, G. Tremewan, g.prep. 0306/2019 D. Wanke; all in PCJM.

1 ♀, [Iran], Kerman, Jiroft, Esfandagheh, 2.iv.2012, N 28°43'42.8", E 057°26'41.0", 1321 m, leg. M. Afsarian, g.prep. 0446/2019 D. Wanke; in PCPS.

4 ♂, Iran, prov. Kerman, Baft-Sirjan road, 2 km after Baft, sandy road, 3 km to Nord, Ras-Kuh village, N29°17' 27", E 56°35'37", Alt. 2543 m, 20.-21.v.2009, leg. H. Rajaei, g.prep. 0110/2018 D. Wanke; 2 ♂, 3 ♀, Iran, Kerman, Bam-Jiroft road, Kuhe Dehbakri, 2152 m, 28°48'01"N, 57°56'05"E, 27.iv.2016, leg. Sh. Feizpour, g.preps (♂) 0126, 0127/2018 D. Wanke, (♀) 0294/2019 D. Wanke; 1 ♀, Iran, prov. Fars, Estahban-Sarwestan road, 22 km before Sarwestan, after Ab-Asemani village, N29°05'51", E053°26'12", Alt. 1890 m, 22.v.2009, leg. Hossein Rajaei, g.prep 0303/2019 D. Wanke; 1 ♂, 1 ♀, Iran, Prov. Fars, ca. 20 km S Jahron, Sistan, Garden Ahmad Najafzadeh., N28°21', E53°22', 30.iii.2011, 870 mNN, leg. Hossein Rajaei, g.prep. (♂) 0132/2018 D. Wanke; 1 ♀, Iran, Fars prov., SE Jahrom, 1080 m, N28°28'45.57", E53°30'24.28", 25.ix.2014, leg. H. Rajaei; 2 ♂, 1 ♀, Iran, Fars, 30 km N Persepolis, 1.v.1975, leg. W. Thomas, g.preps (♂) 0092, 0093/2018 D. Wanke; 1 ♂, Iran, Fars, 40 km W Fasa, 3.v.1975, leg. W. Thomas; 1 ♀, Iran, Fars, 115 km W Shiraz, 9.v.1975, leg. W. Thomas; 1 ♂, Iran, Prov. Fars, ca. 20 km S Jahron, Sistan, N28°21', E53°22', 06.12.2018, 870 m, leg. H. Rajaei, g.prep. 0060/2018 D. Wanke; all in SMNS.

1 ♂, S-Iran, Straße Shiraz-Kazerun, Imam Sade, 1200 m, 3.vi.1969, leg. G. Ebert, g.prep. 0176/2018 D. Wanke; 1 ♀, S-Iran, Miyan-Kotal, östl. Kazerun, 51°40' E, 29°30' N, 1900 m, 4.-7.vi.1969, leg. G. Ebert; 1 ♀, Iran, Fars, Umgebung von Chiraz, ca. 1600 m, 24.iv.1937, coll Brandt; 4 ♂, 1 ♀, S-Iran, Bandar Abbas, km 107 d. Strasse nach Sirdjan, 850 m, 7.iii.1973, leg. G. Ebert, g.prep. (♂) 0185/2018 D. Wanke; 1 ♂, S-Iran, Tangetchogan, 30 km n. Kazerun, 930 m, 23.ii.[19]73, leg. H.G. Amsel, g.prep. 0179/2018 D. Wanke; 1 ♂, S-Iran, 42 km wnw Djahrom, Astragalus Steppe, 1300 m, 26.iii.1973, H. Amsel; 1 ♂, Iran, Fars, Shiraz ESE, Darab N (Pass), 1850-2100 m, 19.v.2005, leg. T. & A. Hofmann; 1 ♂, Iran, Baloutchistan, Kouh i Taftan (Khach), 2500 m, Mai 1938, coll. Brandt, g.prep. 0188/2018 D. Wanke; 6 ♀, Iran, prov. Fars, Estahban-Sarwestan road, 22 km before Sarwestan after Ab-Asemani village, N29°05'51", E53°26'12", 1890mNN, 22.v.2009, leg. Hossein Rajaei, g.prep. 0169/2018 D. Wanke; all in SMNK.

Nychiodes divergaria **Staudinger, 1892**

1 ♂, Iran, Prov. Khuzestan, Mal aqa, 1100 m, 31°35'57" N, 50°00'50" E, 07.x.2016, leg. Mehdi Esfandiari, g.prep. 0418/2019 D. Wanke; 1 ♀, Iran, Prov. Fars, Tange bolhayat, 1300 m, 29°44'02" N, 51°47'00"E, 27.x.2016, leg. Mehdi Esfandiari; all in IMCA.

2 ♂, Türkei, Prov. Van, Paßweg 10 km südlich von Gevas, 2500 m, TF/LF, 30.vii.2001, leg. D. Stadie, H. Löbel, g.preps 0231, 0319/2019 D. Wanke; 2 ♂, 2 ♀, Türkei, Prov. Van, 7 km südlich Güseldere Gecidi, 31.vii.2001, LF, 2300 m, leg. D. Stadie, H. Löbel, g.preps (♂) 0322, 0323/2019 D. Wanke, (♀) 0318/2019 D. Wanke; 3 ♂, 2 ♀, Türkei, Prov. Adiyaman, Nemrut Dagh, 1600-2000 m, N 38°02', E 38°45', 21.-23.viii.2009, LF, e.o., leg. Ralf Fiebig, g.preps (♂) 0321, 0324, 0325/2019 D. Wanke; 1 ♂, Türkei, Prov. Malatya, Nemrut dagi, 1430 m, N 38°00'54", E 38°40'09", 24.v.2009, LF, leg. D. Stadie & H. Löbel, g.prep. 0317/2019 D. Wanke; all in PCDS.

1 ♂, 1 ♀, SW-Türkei, Provinz Mugla, Dalaman, Sarigerne, 50 m, w. 22.v.-5.vi.2000, e.o. (♂) 31.vii.2000, e.o. (♀) 2.-5.vii.2000, leg. M. Leipnitz, g.prep. (♀) 0458/2019 D. Wanke; in PCJG. 3 ♂, 2 ♀, Iran, Prov. Fars, Kum Mts., Saidad, Sahr 1843 m, N 30°00.757', E 053°08.530', 1.vii.2005, leg. G. Petrányi, g.preps (♂) 2184, 2185/2018 H. Rajaei; 4 ♂, 4 ♀, Iran, Prov. Buyer Ahmad, Kuh-E-Dinar, 15 km N from Vazag, N 30°30,140', E 51°42;376', 2350 m, 12.vi.2007, leg. T. Hacz, L. Nadai, g.prep. (♂) 2186/2018 H. Rajaei; 1 ♂, Iran, Prov. Mazandaran, Minokh, Resteh-Ye-Elborz, Balade Valley, 2400 m, N 36°13,409', E 51°36,381', 18.vi.2007, leg. T. Hacz, L. Nadai, g.prep. 2187/2018 H. Rajaei; 1 ♂, Iran, Prov. Fars, Ghir,

1500 m, 11.iv.2004, leg. T. Hacz, B. Benedek, g.prep. 2188/2018 H. Rajaei; 1 ♀, Iran Prov. Hamadan, Nehavand, 1851 m, N 34°02.756‘, E 048°22.614‘, 26.vi.2005, leg. G. Petranyi; 8 ♂, 5 ♀, Iran, Kordestan, Sanandaj, Askaran, 1380 m, N 35°05.084‘, E 046°54.118‘, 25.vi.2005, leg. G. Petrányi, g.preps (♂) 2192, 2193/2018 H. Rajaei (♀) 2183/2018 H. Rajaei; all in PCGP.

1 ♂, Iran, Fars, Moshkan, 10 km NW, 2500 m, 28.v.2004, leg. A. Hofmann, J.-U. Meineke, G. Tremewan, g.prep. 0211/2019 D. Wanke; 1 ♂, 2 ♀, Iran, Shiraz, Meymand 5 km S, Ginstersteppe, 1600 m, 13.x.2010, leg. J.-U. Meineke, A. Hofmann, g.prep. (♂) 0210/2019 D. Wanke; 1 ♀, Iran, Fars, Shiraz E, Dash-e-Arzhan E, 1900-2200 m, 6./7.vi.2002, leg. J.-U. Meineke, A. Hofmann, A. Kallies *et al.*; 1 ♀, Iran, Zagros, Lorestan, Dorud Umg. Kuh-e-Osturkan, 2200 m, 7./8.vii.1999, leg. A. Hofmann, J. Meineke; 1 ♂, Iran, Markazi, Tafresh via Dastgerd, 2300-2500 m, 15./16.vi.2005, leg. J.-U. Meineke, g.prep. 0212/2019 D. Wanke; 4 ♂, 1 ♀, Iran, Kerman, Jiroft NW, Gardaneh, Sarbishan, Shingara vic., 2700-2900 m, 3./4. vi.2002, leg. J.-U. Meineke, A. Hofmann, A. Kallies *et al.*, g.preps (♂) 0223, 0308, 0309/2019 D. Wanke; 1 ♂, 1 ♀, Iran, Kerman, Jiroft W, Shingera, 2800 m, 26./27.5.2004, leg. A. Hofmann, J.-U. Meineke, G. Tremewan, g.prep. (♂) 0218/2019 D. Wanke; 1 ♀, Iran, Kerman, Jiroft W, Shingera, 2800 m, 22./23.5.2004, leg. A. Hofmann, J.-U. Meineke, G. Tremewan, g.prep. 0307/2019 D. Wanke; 2 ♀, Iran, Boyer Ahmad-Va-Kohgiluyeh, Yasuj NW, Sisakht 7 km NNE, 2650-2700 m, 14.vi.2001, leg. A. Hofmann, J.-U. Meineke, W.G. Tremewan, g.prep. 0310/2019 D. Wanke; 1 ♂, Iran, Boyer Ahmad-Va-Kohgiluyeh, Gardaneh, Meymand, 2450-2800 m, 14./15.vi.2001, leg. A. Hofmann, J.-U. Meineke, W.G. Tremewan, g.prep. 0220/2019 D. Wanke; 2 ♀, Iran, Boyer Ahmad-Va-Kohgiluyeh, Yasuj E, Kakan-baba Hassan, 2600-2800 m, 8.vi.2002, leg. J.-U. Meineke, A. Hofmann, Kallies *et al.*, g.prep. 0311/2019 D. Wanke; 2 ♂, Iran, Azerbaijan-e Gharbi prov., Khoy to Ghotur road, Esteran vill., Alt. 1637 m, N 38°27‘03.1“, E 44°44‘33.6“, 1.vii.2013, leg. J.-U. Meineke, H. Rajaei, B. Hafezi, g.preps 0215, 0312/2019 D. Wanke; 2 ♂, 2 ♀, Iran, Esfahan, Gandoman S, Gerdeish-e, 200 m, 12./13. vi.2002, leg. J.-U. Meineke, A. Hofmann, Kallies *et al.*, g.preps (♂) 0216/2019 D. Wanke (♀) 0313/2019 D. Wanke; 4 ♂, Iran, Chaharmahal-va-Bakhtiyari, Borujen S, Dorahun 6 km S, 1850-2100 m, 1.vi.2005, leg. A. Hofmann, J.-U. Meineke, g.prep. 0217/2019 D. Wanke; all in PCJM.

1 ♂, 1 ♀, SW-Türkei, Provinz Mugla, Dalaman, Sarigerne, 50 m, w. 22.v.-5.vi.2000, e.o. 2.-5.viii.2000, leg. M. Leipnitz, g.prep. 0331/2019 D. Wanke; in PCML. 1 ♂, Türkei east, Provinz Van, Gürpinar, 17 km OSO, 2100 m ü.NN, N38°13‘44“, O 43°33‘42“, 29.vi.2008, LF, leg. Ralf & Sylvana Fiebig, g.prep. 0397/2019 D. Wanke; 1 ♀, Türkei Southeast, Provinz Hakkari, 40 km SW von Hakkari, Sürvahalil Gecidi, 2200-2500 m ü.NN, N 37°29‘, O 43°19‘, 03.vii.2011, LF, leg. R. Fiebig & S. Rothe; 3 ♂, Türkei Southeast, Provinz Hakkari, 6,5 km westl. von Hakkari, 2500-2600 m ü.NN, N 37°33‘, O 43°40‘. 29.vi.-03.vii.2011, LF, leg. R. Fiebig & S. Rothe, g.preps 0394, 0395/2019 D. Wanke; 2 ♂, Türkei Southeast, Provinz Sirnak, 6 km NW von Uludere, 1600-2000 m ü.NN, N37°28‘, O42°55‘, 04.vii.2011, LF, leg. R. Fiebig & S. Rothe, g.prep. 0237/2019 D. Wanke; 9 ♂, 7 ♀, Türkei centr., Provinz Adiyaman, Nemrut Dag, N 38°02‘, O 38°45‘, 1600-2000 m, ü.NN, ♀ 21.-23.viii.2009 e.o., leg. R. & S. Fiebig, g.prep. (♂) 2131, 2132/2017 H. Rajaei, (♀) 0441, 0455/2019 D. Wanke; 2 ♂, Türkei centr., Provinz Adiyaman, Nemrut Dag, N 38°02‘07“, O 38°45‘48“, 1700-2000 m, ü.NN, 23.-25.v.2009, LF, leg. R. & S. Fiebig, g.prep. 2133/2017 H. Rajaei; 1 ♂, Türkei centr., Provinz Adiyaman, Nemrut Dag, N 38°02‘07“, O 38°45‘48“, 2000 m, ü.NN, 26.vi.2006, LF, leg. Ralf & Sylvana Fiebig, g.prep. 0235/2019 D. Wanke; 4 ♂, Turkey, Tunceli, Munzur Tal, 16 km NW Tunceli, 1100m ü. NN, N 39°14‘, O 39°28‘, e.o., 06.vii.2011, Ralf Fiebig & S Rothe, all in PCRF.

1 ♂, Republic Armenia, Yeranos Mts. 1600 m, Dvinvillage suburbs, Arat district, 11.-13.vi.2009, leg. Yuriy Shevnin; 1 ♂, Turkey, Bitlis, Tatvan, 1800 m, 30.vi.2001, leg. K. Larsen, g.prep. 0337/2019 D. Wanke; 1 ♂, Turkey, Agri, Ararat N. s. 2050 m, 18 km SE Suveren, 1.vii.2001, leg. K. Larsen, g.prep. 0338/2019 D. Wanke; 1 ♂, Republic Armenia, Aiotzdorsky range, 2000 m, Yeghegnadzor suburbs, 150 km to SE from Yerevan, Mozrov Village, Mountain steppes, 25.-27.vi.2009, leg. Yuriy Shevnin, g.prep. 0374/2019 D. Wanke; 1 ♂, Republic Armenia, Aiotzdorsky range, 2000 m, Yeghegnadzor suburbs, 150 km to SE from Yerevan, Mozrov Village, Mountain steppes, 12.-19.vii.2009, leg. Yuriy Shevnin, g.prep. 0375/2019 D. Wanke; 2 ♂, Republic Armenia, Aiotzdorsky range, 2000 m, Yeghegnadzor suburbs, 150 km to SE from Yerevan, Mozrov Village, Mountain steppes, 21.-23.vii.2009, leg. Yuriy Shevnin, g.prep. 0376/2019 D. Wanke; all in PCPS.

6 ♂, 4 ♀, Iran, Hormozgan, Bandar Abbas, Genu, 2128 m, 27°25‘02“ N, 56°10‘160“ E, 01.v.2016, leg. Sh.Feizpour, g.preps (♂) 0114, 0115/2018 D. Wanke, (♀) 0295/2019 D. Wanke; 8 ♂, 8 ♀, Iran, Kohkiluye va Boyerahmad, yasuj, Sisakht, Dena, 2799 m, 30°57‘23. ,‘N, 51°23‘28.9“E, 30.vii.2016, leg. Sh. Feizpour, g.preps (♂) 0116, 0117/2018 D. Wanke, (♀) 0297/2019 D. Wanke; 1 ♀ Iran, prov. Fars, Shiraz-Kazerun road, 5 km before Dashte Arjan, N 29°40‘34“, E 052°02‘18“, Alt. 2158 m, 23.v.2009, leg. Hossein Rajaei, g.prep. 0296/2019 D. Wanke; 5 ♂, Iran, Lorestan, Dorud, Gahar lake, 2309 m, 33°18‘40.8“N, 49°16‘43“E, 28.vii.2016, leg. Sh. Feizpour, g.prep. 0121/2018 D. Wanke; 1 ♂, 1 ♀, Iran, Azerbaijan-e Gharbi prov., Khoy to Ghotur road, Esteran vill., Alt. 1637 m, N 38°27‘03.1“, E 44°44‘33.6“, 1.vii.2013, leg. H. Rajaei, J.U. Meineke, B. Hafezi, g.preps (♂) 0131/2018 D. Wanke, (♀) 0298/2019 D. Wanke; 1 ♂, Iran, prov. Lorestan, Noorabad-Nahawand road, 25 km to Nahawand, Gardane-Garrin, N34°02‘48“ E 48°20‘31“, Alt. 2135 m, 25.vi.2009, leg. H. Rajaei, J.U. Meineke & A. Hoffmann, g.prep. 0124/2018 D. Wanke; 1 ♂, Iran, prov. Kohkiluye va Boyerahmad, 30 km S Yassuj, road Abshare-Tange-Tamoradi, 8 km before Abshar, N30°31’53”, E51°25’11”, Alt. 2254 m, 24.v.2009, leg. Hossein Rajaei, g.prep. 0119/2018 D. Wanke; 1 ♂, Iran, Shahrud, Shahkouh, Tash, Ayoub Hosseini region, 2588 m, 36°37’18”N, 54°33’42.6”E, 11.vii.2016, leg. Sh. Feizpour, g.prep. 0133/2018 D. Wanke; 3 ♀, Isfahan prov. Hanna protected area, Hanna-Komee road, 15 km after Hanna, Baghak Mt., 2355 m, N 31°10’44”, E 51°33’51”, 10.vi.2010, leg. H. Rajaei, g.prep. 0293/2019 D. Wanke; 4 ♂, Iran, Kerman, Bam-Jiroft road, Kuhe Dehbakri, 2152 m 28°48’01”N, 57°56’05”E, 27.iv.2016, leg. Sh. Feizpour, g.preps 0125, 0128, 0129, 0130/2018 D. Wanke; 11 ♂, Iran, Fars, 30 km N Persepolis, 1.v.1975, leg. W. Thomas, g.preps 0089/2018, 0332, 0333, 0334, 0335/2019 D. Wanke; 1 ♀, Iran, Fars, 40 km

W Fasa, 3.v.1975, leg. W. Thomas; 3 ♂, 1 ♀, Iran, Elburs, vic. Kendevan, 7.-9.viii.1977, 2500-3000 m, leg. W. Thomas, g.preps, (♂) 0082/201, 0256/2019 D. Wanke, (♀) 0437/2019 D. Wanke; 1 ♂, Iran, Elburs, vic. Shemshak, 12.-13.viii.1977, ca. 3000 m, leg. W. Thomas; 1 ♂, Iran, Elburs, Shemshak, 2700 m, 10.-11.viii.1978, leg. W. Thomas, g.prep. 0083/2019 D. Wanke; 1 ♂, NW-Iran, Kaleibar, 1700 m, 3.viii.1977, leg. W. Thomas, g.prep. 0084/2018 D. Wanke; 1 ♂, Iran, Ostan Tehran, Reshteh Ye Alborz, Dizin Gardaneh, 2700-3000 m, 5.-8.vii. 1978, leg. W. L. Blom, g.prep. 0081/2018 D. Wanke; 1 ♂, Iran, Makran, südöstl. Nahu, 1300 m, 19.u.26.iii.1954, Richter u. Schäuffele, g.prep. 0090/2018 D. Wanke; 7 ♂, [Turkey], Kleinasien, Prov. Siirt, 25 km W Uludere, 1200 m, 31.v.[19]81, leg. de Freina, g.preps 0064, 0065/2018 D. Wanke, 0247, 0248, 0249/2019 D. Wanke, 2091/2016 H. Rajaei; 1 ♂, 1 ♀, Türkei, Anatolien, Kurdistan, Elazig SÜ, vii.1976, leg. Czipka, g.preps (♂) 2093/2017 H. Rajaei, (♀) 0431/2019 D. Wanke; 4 ♂, [Turkey], Kleinasien, Prov. Siirt, Umg. Sirnak, 900-1200 m, 02.6.1982, leg. de Freina, g.preps. 0067/2018 D. Wanke, 0250/2019 D. Wanke, 2095/2017 H. Rajaei; 1 ♀, [Turkey], Kleinasien, Prov. Siirt, 16 km NW Sirnak, 1100 m, 09.vii.[19]83, leg. de Freina, g.prep. 0251/2019 D. Wanke; 1 ♂, 1 ♀, [Turkey], Kleinasien, Prov. Hakkari, Sat-Daglari, vic. Varagöz, 1850-2000 m, 21.-24.vii.[19]83, leg. de Freina, g.preps (♂) 2094/2017 H. Rajaei, (♀) 0433/2019 D. Wanke; 8 ♂, 1 ♀, [Turkey], Kleinasien, Prov. Hakkari, Zab-Tal, 20 km östl. Hakkari, 1300-1400 m, 06.-16.vi.[19]81, g.preps (♂) 0068, 0069, 0070, 0071, 0074/2018 D. Wanke, (♀) 0434/2019 D. Wanke; 6 ♂, 2 ♀, Türkei, Van, 5 km W Gevas, 1700-1800 m, 24.vii.-5.viii.[19]92, leg. P. Kautt & V. Weiss, g.preps (♂) 0061, 0062, 0063/2018 D. Wanke, 0257, 0258/2019 D. Wanke, (♀) 0259/2019 D. Wanke; 4 ♂, [Turkey], Kleinasien, Prov. Hakkari, 15 km NW Yüksekova, vic. Suüstü (=Sakitan), 1900 m, 19.-20.vii.1983, leg. de Freina, g.preps 0072/2018 D. Wanke, 0253/2019 D. Wanke; 1 ♂, [Turkey], Kleinasien, Prov. Hakkari, 15 km NW Yüksekova, vic. Suüstü, 1900 m, 15.-16.vii.[19]80, leg. de Freina, g.prep. 0073/2018 D. Wanke; 1 ♂, [Turkey], Kleinasien, Prov. Hakkari, Zab-Tal, 30 km SW Hakkari, 1200-1300 m, 06.-08.6.[19]82, g.prep. 0252/2019 D. Wanke; 1 ♂, Türkei, Zap-Tal, vic. Hakkari, 1.+2.vii.1982, leg. W. Thomas; 2 ♂, [Turkey], Kleinasien, Prov. Hakkari, Umg. Hakkari, Zab-Tal, 1350-1400 m, 10.vii.-12.vii.[19]80, g.prep. 0075/2018 D. Wanke; 1 ♂, [Turkey], Kleinasien, Prov. Hakkari, 40 km Ö Uludere, Mutluca-Tal, vic. Melise, 1150 m, 5.vi.[19]82, leg. de Freina, g.prep. 0255/2019 D. Wanke; 1 ♂, Turkey, Mersin, 10 km SW Güzeloluk, Taurus, 12.vii.1987, 1400 m, leg. M. Fibiger; 2 ♂, [Turkey], Kleinasien, Prov. Bitlis, Bitlis Cay-Tal, vic. Sarikonak, 1050-1100 m, 07.-08.vii.[19]83, leg. de Freina, g.prep. 0087/2018 D. Wanke; 1 ♂, Türkei, Kars, 5 km S Sarikamis, 2200 m, 22.vii.[19]92, leg. P. Kautt & V. Weiss, g.prep. 0085/2018 D. Wanke; 1 ♂, Türkei, Prov. Agri, vic. Cumacay, 1500 m, 3.viii.1978, Lichtf., leg. W. Thomas, g.prep. 0265/2019 D. Wanke; all in SMNS.

17 ♂, Türk., Ost-kurdistan, Van Gölü, ca. 1800 m, 1.-31.Vii.1965, leg. Herbert Noack, g.preps 0163, 0164, 0165, 0167/2018 D. Wanke, 0285, 0286, 0287, 0289, 0290/2019 D. Wanke; 1 ♂, same locality as before, 6.-30.Vii.1965, leg. Herbert Noack, g.prep 0288/2019 D. Wanke; 3 ♂, Ostanatolien, Van Gölü, ca. 1800 m, 1.-31.Vii.1965, leg. Herbert Noack, g.prep. 0291/2019 D. Wanke; all in SMNK. 1 ♂, Iran, Prov. Khuzestan, Mal aqa, 1100 m, 31°35‘57“N, 50°00‘50“E, 07.x.2016, leg. Mehdi Esfandiari; 1 ♀, Iran, Provinz Fars, Tange bolhayat, 1300 m, 29°44‘02“N, 57°47‘00“E, 27.x.2016, leg. Mehdi Esfandiari; all in PCME.

1 ♂, 3 ♀, Iran, Isfahan prov. Hanna protected area, Hanna-Komee road, 15 km after Hanna, Baghak Mt., 2355 m, N 31°10'44'', E 51°33'51'', 10.vi.2010, leg. H. Rajaei, g.preps (♂) 0372/2019 D. Wanke (♀) 0373/2019 D. Wanke; 1 ♂, [Iran] Azarbeijan-e Gharbi, Takab, Shahin Dej., 2.vii.2013, N 36°32'19.7'', E 046°41'43.9'', 1521 m, leg. M. Afsarian, g.prep. 0387/2019 D. Wanke; 7 ♂, Turkey, Malatya, Gündüzbey, 1300 m, 26.vii.1998, leg. K. Larsen, g.preps 0336, 0452/2019 D. Wanke; 1 ♀, Iran, Boyer Ahmad-Va-Kohgiluyeh, Yasuj NW, Sisakht 7 km NNE, 2650-2700 m, 14.vi.2001, leg. A. Hofmann, J.-U. Meineke, W.G. Tremewan, g.prep. 0448/2019 D. Wanke; 1 ♀, Iran, Hormozgan, Mt. Geno, 700 m, 26.iv.2002, leg. Vazrick Nazari, g.prep. 0449/2019 D. Wanke; 1 ♀, Iran, Shiraz, 1600 m, 19.v.1977, leg. Dittrich, g.prep. 0450/2019 D. Wanke; all in PCPS.

1 ♂, W-Iran, Kordestan, 95 km N Kermanschah, Straße nach Sanandaj, 1350 m, 11.vii.1975, leg. Ebert & Falkner, g.prep 0191/2018 D. Wanke; 1 ♂, W-Iran, Lorestan, Dorud, 5 km SE Saravand, Kohyeh, 2300 m, 29.-30.vii.1975, leg. Ebert & Falkner, g.prep. 0193/2018 D. Wanke; 1 ♂, W-Iran, Lorestan, 14 km E Dorud, 1990 m, 6.viii.1975, leg. Ebert & Falkner, g.prep. 0194/2018 D. Wanke; 2 ♂, 1 ♀, Iran, Kordestan, Saghez-Baneh road, 10 km to Baneh Garnadeh-Khan, N 36°04‘13“. E 45°59‘31“, 1976 m NN, 26.-27.vi.2009, leg. H. Rajaei, J.U. Meineke & A. Hofmann, g.preps (♂) 0199, 0200/2018 D. Wanke; 1 ♀, Iran, Kordestan, Sanandaj NW, Saqqez Baneh (pass), 1950-2100 m, 28.u.29.vi.2005, leg. A. Hofmann, g.prep. 0271/2019 D. Wanke; 2 ♂, W-Iran, Kermanschah, Surkhe Dizeh, 56 km NW Schahabad, 1320 m, 14.vii.1975, leg. Ebert & Falkner, g.prep. 0198/2018 D. Wanke; 1 ♂, NW-Iran, 30 km südl. Rezaiyeh, 1400 m, 10.vi.1975, leg. H.G. Amsel, g.prep. 0201/2018 D. Wanke; 1 ♂, NW-Iran, 15 km westl. Rezaiyeh, 1400 m, 11.vi.1975, leg. H.G. Amsel, g.prep. 0202/2018 D. Wanke; 1 ♀, 12 km westl. Rezoiyeh, 1350 m, 30.v.1975, leg. Amsel; 1 ♂, NW-Iran, 50 km Straße Piranshar-Sardascht, 1400 m, Quercetum, 14.vi.1975, leg. H.G. Amsel, g.prep. 0203/2018 D. Wanke; 1 ♂, W-Iran, W-Azarbaijan, 2 km W Sardasht, 1650 m, 3.vii.1975, leg. Ebert & Falkner, g.prep 0205/2018 D. Wanke; 3 ♂, 1 ♀, Iran, prov. Azerbayejan, E-Sharqi, 10 km NW of Miyane, 31.v.-1.vi.2005, leg. P. Gyulai & A. Garai, g.preps (♂) 0204/2018 D. Wanke, 0268/2019 D. Wanke; 1 ♂, 1 ♀, Iran, prov. Azerbayejan, E-Sharqi, 10 km NW of Miyane, 14.-15.vi.2005, leg. P. Gyulai & A. Garai, g.prep. (♂) 0269/2019 D. Wanke; 1 ♂, Iran, prov. Kohkiluye va Boyerahmad, 30 km S Yassuj, road Abshare-Tange-Tamoradi, 8 km before Abshar [=waterfall], N30°31'53'', E51°25'11'', 2254 m NN, 24.v.2009, leg. Hossein Rajaei, g.prep. 0183/2018 D. Wanke; 1 ♂, Iran, Balotchistan, Kouh i Taftan (Khach), 2500 m, vi.1938, coll. Brandt, g.prep. 0189/2018 D. Wanke; 1 ♂, Iran, Prov. Tehran, Elburz mts., 3 km NNW Shemshak, 2860 m NN, N 36°02', E 051°28', 24.vii.2003, (lux), g.prep. 0206/2018 D. Wanke; 1 ♀, N-Iran, Elburs-Mts., Prov. Tehran, Arangeh, 25 km N Karadi, 1550 m, 4.vii.1972, leg. Ebert & Falkner, g.prep. 0272/2019 D. Wanke; 1 ♂, Iran, prov. Fars, S-Zagros, 5 km NE of Saidatshahr, 09.-10.vi.2005, leg. P. Gyu-

lai & A. Garai; 1 ♂, 1 ♀, Iran, prov. Fars, S-Zagros, 40 km SW of Sivand, 09.-10.vi.2005, leg. P. Gyulai & A. Garai, g.preps (♂) 0273/2019 D. Wanke (♀) 0274/2019 D. Wanke; 2 ♂, 1 ♀, S-Iran, Miyan Kotal, östl. Kazerun, 1900 m, 4.-7.vi.1969, N 29°30', E 51°40', leg. G. Ebert, g.preps (♂) 0175, 0177/2018 D. Wanke; 1 ♂, S-Iran, Tangetchogan, 30 km n. Kazerun, 930 m, 23.iii.[19]73, leg. H.G. Amsel, g.prep. 0275/2019 D. Wanke; 1 ♀, Iran, prov. Bushehr, S-Zagros, Thang e Ram near Dalekhi, 400 m, 07.-08.vi.2005, leg. P. Gyulai & A. Garai, g.prep. 0276/2019 D. Wanke; 2 ♂, 1 ♀, S-Iran, Bandar Abbas, km 107 d. Strasse nach Sirdjan, 850 m, 7.iii.1973, leg. G. Ebert, g.prep. (♂) 0187/2018 D. Wanke; 4 ♂, S-Iran, Khusestan, 15 km SE Yassudj, 2050 m, 15.vi.1972, leg. Ebert & Falkner, g.preps 0184/2018 D. Wanke, 0277/2019 D. Wanke; 2 ♂, 2 ♀, S-Iran, Prov. Khuzestan, Yasudj, Sisakht, 50 km NW, 15.-18.vi.1975, leg. Ebert, Falkner, g.preps (♀) 0278, 0438/2019 D. Wanke; 1 ♀, Iran, Prov. Esfahan, NE of Naraq, Kuh-e Goran, 2500 m NN, N 34°05', E 050°54', 06.vii.2003, leg. G. Ebert & R. Trusch, g.prep. 0439/2019 D. Wanke; 1 ♂, S-Iran, Fars, Kaserun, Mian-kotal, 1900 m, 11.vi.1972, leg. Ebert & Falkner, g.prep. 0173/2018 D. Wanke; 1 ♂, S-Iran, Straße Shiraz-Kazerun, Imam Sade, 1200 m, 3.vi.1969, leg. G. Ebert, g.prep. 0178/2018 D. Wanke; 2 ♂, Iran, prov. Boyerahmad-va-Kohgiluyeh, SE-Zagros, Kuh-e-Dena, 5 km SW of Sisakht, 2450 m, 04.-05.vi.2005, g.preps 0182/2018 D. Wanke, 0270/2019 D. Wanke; 1 ♂, Iran, prov. Kerman, Baft-Sirjan road 2 km after Baft, sandy road, 3 km to Nord, Ras-Kuh village, N 29°17'27'', E 56°35'37'', 2543 m NN, 20.-21.v.2009, leg. Hossein Rajaei, g.prep. 0170/2018 D. Wanke; 3 ♂, S-Iran, Prov. Fars, Tange Surkh, 50 km NW Ardekan, 2250mNN, 12.-15.vi.1975, leg. Ebert, Falkner, g.preps 0172/2018 D. Wanke, 0279/2019 D. Wanke; 1 ♂, Iran, Chaharmahal-va-Bakhtiyari, Borujen S Dorahun 6 km S, 1850-2100 m, 1.vi.2005, leg. A. Hofmann & J.-U. Meineke, g.prep. 0281/2019 D. Wanke; all in SMNK.

1 ♂, Türkei, Anatolia centr., Umg. Göreme, 15.-19.vi.1991, leg. Dr. Löbel, g.prep. 0402/2019 D. Wanke; 1 ♂, O-Türkei, Malatya, Recadive Paß, südl. Sürgü, 1500 m, 27.vi.1979, leg. Groß, g.prep. 2039/2016 H. Rajaei; 1 ♀, O-Türkei, Elazig, Hazar See, NW Ufer, 1250 m, 30.vi.1979, leg. Groß, g.prep. 2040/2016 H. Rajaei; 1 ♂, Syria, Taurus, Marasch, v.[19]31, g.prep. 0405/2019 D. Wanke; 1 ♂, Syria s. Taurus m. Marasch, vi.1930, g.prep. 0404/2019 D. Wanke; 1 ♀, Syria s. Taurus m. Marasch, vi.1931, 0461/2019 D. Wanke; 1 ♂, [Turkey] Asia min. NW Ende d. Beysehir gölü, 14.-18.vi.1966, leg. J. Klimesch, g.prep. 0406/2019 D. Wanke; 1 ♂, Türkiye, Konya, 55 km, W Konya, 1300 m, 26.vii.1990, leg. H. Falkner, g.prep. 0459/2019 D. Wanke; 1 ♂, 1 ♀, Asia min. Turcia, Köprüköy, Kizilirmak, 750 m, 5.-8.vi.1969, leg. G. Friedel, g.prep. (♂) 0403/2019 D. Wanke, (♀) 0460/2019 D. Wanke; 1 ♀, [Turkey] Asia minor, Sille p. Konya, 10.vi.1966, leg. J. Klimesch, 0462/2019 D. Wanke; 2 ♂, Persia sept, Elburs mts.c.s. Tacht i Suleiman, Särdab Tal (Vandarban), 25-2700 m, 14.-18.vii.[19]37, leg. E.Pfeiffer & W. Forster München, g.prep. 0238/2019 D. Wanke; in ZSM.

APPENDIX TABLE. Sequenced specimens of *Nychiodes*, with identification, sampling site and process ID in the Barcode of Life Data Systems (BOLD). Tissue provided or data generated by: Antonio S. Ortiz(1); Axel Hausmann(2); Bernd Mueller(3); Dirk Stadie(4); Feza Can(5); Gabriele Fiumi(6); Gergely Petrányi(7); Iva Mihoci(8); Jörg Gelbrecht(9); Marco Infusino(10); Muhammad Ashfaq(11); Norbert Poell(12); Wanke *et al.* (current paper)(13).

Taxon Identification	Sampling Site	Process ID
Nychiodes admirabila(13)	Iran, Kohkiluye va Boyerahmad, yasuj, Sisakht, 30.vii.2016, leg. Sh. Feizpour	GMECA024-20
Nychiodes admirabila(13)	Iran, Kohkiluye va Boyerahmad, yasuj, Sisakht, 30.vii.2016, leg. Sh. Feizpour	GMECA025-20
Nychiodes admirabila(13)	Türkei, Prov. Malatya, Nemrut dagi, 1430 m, 24.v.2009, leg. D. Stadie & H. Löbel	GMECA027-20
Nychiodes admirabila(4)	Iran, Fars, Estahban-Sarwestan road, after Ab-Asemani, 22.v.2009, Hossein Rajaei	GWOTK551-12
Nychiodes amygdalaria(4)	Turkey, Erzurum, Ispir Umg., Koepruekoey Umg., 02.viii.2001, Dirk Stadie	GWOTK550-12
Nychiodes amygdalaria(4)	Turkey, Tunceli, Munzur Tal, 16 km NW Tunceli, 06.vii.2011, Ralf Fiebig	GWOTK549-12
Nychiodes amygdalaria(5)	Turkey, Isparta, Akdeniz, Isparta, Egirdir-Yenisarbademli, 27.vi.2007, F. Can	GWORC570-07
Nychiodes amygdalaria(5)	Turkey, Isparta, Akdeniz, Isparta, Egirdir-Yenisarbademli, 27.vi.2007, F. Can	GWORC571-07
Nychiodes amygdalaria(9)	Turkey, Artvin, Karadeniz, Artvin, Barhal bel. Yusufeli, 28.x.1995, J. Gelbrecht & S. Beshkov	GWORA546-08
Nychiodes amygdalaria(9)	Turkey, Erzurum, Dogu Anadolu, Dogu Karadeniz Daglari: Korga Dagi Koprukoy, Ispir, 04.viii.2001, J. Gelbrecht, S. Beshkov, R. Busse & A. Kazanci	GWORA544-08

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APPENDIX. (Continued)

Taxon Identification	Sampling Site	Process ID
Nychiodes andalusiaria[(1)]	Spain, Lugo, Galicia, Degrada, 16.viii.2012, J.J. Guerrero	IBLAO915-12
Nychiodes andalusiaria[(1)]	Spain, Lugo, Galicia, Degrada, 29.vii.2010, J.J. Guerrero	IBLAO1106-14
Nychiodes andalusiaria[(3)]	Spain, Castilla y Leon, Avila, Sierra de Gredos, Platforme de Gredos, 21.vii.2003, P. Skou	GWOSM071-11
Nychiodes antiquaria[(11)]	Pakistan, Ajk, AJK, Rhamboor, 18.vi.2011, S. Akhtar	MAMOT1190-11
Nychiodes antiquaria[(12)]	Kyrgyzstan, Prov. Jalal-Abad, Distr. Aksy, At-Oynok-Mountains, Kurp-Sai, 02.vi.2010, leg. N. Poell	GWOSM128-11
Nychiodes antiquaria[(13)]	Kyrgyzstan, Jalal Abad, Chatkal Valley 2 km NE Jany Bazar, 26.vi.2016, leg. D. Bartsch	GMECA001-20
Nychiodes antiquaria[(13)]	Kyrgyzstan, Naryn Slopes 1 km S Kyzyl-Oi, 4.vii.2015, at light, leg. D. Bartsch	GMECA003-20
Nychiodes antiquaria[(13)]	Tadjikistan, Darvaz mts., Kugireui range, Host vill, Kalaishum city environs, 1500 m, 4.vii.2014, leg. Valentina Zurilina	GMECA037-20
Nychiodes antiquaria[(13)]	Tadjikistan, Darvaz mts., Kugireui range, Host vill, Kalaishum city environs, 1500 m, 4.vii.2014, leg. Valentina Zurilina	GMECA038-20
***Nychiodes convergata* sp. nov.**[(2)]	Israel, Northern, Hermon, Mt. Hermon, Up. Cable Stat, 10.vi.2000, G. Mueller	GWOR700-07
***Nychiodes convergata* sp. nov.**[(2)]	Israel, Northern, Hermon, Mt. Hermon, Up. Cable Stat, 10.vi.2000, G. Mueller	GWOR701-07
Nychiodes dalmatina[(2)]	Greece, Epirus, Thesprotia, Fascomilia, 15.vii.1997, P. Schaider	GWORD448-07
Nychiodes dalmatina[(2)]	Greece, Thassos, Theologos, 03.vi.2010, M. Leipnitz	GWOSI285-10
Nychiodes dalmatina[(2)]	Greece, Thesprotia, env. Plataria, 30.v.1993	GWORN501-09
Nychiodes dalmatina[(3)]	Bulgaria, Blagoevgrad/Sandanski, Pirin mts., Lilyanovo, 14.viii.1981, B. Mueller	GWORU419-10
Nychiodes dalmatina[(3)]	Greece, Central Macedonia, Serres, 2 km W Angistro, 30.viii.1980, P. Skou	GWOSM069-11
Nychiodes dalmatina[(3)]	Greece, West Macedonia, Florina, Limni Mikra Prespa near Karies, 24.vi.2004, B. Skule	GWOSM079-11
Nychiodes dalmatina[(8)]	Croatia, Splitsko-dalmatinska, Dalmatia, NP Mt. Biokovo L3, 12.ix.2007, I. Mihoci, M. Vajdic	GWOSI028-10
Nychiodes divergaria[(13)]	[Iran], Azarbeijan-e Gharbi, Takab, Shahin Dej., 2.vii.2013, leg. M. Afsarian	GMECA035-20
Nychiodes divergaria[(13)]	Iran, Kohkiluye va Boyerahmad, yasuj, Sisakht, Dena, 30.vii.2016, leg. Sh. Feizpour	GMECA009-20
Nychiodes divergaria[(13)]	Iran, Azerbaijan-e Gharbi prov., Khoy to Ghotur road, Esteran vill., 1.vii.2013, leg. H. Rajaei, J.U. Meineke, B. Hafezi	GMECA014-20
Nychiodes divergaria[(13)]	Iran, Azerbaijan-e Gharbi prov., Khoy to Ghotur road, Esteran vill., 1.vii.2013, leg. H. Rajaei, J.U. Meineke, B. Hafezi	GMECA015-20
Nychiodes divergaria[(13)]	Iran, Hormozgan, Bandar Abbas, Genu, 01.v.2016, leg. Sh. Feizpour	GMECA008-20
Nychiodes divergaria[(13)]	Iran, Hormozgan, Bandar Abbas, Genu, 01.v.2016, leg. Sh. Feizpour	GMECA018-20
Nychiodes divergaria[(13)]	Iran, Isfahan prov. Hanna protected area, Hanna-Komee road, 15 km after Hanna, Baghak Mt., 10.vi.2010, leg. H. Rajaei	GMECA034-20
Nychiodes divergaria[(13)]	Iran, Kerman, Bam-Jiroft road, Kuhe Dehbakri, 27.iv.2016, leg. Sh. Feizpour	GMECA022-20

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APPENDIX. (Continued)

Taxon Identification	Sampling Site	Process ID
Nychiodes divergaria[13]	Iran, Kerman, Bam-Jiroft road, Kuhe Dehbakri, 27.iv.2016, leg. Sh. Feizpour	GMECA023-20
Nychiodes divergaria[13]	Iran, Kohkiluye va Boyerahmad, yasuj, Sisakht, Dena, 30.vii.2016, leg. Sh. Feizpour	GMECA017-20
Nychiodes divergaria[13]	Iran, Lorestan, Dorud, Gahar lake, 28.vii.2016, leg. Sh. Feizpour	GMECA013-20
Nychiodes divergaria[13]	Iran, prov. Fars, Shiraz-Kazerun road, 5 km before Dashte Arjan, 23.v.2009, leg. Hossein Rajaei	GMECA016-20
Nychiodes divergaria[13]	Iran, Prov. Khuzestan, Mal aqa,, 07.x.2016, leg. Mehdi Esfandiari	GMECA040-20
Nychiodes divergaria[13]	Iran, prov. Kohkiluye va Boyerahmad, 30 km S Yassuj, road Abshare-Tange-Tamoradi, 8 km before Abshar, 24.v.2009, leg. Hossein Rajaei	GMECA020-20
Nychiodes divergaria[13]	Iran, prov. Lorestan, Noorabad-Nahawand road, 25 km to Nahawand, Gardane-Garrin, 25.vi.2009, leg. H. Rajaei, J.U. Meineke & A. Hoffmann	GMECA019-20
Nychiodes divergaria[13]	Iran, Shahrud, Shahkouh, Tash, Ayoub Hosseini region, 11.vii.2016, leg. Sh. Feizpour	GMECA021-20
Nychiodes divergaria[13]	Isfahan prov. Hanna protected area, Hanna-Komee road, 15 km after Hanna, Baghak Mt., 10.vi.2010, leg. H. Rajaei	GMECA010-20
Nychiodes divergaria[13]	Republic Armenia, Aiotzdorsky range, Yeghegnadzor suburbs, 150 km to SE from Yerevan, Mozrov Village, Mountain steppes, 25.-27.vi.2009, leg. Yuriy Shevnin	GMECA036-20
Nychiodes divergaria[13]	Türkei, centr., Provinz Tunceli, Munzur Tal 16 km NW von Tunceli, 06.vii.2011, leg. R. Fiebig & S. Rothe	GMECA039-20
Nychiodes divergaria[13]	Türkei, Prov. Adiyaman, Nemrut Dagh, 21.-23.viii.2009, leg. Ralf Fiebig	GMECA029-20
Nychiodes divergaria[2]	Turkey, Erzurum, Dogu Anadolu, Dogu Karadeniz Daglari: Korga Dagi Koprukoy, Ispir, 28.vii.2001, J. Gelbrecht, S. Beshkov, R. Busse, A. Kazanci & E. Schwabe	GWORA559-08
Nychiodes divergaria[2]	Turkey, Mugla, Aegean Region, Dalaman, Sarigerne, 05.vi.2000, M. Leipnitz	GWORA556-08
Nychiodes divergaria[4]	Iran, Kerman, Baft-Sirjan road, 2 km after Baft, 21.v.2009, Hossein Rajaei	GWOTK529-12
Nychiodes divergaria[4]	Iran, Kordestan, Saghez-Baneh road, 10 km to Baneh, Garnadeh-Khan, 27.vi.2009, Hossein Rajaei	GWOTK542-12
Nychiodes divergaria[4]	Turkey, Adiyaman, Nemrut Dagh, 23.viii.2009, Ralf Fiebig	GWOTK560-12
Nychiodes divergaria[4]	Turkey, Hakkari, 5 km W Hakkari, 03.vii.2011, Ralf Fiebig	GWOTK536-12
Nychiodes divergaria[4]	Turkey, Nevsehir, Aktepe, 27.viii.2009, Ralf Fiebig	GWOTK561-12
Nychiodes divergaria[4]	Turkey, Van, Gevas 10 km S, 30.vii.2001, Dirk Stadie	GWOTK534-12
Nychiodes divergaria[4]	Turkey, Van, Gevas 10 km S, 30.vii.2001, Dirk Stadie	GWOTK553-12
Nychiodes divergaria[7]	Iran, Mazandaran, Resteh-Ye-Elborz, Minokh, Baladeh Valley, 18.vi.2007, Hacz T. - Nadai L.	GWORP217-09
Nychiodes divergaria[7]	Iran, Boyer Ahmadi-e Kohkiluyeh, Kuhha-ye-Zagros, Kuh-e-Dinar, 15 km N of Vazag, 12.vi.2007, Hacz T. - Nadai L.	GWORP224-09
Nychiodes divergaria[7]	Iran, Fars, Kum Mts., Saidatsahr, 01.vii.2005, Petranyi G.	GWORP223-09
Nychiodes divergaria[9]	Turkey, Antalya, Antalya 35 km South from Kemer, 25.ix.2009, A. & A. Saldaitis	GWOSQ159-11
Nychiodes divergaria[9]	Turkey, Erzurum, Dogu Anadolu, Dogu Karadeniz Daglari, Ovit Dagi, 5 km sudl. Ovit Dagi geciti, 27.vi.2001, J. Gelbrecht, S. Beshkov, R. Busse, A. Kazanci & E. Schwabe	GWORA558-08

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APPENDIX. (Continued)

Taxon Identification	Sampling Site	Process ID
Nychiodes divergaria[9]	Turkey, Erzurum, Dogu Anadolu, Dogu Karadeniz Daglari: Korga Dagi Koprukoy, Ispir, 28.vi.2001, J. Gelbrecht, S. Beshkov, R. Busse, A. Kazanci & E. Schwabe	GWORA560-08
Nychiodes divergaria[9]	Turkey, Nevsehir, Central Anatolia, Goereme, 19.vi.1991, Dr. Loebel	GWORN499-09
***Nychiodes eberti* sp. nov.**[2]	Turkey, 31.vii.1995, Gelbrecht	GWORN500-09
Nychiodes farinosa[13]	Iran, Fars prov., Shiraz-Kazeroun road, Dasht-e Arjan, 12.vi.2010, leg. H. Rajaei	GMECA005-20
Nychiodes farinosa[7]	Iran, Hamadan, Kuhha-ye-Zagros, Nehavand, 26.vi.2005, Petranyi G.	GWORP228-09
Nychiodes farinosa[7]	Iran, Hamadan, Kuhha-ye-Zagros, Nehavand, 26.vi.2005, Petranyi G.	GWORP229-09
Nychiodes hispanica[1]	Spain, Andalusia, Granada, Puebla de Don Fadrique, 13.vii.2010, C. Abad	IBLAO113-11
Nychiodes hispanica[2]	Morocco, Marrakesh-Tensift-El Haouz, H. Atlas, Ait el Qaq, 10.viii.2012, G. Mueller & E. Revay	GWOTM824-14
Nychiodes hispanica[2]	Morocco, Marrakesh-Tensift-El Haouz, H. Atlas, Oukaimeden, 10.viii.2012, G. Mueller & E. Revay	GWOTM718-14
Nychiodes hispanica[2]	Spain, Andalusia, Granada, Siesrra Nevada, 31.xii.2009, Bernd Mueller	GWOST182-11
Nychiodes hispanica[2]	Spain, Castilla-La Mancha, Albacete, vic. Riopar, 06.viii.1992, E. Aistleitner	GWORO331-09
Nychiodes hispanica[2]	Spain, Castilla-La Mancha, Albacete, vic. Riopar, 14.vii.1992, E. Aistleitner	GWORO330-09
Nychiodes hispanica[2]	Spain, Castilla-La Mancha, Albacete, vic. Riopar, 23.vii.1992, Aistleitner	GWOTZ120-16
Nychiodes hispanica[2]	Spain, Castilla-La Mancha, Albacete, vic. Riopar, 23.vii.1992, Aistleitner	GWOTZ121-16
Nychiodes hispanica[3]	Morocco, Meknes-Tafilalet Region, Ifrane, Moyen Atlas, Ifrane, 30.vi.1994, H. Loebel	GWORU414-10
Nychiodes hispanica[3]	Morocco, Meknes-Tafilalet Region, Ifrane, Moyen Atlas, Ifrane, 30.vi.1994, H. Loebel	GWORU415-10
Nychiodes hispanica[3]	Spain, Andalusia, Malaga, Algatocin, 28.vii.1998, N. Poell	GWORU433-10
Nychiodes hispanica[3]	Spain, Andalusia, Sierra Nevada, S Puerto de la Ragua, 12.vii.2009, B. Mueller	GWORU431-10
Nychiodes hispanica(3)	Spain, Andalusia, Sierra Nevada, S Puerto de la Ragua, 15.vii.2009, B. Mueller	GWORU430-10
Nychiodes hispanica[3]	Spain, Andalusia, Sierra Nevada, S Puerto de la Ragua, 18.vii.2009, B. Mueller	GWORU429-10
Nychiodes leviata[13]	Iran, Lorestan, Dorud, Gahar lake, 28.vii.2016, leg. Sh. Feizpour	GMECA004-20
Nychiodes leviata[13]	Iran, Lorestan, Kuh-e Garin, Gard ye Gema Siab O, 25.vi.2009, leg. A. Hofmann, J.-U. Meineke, H. Rayai	GMECA026-20
***Nychiodes mirzayansi* sp. nov.**[13]	Iran, Kerman, Jiroft NW, Gardaneh, Sarbishan, Shingara vic., 3./4.vi.2002, leg. J.-U. Meineke, A. Hofmann, A. Kallies et al.,	GMECA028-20
Nychiodes notarioi[1]	Spain, Aragon, Huesca, Aineto, 08.viii.2007, G. King	IBLAO216-11
Nychiodes notarioi[1]	Spain, Aragon, Huesca, Aineto, 08.viii.2007, G. King	IBLAO217-11
Nychiodes notarioi[1]	Spain, Castilla-La Mancha, Cuenca, Huelamo, 11.vii.2010, J.J. Guerrero	IBLAO111-11
Nychiodes notarioi[1]	Spain, Castilla-La Mancha, Cuenca, Huelamo, 11.vii.2010, J.J. Guerrero	IBLAO112-11
Nychiodes notarioi[1]	Spain, Cuenca, Castilla-La Mancha, Puerto del Cubillo-Tragacete, 14.vi.2012, J.J. Guerrero	IBLAO913-12
Nychiodes notarioi[1]	Spain, Huesca, Aragon, Biascas de Obarra, 19.vii.2012, J.J. Guerrero	IBLAO839-12
Nychiodes notarioi[1]	Spain, Huesca, Aragon, Biascas de Obarra, 19.vii.2012, J.J. Guerrero	IBLAO914-12

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APPENDIX. (Continued)

Taxon Identification	Sampling Site	Process ID
Nychiodes notarioi[3]	Spain, Aragon, Teruel, Sierra de Albarracin, 3 km WSW Moscardon, 06.viii.2007, P. Skou	GWOSM073-11
Nychiodes notarioi[3]	Spain, Aragon, Teruel, Sierra de Albarracin, Albarracin, Val de Vecar, 05.viii.2007, P. Skou	GWOSM072-11
Nychiodes notarioi[3]	Spain, Castilla-La Mancha, Cuenca, Sierra de Cuenca, Una, 09.vii.2002, B. Skule	GWOSM076-11
Nychiodes notarioi[3]	Spain, Castilla-La Mancha, Cuenca, Sierra de Cuenca, Una, 09-.vii.2002, B. Skule	GWOSM077-11
Nychiodes notarioi[3]	Spain, Catalonia, Barcelona, Sierra del Montseny, 08.vii.1993, B. Mueller	GWORU412-10
Nychiodes notarioi[3]	Spain, Catalonia, Barcelona, Sierra del Montseny, 08.vii.1993, B. Mueller	GWORU413-10
Nychiodes obscuraria[2]	France, Provence-Alpes-Cote d'Azur, 30.vi.2006, Koschwitz & Leipnitz	GWORD415-07
Nychiodes obscuraria[2]	France, Provence-Alpes-Cote d'Azur, 30.vi.2006, Koschwitz & Leipnitz	GWORD416-07
Nychiodes obscuraria[2]	France, Provence-Alpes-Cote d'Azur, 30.vi.2006, Koschwitz & Leipnitz	GWORD417-07
Nychiodes obscuraria[2]	France, St. Crepin, 02.vii.2009, Herzet NL. Leipnitz	GWOSC944-10
Nychiodes obscuraria[2]	Italy, Calabria, Prov. Cosenza, Sila, Lago Cecita, Longobucco, 13.viii.2013, A Hausmann	GWOTA909-13
Nychiodes obscuraria[3]	Italy, Trentino-Alto Adige/Sudtirol, Vinschgau, Staben, 18.vii.1984, E. Loser	GWORU411-10
Nychiodes obscuraria[6]	Italy, Emilia-Romagna, Forli, Castrocaro Terme, 01.vii.2008, G. Govi	GWOTH931-12
Nychiodes palaestinensis[2]	Israel, Haifa, Carmel, 2 km S Uni Haifa, 31.iii.2003, G.Mueller	GWOR352-07
Nychiodes palaestinensis[2]	Israel, Haifa, Carmel, Carmel Haifa, 15 km South of Haifa, 30.vi.2003, Mueller, Kravchenko	GWOR237-07
Nychiodes palaestinensis[2]	Israel, Jerusalem, 10 km West of Jerusalem, 31.v.2003, Mueller, Kravchenko	GWOR369-07
Nychiodes palaestinensis[2]	Israel, Northern, Hermon, Mt. Hermon, Up. Cable Stat, 10.vi.2000, G. Mueller	GWORE2087-09
Nychiodes palaestinensis[2]	Israel, Northern, Hermon, Mt. Hermon, Up. Cable Stat, 10.vi.2000, G. Mueller	GWOR363-07
Nychiodes palaestinensis[2]	Israel, Northern, Hermon, Mt. Hermon, Up. Cable Stat, 10.vi.2000, G. Mueller	GWOR364-07
Nychiodes palaestinensis[2]	Israel, Northern, Hermon, Mt. Hermon, Up. Cable Stat, 10.vi.2000, G. Mueller	GWOR365-07
Nychiodes palaestinensis[2]	Israel, Northern, Yiftakh Rocks, 30.v.2003, Mueller, Kravchenko	GWOR353-07
Nychiodes palaestinensis[2]	Israel, Northern, Yiftakh, 30.v.2003, leg. Mueller & Kravchenko	GWOR235-07
Nychiodes palaestinensis[2]	Israel, Northern, Yiftakh, 30.v.2003, leg. Mueller & Kravchenko	GWOR236-07
Nychiodes palaestinensis[2]	Jordan, Ajloun, oak forest, 12.v.2010, Schellhorn	GWOSI541-10
Nychiodes palaestinensis[2]	Jordan, Ajloun, oak forest, 12.v.2010, Schellhorn	GWOSI542-10
Nychiodes palaestinensis[2]	Jordan, Ajloun, oak forest, 12.v.2010, Schellhorn	GWOSI543-10

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APPENDIX. (Continued)

Taxon Identification	Sampling Site	Process ID
Nychiodes palaestinensis(2)	Jordan, Al Asimah, Badran, 20 km N Amman, 15.v.1999, Li, Mueller	GWOR699-07
Nychiodes palaestinensis(2)	Jordan, Al Asimah, Badran, 20 km N Amman, 15.v.1999, Li, Mueller	GWORB1191-07
Nychiodes palaestinensis(2)	Jordan, Al Asimah, Badran, 20 km N Amman, 15.v.1999, Li, Mueller	GWORE2086-09
Nychiodes palaestinensis(2)	Jordan, Al Karak, Al Karak, Jibal Abu al Idham, 30.xi.2002, Li, Mueller	GWOR123-07
Nychiodes palaestinensis(2)	Jordan, Dhana NR, juniper/oak on sand stone, 05.v.2010, Schellhorn	GWOSO568-11
Nychiodes palaestinensis(2)	Jordan, Dhana NR, juniper/oak on sand stone, 05.v.2010, Schellhorn	GWOSO569-11
Nychiodes palaestinensis(2)	Jordan, Dhana NR, juniper/oak on sand stone, 05.v.2010, Schellhorn	GWOSO570-11
Nychiodes palaestinensis(2)	Syria, Tartus, Al-Alawijin mts., vic. Safita, 15.v.1998, T. Drechsel & H. Loebel	GWOTC324-12
Nychiodes palaestinensis(2)	Syria, Tartus, Al-Alawijin mts., vic. Safita, 15.v.1998, T. Drechsel & H. Loebel	GWOTC325-12
Nychiodes ragusaria(10)	Italy, Sicily, Bosco di Malabotta, 08.viii.2007, M. Infusino	GWORB1552-08
Nychiodes ragusaria(2)	Italy, Calabria, Coccorina, Tropea, 12.vi.2008, Schneider, Leipnitz	GWORM285-09
Nychiodes ragusaria(2)	Italy, Calabria, Coccorina, Tropea, 12.vi.2008, Schneider, Leipnitz	GWORM286-09
Nychiodes ragusaria(2)	Italy, Calabria, Coccorina, Tropea, 12.vi.2008, Schneider, Leipnitz	GWORM287-09
Nychiodes ragusaria(2)	Italy, Calabria, Cosenza, Coccorino nr Tropea, 31.vii.2008, Schneider	GWORZ718-10
Nychiodes ragusaria(3)	Italy, Calabria, Vibo Valentia, Coccorino, 15.vi.2008, Schneider	GWORU417-10
Nychiodes ragusaria(3)	Italy, Calabria, Vibo Valentia, Coccorino, 15.vi.2008, Schneider	GWORU418-10
Nychiodes subfusca(13)	Iran, Fars prov., Shiraz-Kazeroun road, Dasht-e Arjan, 12.vi.2010, leg. H. Rajaei	GMECA006-20
Nychiodes subfusca(13)	Iran, Fars prov., Shiraz-Kazeroun road, Dasht-e Arjan, 12.vi.2010, leg. H. Rajaei	GMECA033-20
Nychiodes subfusca(7)	Iran, Boyer Ahmadi-e Kohkiluyeh, Kuhha-ye-Zagros, Kuh-e-Dinar, 15 km N of Vazag, 12.vi.2007, Hacz T. - Nadai L.	GWORP230-09
Nychiodes subfusca(7)	Iran, Boyer Ahmadi-e Kohkiluyeh, Kuhha-ye-Zagros, Kuh-e-Dinar, 15 km N of Vazag, 12.vi.2007, Hacz T. - Nadai L.	GWORP231-09
Nychiodes subfusca(7)	Iran, Boyer Ahmadi-e Kohkiluyeh, Kuhha-ye-Zagros, Kuh-e-Dinar, 15 km N of Vazag, 12.vi.2007, Hacz T. - Nadai L.	GWORP232-09
Nychiodes subvirida(13)	Iran, prov. Fars, Estahban-Sarwestan road, 22 km before Sarwestan after Ab-Asemani village, 22.v.2009, leg. H. Rajaei	GMECA032-20
Nychiodes subvirida(13)	Iran, Prov. Fars, ca. 20 km S Jahron, Sistan, 06.xii.2018, 870 m, leg. H. Rajaei	GMECA002-20
Nychiodes subvirida(13)	Iran, Kerman, Bam-Jiroft road, Kuhe Dehbakri, 27.iv.2016, leg. Sh. Feizpour	GMECA007-20
Nychiodes subvirida(13)	Iran, Prov. Fars, ca. 20 km S Jahron, Sistan, Garden Ahmad Najafzadeh., 30.iii.2011, leg. Hossein Rajaei	GMECA012-20

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APPENDIX. (Continued)

Taxon Identification	Sampling Site	Process ID
Nychiodes subvirida(13)	Iran, prov. Kerman, Baft-Sirjan road, 2 km after Baft, sandy road, 3 km to Nord, Ras-Kuh village, 20.-21.v.2009, leg. H. Rajaei	GMECA011-20
Nychiodes subvirida(13)	Türkei, Prov. Adiyaman, Nemrut Dagh, 21.-23.viii.2009, leg. Ralf Fiebig	GMECA030-20
Nychiodes subvirida(7)	Iran, Fars, Ghir, 11.iv.2004, Hacz T., Benedek B.	GWORP225-09
Nychiodes subvirida(7)	Iran, Fars, Lar, 30.iii.2009, Petranyi G.	GWORP226-09
Nychiodes subvirida(7)	Iran, Fars, Lar, 30.iii.2009, Petranyi G.	GWORP227-09
Nychiodes subvirida(7)	Iran, Hamadan, Kuhha-ye-Zagros, Nehavand, 26.vi.2005, Petranyi G.	GWORP219-09
Nychiodes subvirida(7)	Iran, Kordestan, Sanandaj, Askaran, 25.vi.2005, Petranyi G.	GWORP218-09
Nychiodes waltheri(12)	Iran, Khorasan, Golestan National Park, Almeh, 17.vi.2007, N. Poell	GWORE1241-08
Nychiodes waltheri(12)	Iran, Khorasan, Golestan National Park, Almeh, 17.vi.2007, N. Poell	GWORE1242-08
Nychiodes waltheri(13)	Iran N, E Alborz, Prov. Mazanderan, E Gorgan, S Aliabad, oberh. Shirinabad, 21.v.2005, leg. Trusch, Petschenka, Müller	GMECA031-20
Nychiodes waltheri(2)	Bulgaria, Kardjali, E. Rhodopi mts., Studen Kladenez, 23.v.1990, Beschkow	GWOSM078-11
Nychiodes waltheri(2)	Turkey, Burdur, Burdur, Boncuk Daglari, Kozagac, Kozdag, 27.ix.1998, M. Leipnitz	GWORU427-10
Nychiodes waltheri(2)	Turkey, Tunceli, 9.5 km NE Ovacik, 24.viii.2009, R. & S. Fiebig	GWOSN895-11
Nychiodes waltheri(3)	Turkey, Erzurum, Dogu Anadolu, Korga Dagi Koprukoy bei Ispir, 19.viii.2002, H. Loebel & D. Stadie	GWORA551-08
Nychiodes waltheri(3)	Turkey, Mugla, Aegean Region, Boncuk Daglari, Kozdag gecidi, 15 km S Cavdir, 29.x.1998, M. Leipnitz	GWORA552-08
Nychiodes waltheri(3)	Turkey, Mugla, Aegean Region, Boncuk Daglari, Kozdag gecidi, 15 km S Cavdir, 29.x.1998, M. Leipnitz	GWORA553-08
Nychiodes waltheri(9)	Greece, South Aegean, Samos, Kokkari, 12.v.2012, May	GBLAA569-14
Nychiodes waltheri(9)	Turkey, Erzurum, Dogu Anadolu, Korga Dagi Koprukoy bei Ispir, 19.viii.2002, H. Loebel & D. Stadie	GWORA549-08
Nychiodes waltheri(9)	Turkey, Erzurum, Dogu Anadolu, Korga Dagi Koprukoy bei Ispir, 19.viii.2002, H. Loebel & D. Stadie	GWORA550-08

Original research paper 5

First captive rearing of the Iranian endemic *Nychiodes subvirida* Brandt, 1938 (Geometridae: Ennominae, Boarmiini)

Dominic Wanke, Michael Leipnitz, Hossein Rajaei

Published (2021) in Entomologische Zeitschrift, Schwanfeld 131 (2): 123–125

Painting of *Nychiodes subvirida* by Maria Werner

First captive rearing of the Iranian endemic *Nychiodes subvirida* Brandt, 1938 (Geometridae: Ennominae, Boarmiini)

● Dominic Wanke, Michael Leipnitz & Hossein Rajaei

Abstract. *Nychiodes subvirida* Brandt, 1938 is an endemic species in southern Iran, with unknown host-plants and larval stages. Gravid female specimens of this species were collected from Fars province, Iran, and their offspring were reared in captivity. Experiments with several potential host-plants are reported and discussed. Larvae were successfully reared on the rosaceous plants *Prunus dulcis* und *Prunus tenella*. Eggs, larvae, pupae and adults are described and partially illustrated.

Zusammenfassung. *Nychiodes subvirida* Brandt, 1938, ist eine endemische Art aus dem Süden Irans, deren Nahrungspflanzen sowie Larvenstadien noch immer unbekannt sind. In der iranischen Provinz Fars wurden gravide weibliche Tiere dieser Art gesammelt und deren Larven erfolgreich in Gefangenschaft gezüchtet. Versuche mit verschiedensten Wirtspflanzen werden berichtet und diskutiert. Die Larven konnten an den Rosengewächsen (Rosaceae) *Prunus dulcis* und *Prunus tenella* aufgezogen werden. Eier, Larvenstadien, Puppe sowie Adulte Tiere sind beschrieben und teilweise abgebildet.

Keywords. Almond, Fars, host-plant, Iran, Oriental Region, larval stages, life history, *Prunus*.

Introduction

Nychiodes Lederer, 1853 are large, robust moths characterized usually by the presence of prominent ante- and postmedial lines on the forewing. Recent taxonomic reviews list 25 species, distributed only in the Palearctic Region with a hotspot of species diversity occurring in the Middle East (Müller et al. 2019, Wanke et al. 2020).

The biology of the European species is well-known. Most species have been bred in captivity, mainly on different species of Rosaceae (Müller et al. 2019). However, our knowledge of the biology of non-European species is only fragmentary. Wilthsire (1943) described host plants and larval stages of four *Nychiodes* species (*N. divergaria* Staudinger, 1892, *N. subfusca* Brandt, 1938, *N. farinosa* Brandt, 1938, *N. admirabila* Brandt, 1938). Recently, *N. divergaria* has been observed as a pest of peach trees (*Prunus persica*) in Turkey (Bolu 2019). Larvae also feed on *Amelanchier*, *Cotoneaster*, *Crataegus* and *Prunus* species, but *Prunus* are the most commonly reported host-plants for *Nychoides* larvae (Wiltshire 1943, Wiltshire 1957, Flamigni et al. 2007, Redondo et al. 2009, Müller et al. 2019).

The larvae of *Nychiodes* are characterized by having sluggish habits and an orange collar. Furthermore, the presence of more or less developed pairs of dorsal spurs on segments five to seven [A1–A4] is characteristic (Wiltshire 1943). In their natural habitat, detection of *Nychiodes* larvae in dense and twiggy bushes is very difficult (Wiltshire 1943). One species with an unknown biology is *Nychiodes subvirida*. Adults of this species are characterized by yellow-brown speckled wings with a yellow postmedial line. The species is endemic to southern Iran, distributed from Fars to Taftan in the eastern parts of Sistan and Baluchestan and occurring in altitudes from 200 m to 2800 m (Wanke et al. 2020). Here we present the first observations on the larval morphology and potential host plants of *N. subvirida*.

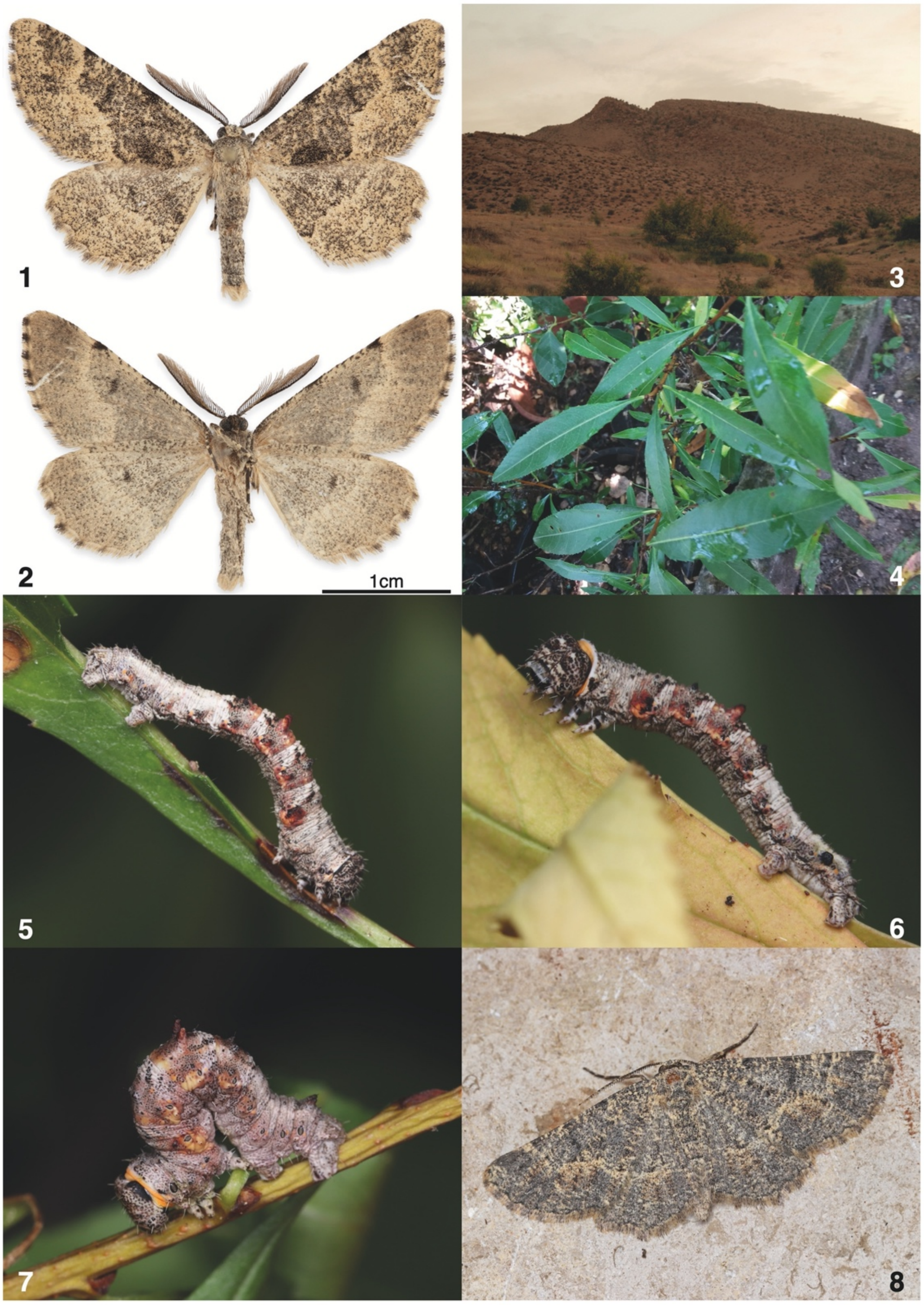
Material and Methods

The third author collected several specimens of *N. subvirida* on 6.XII.2018, at a black light, in the southern Iranian province of Fars, around 20 km south of Jahrom at an altitude of 870 m (28°20'54.21"N, 53°21'55.62"E; Figs 1, 2). Female specimens were kept in captivity and subsequently laid eggs after two days. The eggs were kept in a refrigerator (5 °C) for two weeks to avoid hatching and taken to Germany for captive breeding. First and second instars were kept in a round Polyethylene box (20 mm diameter × 35 mm height), with a layer of toilet paper at the bottom. After ecdysis into the third instar (L3), breeding was continued in a bigger Polyethylene box (40 mm diameter × 120 mm height). Pupation took place in the latter box, on a substrate of toilet paper and beech sawdust.

Food-plants

Due to a very short stay in the sampling site, the host plants of *N. subvirida* could not be identified in their natural habitat. However, the habitat (Fig. 3) was mainly covered by different *Astragalus* species as well as *Prunus scoparia*, an endemic species to Iran (Sabeti 1975, Yazbek 2010). In captive breeding, multiple host plants of European *Nychiodes* species were tested (e.g. *P. spinosa* and other Rosaceae) without success (Table 1). The second author referred to observations of *Nychiodes* larvae from Turkey, which fed on wild almond. Therefore, dwarf Russian almond (*P. tenella*, Fig. 4) was offered to the larvae, which readily fed upon it. Additionally, *P. dulcis*, a tree which is commonly planted in vineyards, were also accepted by the larvae. However, due to the use of pesticides in vineyards, we continued to feed the larvae with *P. tenella*. The larvae only accepted slightly wilted or dry leaves of these plant species (Tab. 1).

Prunus consists of more than 200 species primarily distributed in the Northern Hemisphere, with a main center of diversity in Asia (Das et al. 2011, Shi et al. 2013, Yazbek & Oh 2013, Falatoury 2019). A total of 53 *Prunus* species are found in Iran (Falatoury 2019). Notably, *P. tenella*, which was accepted by captive larvae, is only found in the Ukraine and south Russia, northern parts of Kazakhstan, the northern Balkans, Austria and Hungary (Browicz & Zohary 1996) and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thus cannot be a natural host plant. Conversely, the second accepted host plant, *P. dulcis*, could be a natural host of *N. subvirida*. This species is distributed throughout the Middle East and Central Asia and, together with *P. scoparia,* matches the distribution range of *N. subvirida* in southern Iran (Sabeti 1975, Yazbek 2010, Wanke et al. 2020).

Developmental stages

Ovum. Freshly laid eggs are grey bluish-green. After one or two days, the eggs' colour first changes to dirty yellow-orange and then to red-orange. After three to four further days, the colour changes to brown-red with a violet tinge. Before hatching, the eggs are greyish brown.

Larva. The first instar (L1) is black-brown in colour, with some greyish white highlights on the edge of each segment. The head capsule is black. The second instar (L2) is grey to grey-brown, without any characteristic markings. The third instar (L3) is mostly light-grey, with reddish-brown colouration on the dorsolateral portion of A1 through A4 and the lateral portion of A5 through A10 the other abdominal segments, intermixed with yellow-orange spots (Figs 5, 6). From this stage on, the larva develops its distinctive orange collar, which is characteristic for the genus (Figs 6, 7). A pair of dorsal spurs are visible on abdominal segments A2 through A4, and A8. The spurs on A3 are the largest (Figs 5, 6). In the fourth instar (L4), the colour of the thoracic and abdominal segments becomes darker. In the fifth instar (L5) the larva is 40–45 mm long (n=2) with slightly flatter dorsal spurs, the background colour of all segments red-brown, with darker colour on first four abdominal segments, intermixed with warm yellow spots and black dots. The collar ring is strongly orange and very prominent. The spiracles dark-brown to black (Fig. 7). The larvae of *N. subvirida* are notably sluggish in behaviour, as observed by Wiltshire (1943) for other species of this group.

Figures 1–8. Life history of *Nychiodes subvirida* Brandt, 1938. **1, 2.** Adult male, **1.** Dorsal, **2.** Ventral. **3.** Habitat where specimens were collected (Iran, Fars, ca. 20 km S Jahrom). **4.** The dwarf Russian almond (*Prunus tenella*) served as food source for the rearing of *N. subvirida* larvae. **5, 6.** Third instar (L3). **7.** Fifth instar (L5) before pupation, with orange collar well-visible. **8.** Adult female of *N. subvirida* reared in captivity (Photos 4–8: Michael Leipnitz).

Tab. 1. Reactions of larval *Nychiodes subvirida* Brandt, 1938 to rosaceous plants under captive conditions.

Plant species	Larval reaction
Amelanchier ovalis	Rejected
Cotoneaster integerrimus	Rejected
Cotoneaster tomentosus	Rejected
Crataegus laevigata	Rejected
Crataegus monogyna	Rejected
Prunus cerasifera	Rejected
Prunus dulcis	Accepted (slightly wilted or dry leaves)
Prunus spinosa	Rejected
Prunus tenella	Accepted (slightly wilted or dry leaves)
Pyracantha coccinea	Rejected

Pre-pupal phase and Pupa. The pre-pupal phase lasts around four days. During this time, the larvae becomes compressed and its colour becomes less intense. In this phase, the larvae drop one yellow-white fluid excrement. This specific dropping behavior has been observed by the second author also in other *Nychiodes* larvae. Whether this is unique to the genus *Nychiodes* or occurs also in other genera needs to be investigated. Pupation took place in paper tissue and beech sawdust. The pupa is 10–15 mm long, with a glossy brown colour. Two (out of six) larvae completed their development to the pupal stage. Only one adult female hatched three to four weeks after pupation at room temperature (Fig. 8).

Acknowledgements. Thanks to Ramin Boroomandi, Mohsen Boroomandi and Ahmad Najafzadeh for their help and kind support to the third author during fieldwork and searching for the female specimen of *Nychiodes subvirida*. Many thanks to Jessica Awad (SMNS) for linguistic proof reading and valuable comments on the manuscript.

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Original research paper 6

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Published (2022) in Nota Lepidopterologica 46: 1–17
https://doi.org/10.3897/nl.46.94940

Painting of *Aphilopota tyttha* by Sonia Bigalk

Nota Lepi. 46 2023: 1–17 | DOI 10.3897/nl.46.94940 Research Article

The African endemic species "*Nychiodes*" *tyttha* Prout, 1915 (Lepidoptera, Geometridae, Ennominae) belongs to the genus *Aphilopota* Warren, 1899

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https://zoobank.org/B8A2AB4C-CD6E-4D43-8867-31FDE762C3E4

Received 16 September 2022; accepted 9 November 2022; published: 12 January 2023
Subject Editor: Théo Léger.

Abstract. An extensive examination of the external and internal morphological characters of the genus *Nychiodes* shows that "*Nychiodes*" *tyttha* Prout, 1915 is incorrectly placed in this genus. The systematic position of this species was investigated by using a multigene analysis, including one mitochondrial and up to nine protein-coding nuclear gene regions, and morphological characters. These results support a re-classification of this species as *Aphilopota tyttha*, **comb. nov.** A re-description supported by illustrations of morphological characters for *A. tyttha* is provided.

Introduction

Prout (1915) described an African geometrid species *tyttha* and placed it in the genus *Nychiodes* Lederer, 1853. In his description, he mentioned the much smaller size and slight differences in venation of *N. tyttha* from other *Nychiodes* species (Prout 1915). Since size can be influenced by various parameters (e.g., the amount of available nutrition), more informative are characters such as differences in venation, widely used in Geometridae for differential diagnoses of genera (Hausmann 2001; Awmack and Leather 2002; Wanke et al. 2020).

Recently, the genus *Nychiodes* has undergone intensive integrative taxonomic revisions (Müller et al. 2019; Wanke et al. 2020). The genus contains 25 species, distributed from western Europe and North Africa to Iran, Afghanistan and Pakistan. *Nychiodes tyttha* has remained as the only species outside the mentioned distribution range, occurring in central and southern Africa (Janse 1932). The results of our investigation of morphological characters strongly support *N. tyttha* being excluded from the genus *Nychiodes* (Wanke et al. 2020). However, a suitable genus for this species could not be found until now in the absence of data allowing a molecular analysis. For this study, we aimed to extract DNA to clarify the systematic position of *N. tyttha*. This allowed a multi-gene molecular phylogenetic analysis to be conducted together with an examination of morphological characters.

Material and methods

Specimens used in this study are deposited the following collections (acronyms after Evenhuis 2007):

NHMUK	Natural History Museum, London, United Kingdom;
HSS	Private Collection of Hermann Staude, South Africa;
SMNS	Staatliches Museum für Naturkunde Stuttgart, Germany;
ZSM (SNSB)	Zoologische Staatssammlung München (Staatliche Naturwissenschaftliche Sammlungen Bayerns), Germany.

Morphological examination

For the documentation of external characters, a Visionary Digital photography system (LK Imaging System, Dun. Inc., equipped with a Canon EOS 5DSR camera), an Olympus E3 digital camera, as well as a Leica digital microscope (Z16 APO) were used. Standard techniques were followed for the preparation of genitalia (e.g. Robinson 1976) and evertion of the vesica took place following the method described by Sihvonen (2001). Finally, genitalia were embedded in Euparal as permanent slides and photographed with a Keyence VHX-5000.

Molecular data generation

Extraction of DNA and amplification of the "DNA barcode" fragment (658 base-pairs of the 5' terminus) of the mitochondrial Cytochrome-C Oxidase I of the holotype of *Nychiodes tyttha*, was carried out at the Canadian Centre for DNA barcoding (CCDB, Guelph), in the framework of the Lepidoptera Campaign of the international Barcode of Life program (iBOL; www.lepbarcoding.org), using a protocol for old museum specimens based on Next-Generation-Sequencing (Hausmann et al. 2016; Prosser et al. 2016). Extraction and amplification of non-type specimens were also carried out at the Canadian Centre for DNA barcoding (CCDB, Guelph) using standard protocols (e.g., Ivanova et al. 2006). *Nychiodes tyttha* specimens used for analysis of the "barcode" fragment and metadata are available on BOLD. Sample ID numbers are: BC ZSM Lep 106645 (holotype); BC ZSM Lep 13914; BC ZSM Lep 98802. As the holotype's DNA was extracted in Canada no extract was left after DNA barcoding for genomic DNA analysis. Sample BC ZSM Lep 98802 was repatriated from Guelph and amplification of further genes was done at the molecular laboratory in Finnish Museum of Natural History "Luomus", (Helsinki) using the DNeasy Blood and Tissue kit (Qiagen), following the manufacturer's protocol. DNA amplification and sequencing were carried out following protocols proposed by (Wahlberg and Wheat 2008; Wahlberg et al. 2016). One mitochondrial (cytochrome oxidase subunit I, COI) and up to ten protein-coding nuclear gene regions, Arginine Kinase (ArgK), carbamolyphosphate synthetase (CAD), sarco/endoplasmic reticulum calcium ATPase (Ca-ATPase), Elongation factor 1 alpha (EF-1α), glyceraldehydes-3-phosphate dehydrogenase (GAPDH), isocitrate dehydrogenase (IDH), cytosolic malate dehydrogenase (MDH), sorting nexin-9-like (Nex9), ribosomal Protein (RpS5), and wingless (wgl), were sequenced for phylogenetic analyses.

Multiple sequences were aligned using Muscle algorithms as implemented in MEGA11 (Tamura et al. 2021) for each gene including other sequences of Boarmiini (see Appendix 1, Fig. A1) retrieved from the local VoSeq database (Peña and Malm 2012). For the phylogenetic hypothesis of Boarmiini, a total of 300 taxa, from Murillo-Ramos et al. (2019) were incorporated into our dataset, of which two geometroid species (Sematuridae: *Mania lunus* (Linnaeus, 1758) and Uraniidae: *Urania leilus* (Linnaeus, 1758)) served as outgroups. The newly produced DNA sequences through this study were managed with the VoSeq database. The final dataset included a total length of 7662 bp including gaps, and missing data made up 34% of the final data matrix. The sequences described here are accessible via GenBank with the following accession numbers: ON980557–ON980558; ON982490–ON982496. All GenBank accession numbers of the 300 taxa are provided in the Suppl. material 1.

DNA Barcoding analyses

Three different analyses where performed. First, COI fragments of "*Nychiodes*" *tyttha* (sequences of holotype and two non-type specimens) were compared to available sequences in the Barcode of Life Datasystems (BOLD) identification engine to search for the genetically nearest neighbor. Second, a neighbor-joining tree (K2P on BOLD) was constructed with the sequence of the holotype of "*Nychiodes*" *tyttha* and 99 samples suggested by BOLD as related taxa to find the genetically nearest neighbor. Finally, the minimum p-distance of "*Nychiodes*" *tyttha* from *Nychiodes dalmatina* was calculated, to calculate the distance to the genus *Nychiodes*.

Phylogenetic analysis

The molecular data set partitioned by gene and codon position was analysed using maximum likelihood as implemented in IQ-TREE 2.1.3 (Minh et al. 2020). Best-fitting substitution models were selected by ModelFinder (Kalyaanamoorthy et al. 2017) with "-m MFP+MERGE" option. The best-fit models were chosen as follows: GTR+F+I+G4 for ArgK, COI, Nex9, and wingless; TIMe+I+G4 for Ca-ATPase; TIM2+F+I+G4 for CAD and IDH; SYM+I+G4 for EF-1α, GAPDH, MDH, and RpS5. The phylogenetic analysis was carried out with "-spp" option (edge proportional) that allows each partition to have its own evolutionary rate. We evaluated the node supports with ultrafast bootstrap approximations (UFBoot2) and the SH-like approximate likelihood ratio test (Guindon et al. 2010; Hoang et al. 2018) using the "-B 1000 -alrt 1000" option. To reduce the risk of overestimating branch supports in ultrafast bootstrap approximation analysis, we used the "-bnni" option, which optimizes each bootstrap tree using a hill-climbing nearest-neighbour-interchange (NNI) search. The resulting tree was rooted and visualized in FigTree v1.4.2 (Rambaut 2015).

Results

The comparison of the COI fragments only of "*Nychiodes*" *tyttha* (holotype and two non-type specimens) with data from the BOLD database, suggested that the genetically nearest neighbors are in the genera *Jankowskia* Oberthür, 1884, *Tephronia* Hübner, 1825 and *Peribatodes* Wehrli, 1943 (genetic distances of 6.4–7.9%). When a neighbor-joining tree (K2P on BOLD) was constructed using the holotype DNA barcode sequence with the 99 nearest samples provided by BOLD, an Australian species, *Aeolochroma* sp. ANIC1 (BOLD:AAV4042), which is 8.33% divergent by p-distance, separated "*N.*" *tyttha* from the above and other genera. Sequences from the other two specimens of "*N.*" *tyttha* (BC ZSM Lep 106645, BC ZSM Lep 98802) were 1.23–1.39% divergent. By contrast, the minimum p-distance (COI, K2P, BOLD gap analysis) from *Nychiodes dalmatina* is 10.4%.

Additionally, five out of the eleven target genes of a single non-type specimen of "*Nychiodes*" *tyttha* were successfully amplified and sequenced (COI-1,COI-2, wgl, Ca-ATPase, Nex9). In the multigene phylogenetic analysis "*Nychiodes*" *tyttha* clustered as sister to other species of *Aphilopota*

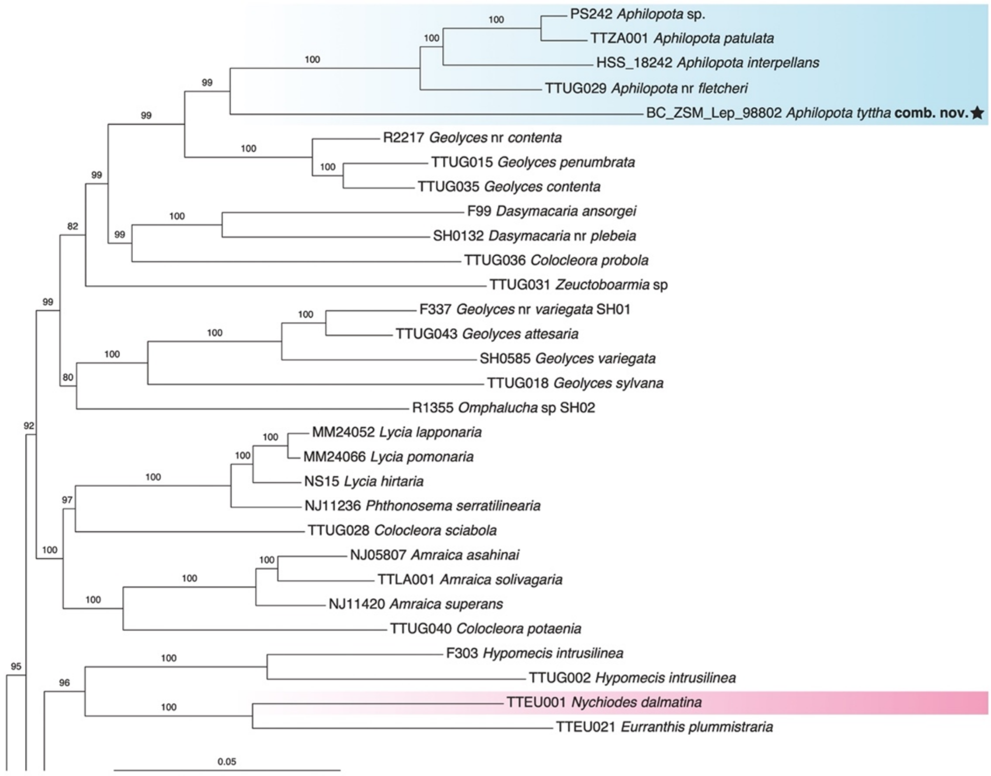


Figure 1. Phylogenetic position of *Aphilopota tyttha*, comb. nov. (marked with a star) within the tribe Boarmini, supporting the tentative combination in genus *Aphilopota*. The numbers above the branches are the bootstrap values of the maximum likelihood IQ-TREE analysis. The complete tree is shown in Appendix 1, Fig. A1.

Warren, 1899 (Fig. 1, Appendix 1, Fig. A1). Moreover, the results of our morphological examination served as an additional line of evidence and revealed that “*Nychiodes*” *tyttha* has the diagnostic generic characters of *Aphilopota*, supporting its affiliation to this genus (for detailed comparison see the taxonomy part). The species is re-described in the taxonomic part of the discussion.

Discussion

Systematics

The results of our multi-gene molecular phylogenetic analysis show that “*Nychiodes*” *tyttha* groups as sister to *Aphilopota* (UFB = 97%). The phylogenetic analysis would allow us either to classify “*N.*” *tyttha* in a monotypic genus as sister to *Aphilopota*, or to combine it with other *Aphilopota*. The classification as sister to *Aphilopota* may not hold when more species of this genus are added to the dataset. Currently the genus *Aphilopota* consists of 44 species, distributed exclusively in Africa and Madagascar (Scoble 1999; Scoble and Hausmann 2007), but the genus urgently needs taxonomic revision. The detailed morphological investigation of the taxon *tyttha* in the framework of the present study supports its combination with *Aphilopota*. Consequently, we transfer "*N.*" *tyttha* to the genus *Aphilopota*.

In the following diagnosis (see taxonomy part), the morphological characters of *Aphilopota tyttha* comb. nov. are compared to the type species of the genera *Aphilopota* (*A. interpellans* (Butler, 1875)) and *Nychiodes* (*N. obscuraria* (Villers, 1789)), which support the new combination.

Taxonomy

Aphilopota tyttha (Prout, 1915), comb. nov.

Figs 2–11, 17, 18, 21

Nychiodes tyttha Prout, 1915. Novitates zoologicae: a journal of zoology in connection with the Tring Museum, 22, 363. Holotype ♂ (Eritrea, Caraiai). Deposited in NHMUK (examined).

Type material examined. Holotype, ♂, Eritrea, Caraiai, 21.xi.1905, N. Beccari, Geometridae genitalia slide No. 4976, Rothschild Bequest B.M. 1939-1, NHMUK010920109, DNA barcode sample ID BC ZSM Lep 106645, DNA barcode process ID GWOTZ396-19, BIN BOLD:AAW8833 [579 bp]; in NHMUK

Additional material examined. 1♀, Eritrea, Caraiai, 21.xi.1905, N. Beccari, Geometridae genitalia slide No. 4977, NHMUK014173598; 1 ♂, Kenya, Kitale, 14.9.[19]25, leg. G.W. Jeffery, NHMUK010920119; 1 ♂, [Namibia], Sissekab, N.W. of Otavi, 1300 m, leg. K. Jordan, 11.xi.1933, NHMUK010920120; all in NHMUK. 1 ♂, South Africa, Mkuze Chaos, 27°39.490'S, 032°00'E, 28.xii.1990, 220 m, leg. H.S. Staude; in HSS. 1 ♂, Ethiopia, Bahar Dar, iii.1969, Lichtfang, leg. Schäuffele, g.prep. 0732/2020 D. Wanke; in SMNS. 1 ♂, Äthiopien [Ethiopia], Awassa, Awassa Lake, Reg. Bale, 07°02.886'N, 038°27.491'E, 23.–24.v.1999, leg. R. Beck & M. Hiermeier; 1 ♂, S. Ethiopia – SN, Arba Minch, Nechisar NP, 2.75 km SW headquarter, 1170 m (lux), 06°00'13.6"N, 37°33'23,4"E, 22.ii.2012, leg. Hacker & Schreier; all in ZSM.

Remark. The genus *Aphilopota* needs taxonomic revision, based on a broad integrative taxonomic approach. Therefore, a comparison with other species of this genus, except of the type species *A. interpellans*, is not possible and also not necessary here.

Diagnosis. In *A. tyttha* labial palpi thin, about two thirds of the diameter of the eye (labial palpi thick, about one diameter of the eye in *A. interpellans* and *N. obscuraria*) (Fig. 2). Proboscis reduced (similar in *A. interpellans* and *N. obscuraria*) (Fig. 2). In the forewing venation of *A. tyttha* R1 arising from the cell, not reaching costa, R2 fused with R1 (similar in *A. interpellans*; arising from the cell, R1 and R2 share a common stalk in *N. obscuraria*) (Fig. 4). In the male genitalia (Figs 17–20) of *A. tyttha* valva thin, without any ampulla or harpe (similar in *A. interpellans*; valva equipped with the two main processes ampulla superior and ampulla inferior in *N. obscuraria*). Juxta of *A. tyttha* forked, large and straight, reaching up to the gnathos (juxta forked, large and tip thick, reaching far beyond the gnathos, apex bent in *A. interpellans*; juxta anchor-shaped in *N. obscuraria*). Aedeagus in *A. tyttha* thin tapered, with one long and sclerotized cornutus (aedeagus funnel-shaped, without strong cornutus in *A. interpellans*; thickness of aedeagus variable with one sclerotized cornutus variable in length in *N. obscuraria*). In female genitalia (Figs 21–24) of *A. tyttha* ovipositor telescopic and strongly elongated (similar in *A. interpellans*; not elongated in *N. obscuraria*). Corpus bursae of *A. tyttha* arched, tube-like elongated (arched, long in *A. interpellans*; round membranous in *N. obscuraria*). Signum absent in *A. tyttha* (similar in *A. interpellans*; signum stellate in *N. obscuraria*).

Tribal assignment. According to the molecular phylogenetic analysis (Fig. 1, Appendix 1, Fig. A1) and morphology (Figs 2–24), *Aphilopota tyttha* is classified in Boarmiini.

Figure 2. Head structures of male specimens of **A, B.** *Aphilopota tyttha* (Prout), comb. nov., **C, D.** *Aphilopota interpellans* (Butler), and **E, F.** *Nychiodes obscuraria* (Villers). **A, C, E.** Head in ventral view; **B, D, F.** Lateral view.

Re-description. Wingspan ♂ 21–25 mm, ♀ 28 mm, average length of forewing 11.2 mm (n = 7). Antennae bipectinate in both sexes. Frons weakly convex, just reaching over the eyes, densely scaled. Labial palpi thin, about two third of the diameter of the eye. Proboscis reduced, represented by barely visible rudimentary slats (Fig. 2A). Chaetosemata as two small patches, each located between the eye margin and the antennal base (Fig. 2B). Foreleg epiphysis approximately as long as tibia. Base of the epiphysis starting after one fourth of tibia. Mesotibia with one pair of spurs, hindtibia with two pairs of spurs (Fig. 3). Head, thorax and abdomen concolorous with wings.

Ground colour of wings beige brown, transverse lines present in dark brown to black. Terminal line continuous, concolorous with transverse lines. In forewing antemedial line curved towards termen. Postmedial line curved between R5/M1 and M2. Medial area with more darker scales

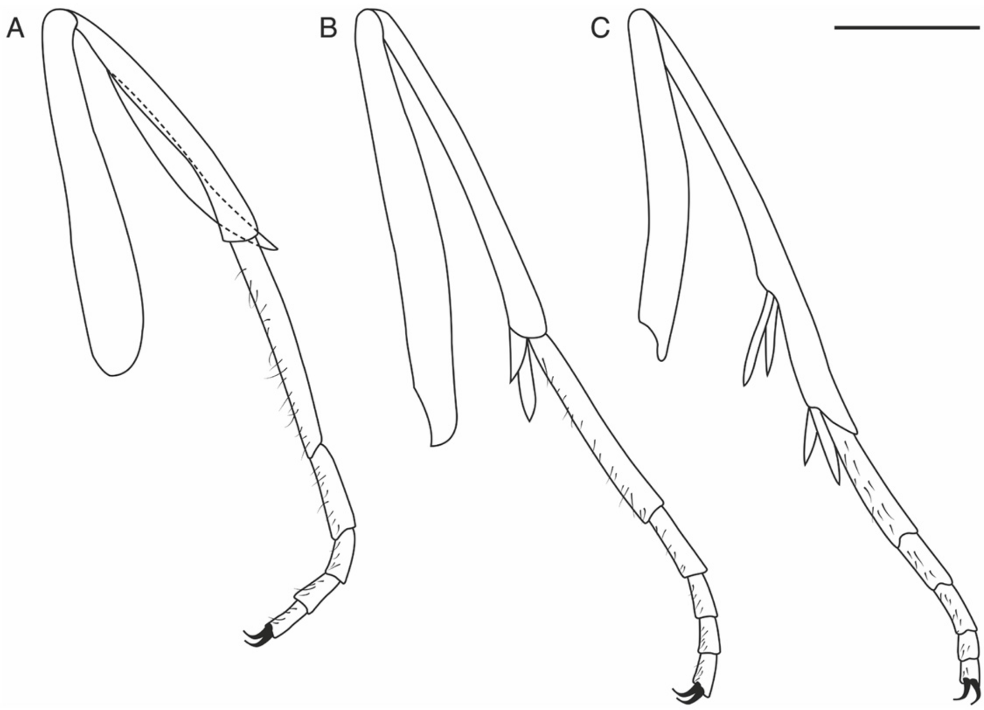


Figure 3. Drawings of the legs of *Aphilopota tyttha* (Prout) comb. nov. **A.** Foreleg; **B.** Midleg; **C.** Hindleg.

intermixed. In hindwing antemedial line curved towards termen on M1. Discal spots only present on underside (Figs 5–11).

In forewing, vein R1 arising from the cell, not reaching costa, R2 merged with R1, R3–5 with a common stalk arising from the cell. In hindwing Sc+R1 strongly curved in basal area, approximating to the cell, M2 absent, A3 and A1+2 originating separately (Fig. 4).

In male genitalia uncus strongly sclerotized, short, basally broad and triangular, apically pointed. Gnathos well developed and strongly sclerotized, triangular. Costa of valva sclerotized, valva thin, without any ampulla or harpe. Juxta forked and big, reaching up to gnathos. Saccus tapering. Aedeagus thin tapered, carrying one long and sclerotized cornutus. Cornutus almost same length as aedeagus (Figs 17–18).

Female genitalia thin and long, with strongly elongated ovipositor. Apophyses posteriores very long, apophyses anteriores 1/3 length of apophyses posteriors. Antrum sclerotized. Ductus bursae short, bend. Corpus bursae tube-like, elongated. Signum absent (Fig. 21).

Phenology. Adults observed from November to May.

Biology. Unknown.

Habitat. Investigated specimens collected at elevations from 220 to 1300 m in dry savanna ecoregions.

Distribution. In East Africa (Eritrea, Ethiopia, Kenya), south-western Africa (Namibia) and South Africa (Janse 1932).

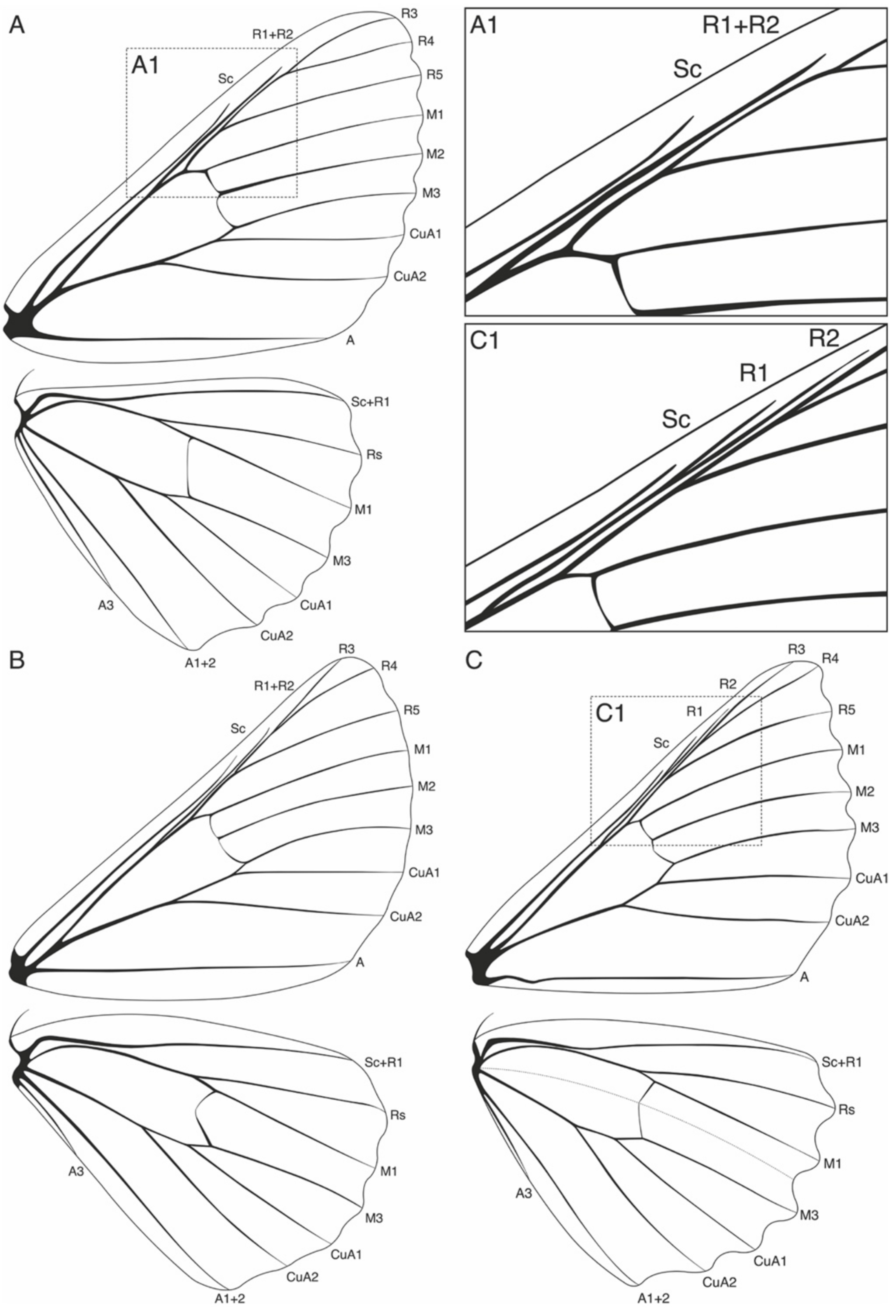
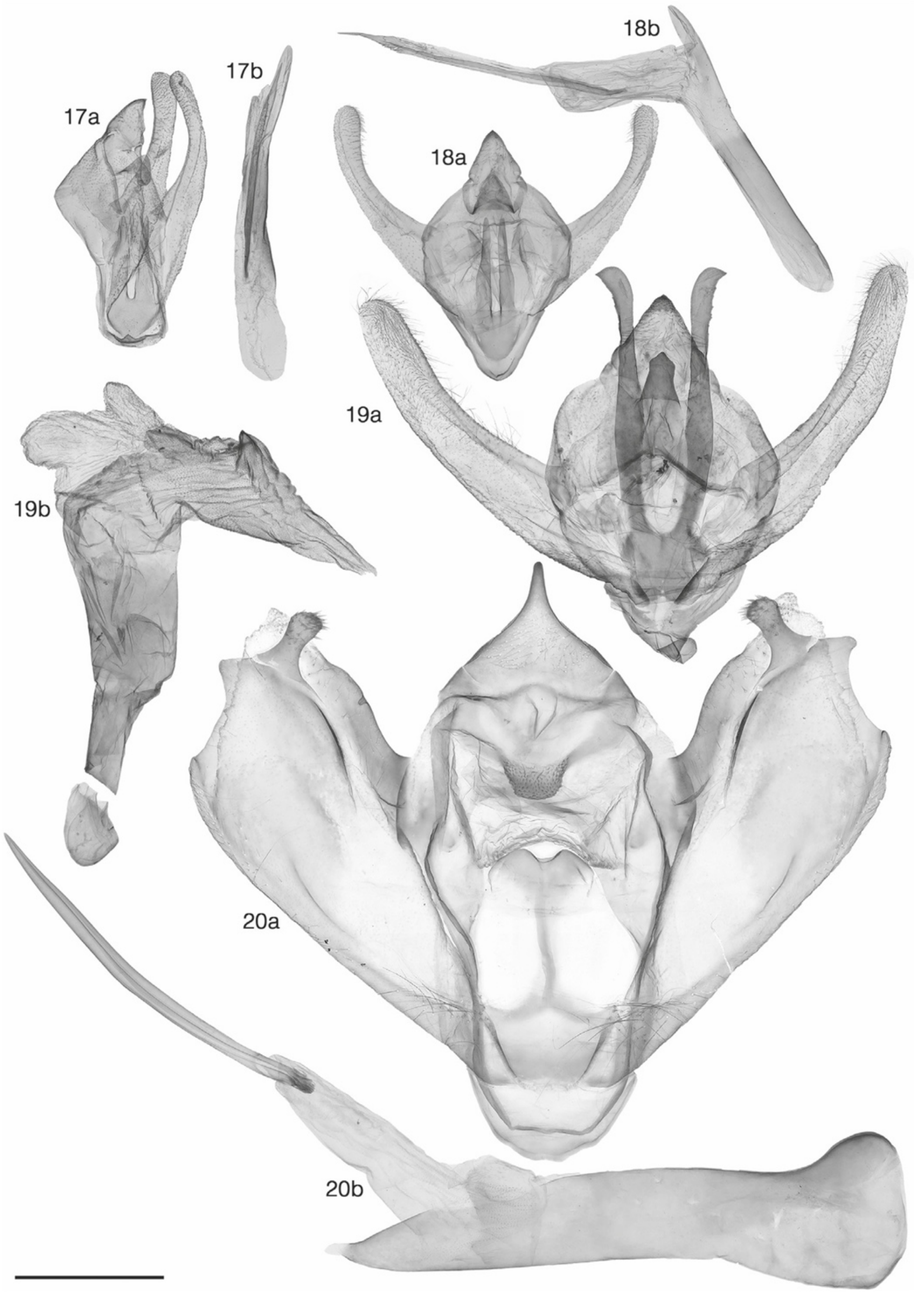
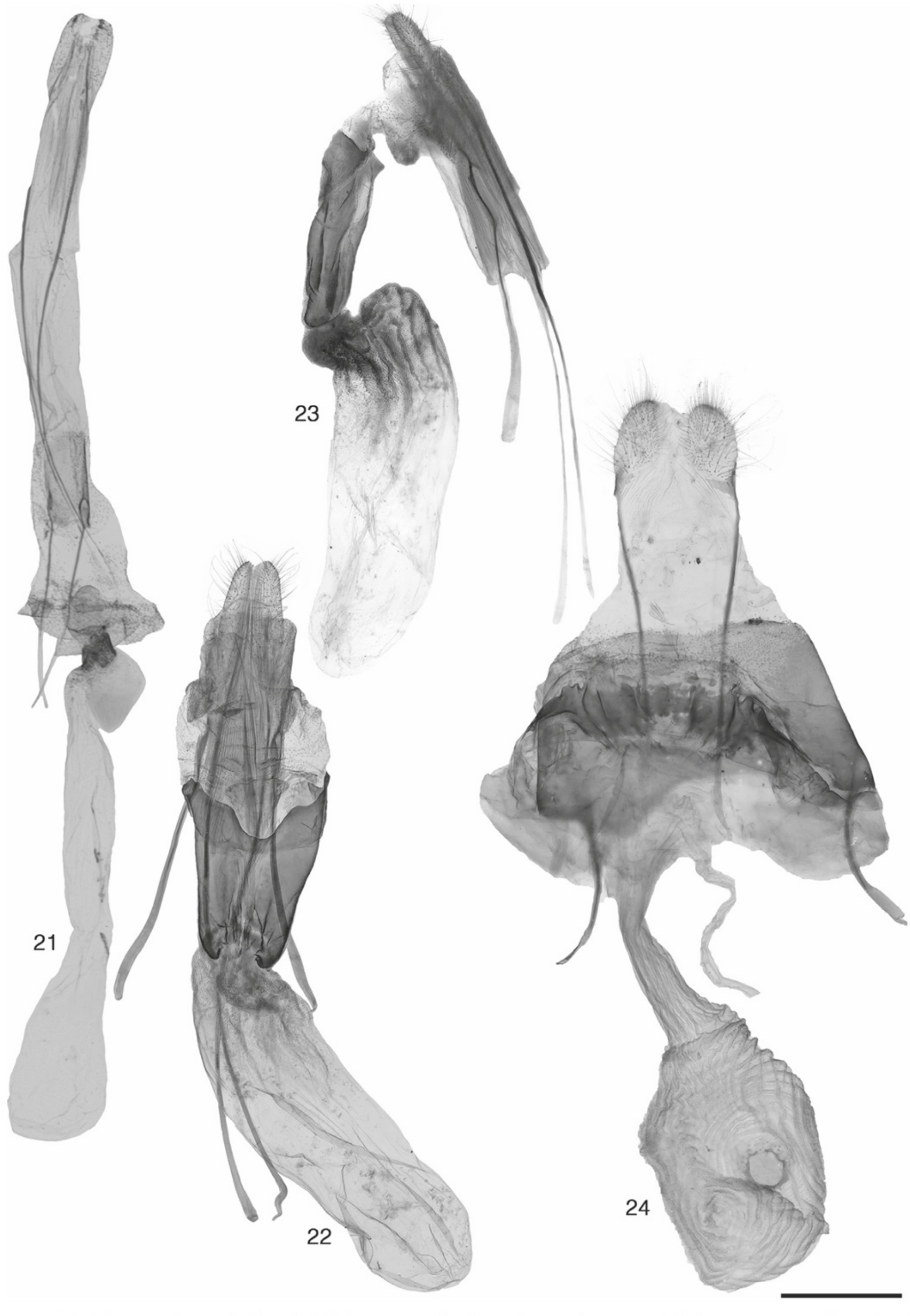


Figure 4. Wing venation drawings of male specimens of **A.** *Aphilopota tyttha* (Prout) comb. nov.; **B.** *Aphilopota interpellans* (Butler), and **C.** *Nychiodes obscuraria* (Villers). In the forewing of *A. tyttha* and *A. interpellans* vein R2 is fused with R1 (rectangle A1), vein R1 and R2 share a common stalk in *N. obscuraria* (rectangle C1). Remark: as in the genus *Nychiodes*, the veins R1 and R2 are on a common stalk. This suggests that the veins R1 + R2 are fused to one vein in the genus *Aphilopota*; therefore, here we name this vein R1+R2.

Figures 5–16. Wing pattern of *Aphilopota tyttha* (Prout), comb. nov., *Aphilopota interpellans* (Butler) and *Nychiodes obscuraria* (Villers). **5–11.** *A. tyttha* (**5.** Holotype, Eritrea, Caraiai, g.prep. 4976, NHMUK010920109; **6.** Ethiopia, Awassa, Awassa Lake; **7.** Kenya, Kitale, NHMUK010920119; **8.** [Namibia], Sissekab, N.W. of Otavi, NHMUK010920120; **9.** Ethiopia, Bahar Dar, g.prep. 0732/2020 D. Wanke; **10.** South Africa, Mkuze Chaos; **11.** Eritrea, Caraiai, NHMUK014173598); **12–14.** *A. interpellans* (**12.** South Africa, KwaZuluNatal, Vryheid, g.prep. 1314/2022 D. Wanke; **13.** [South Africa], Transvaal, Bords du Limpopo, g.prep. 1316/2022 D. Wanke; **14.** South Africa, KwaZuluNatal, Vryheid, g.prep. 1315/2022 D. Wanke); **15–16.** *N. obscuraria* (**15.** Spain, Albarracin, g.prep. 2096/2017 H. Rajaei; **16.** Spain, Albarracin, g.prep. 2097/2017 H. Rajaei); a = upperside; b = underside. Scale bar: 1 cm.



Figures 17–20. Male genitalia of *Aphilopota tyttha* (Prout), comb. nov., *Aphilopota interpellans* (Butler) and *Nychiodes obscuraria* (Villers). **17–18.** *A. tyttha* (**17.** Holotype, Eritrea, Caraiai, g.prep. 4976, NHMUK010920109; **18.** Ethiopia, Bahar Dar, g.prep. 0732/2020 D. Wanke); **19.** *A. interpellans* (South Africa, KwaZuluNatal, Vryheid, g.prep. 1314/2022 D. Wanke); **20.** *N. obscuraria* (Spain, Albarracin, g.prep. 2096/2017 H. Rajaei). a = genitalia capsule; b = aedeagus. Scale bar: 1 mm.



Figures 21–24. Female genitalia of *Aphilopota tyttha* (Prout), comb. nov., *Aphilopota interpellans* (Butler) and *Nychiodes obscuraria* (Villers). **21.** *A. tyttha* (Eritrea, Caraiai, g.prep. 4977, NHMUK014173598); **22–23.** *A. interpellans* (South Africa, KwaZuluNatal, Vryheid, g.prep. 1315/2022 D. Wanke; **22.** Ventral view; **23.** Lateral view); **24.** *N. obscuraria* (Spain, Albarracin, g.prep. 2097/2017 H. Rajaei). Scale bar: 1 mm.

Acknowledgements

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Appendix 1

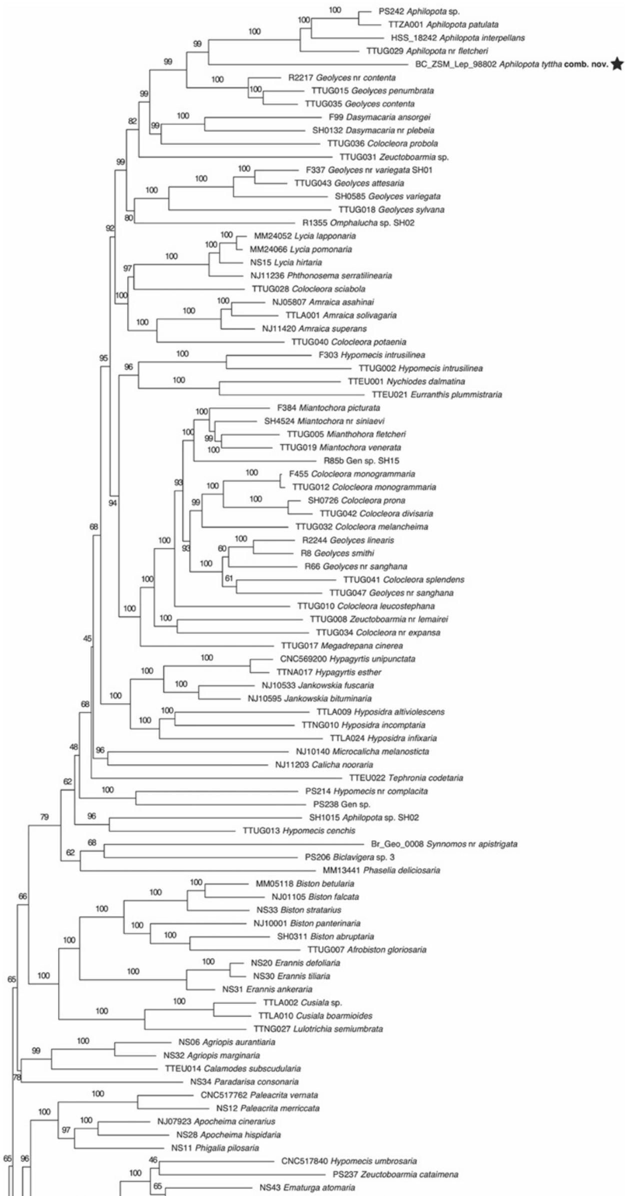

Figure A1. Complete phylogenetic analysis from IQ-TREE, showing the phylogenetic position of *Aphilopota tyttha* comb. nov. (marked with a star) within the tribe Boarmiini. Support values are indicated above the branch. Node confidence values were estimated based on 1000 ultrafast bootstrap replicates.

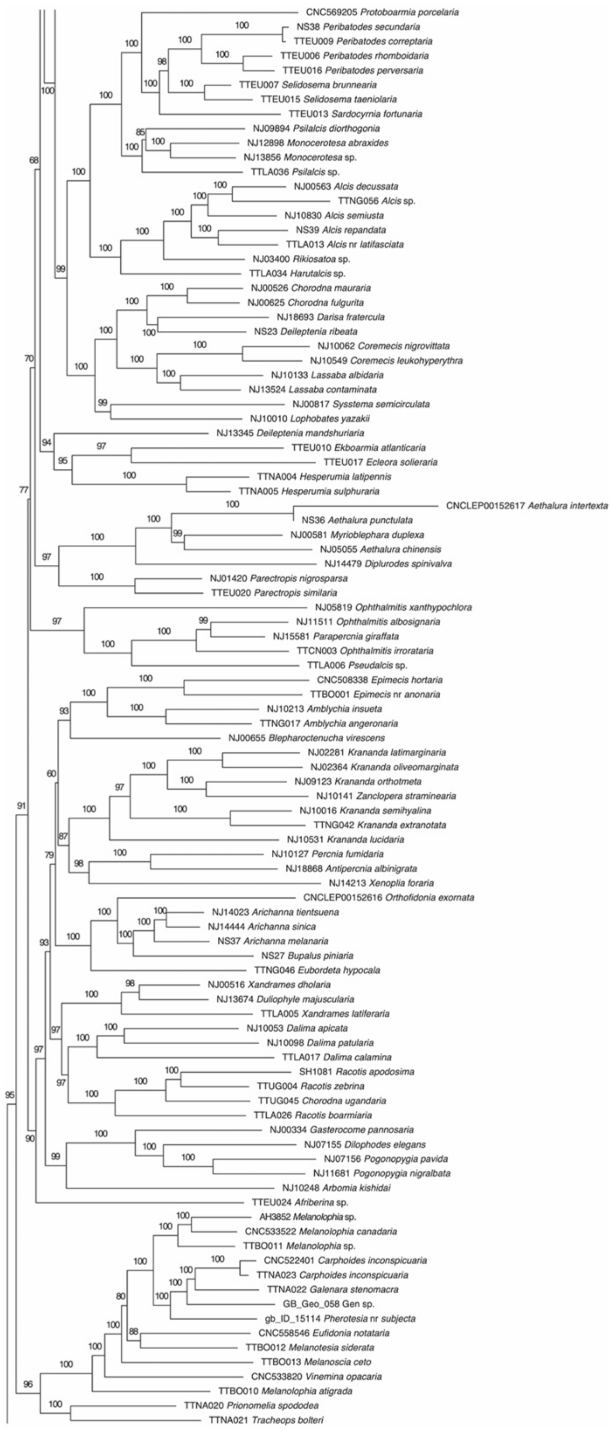

Figure A1. Continued.

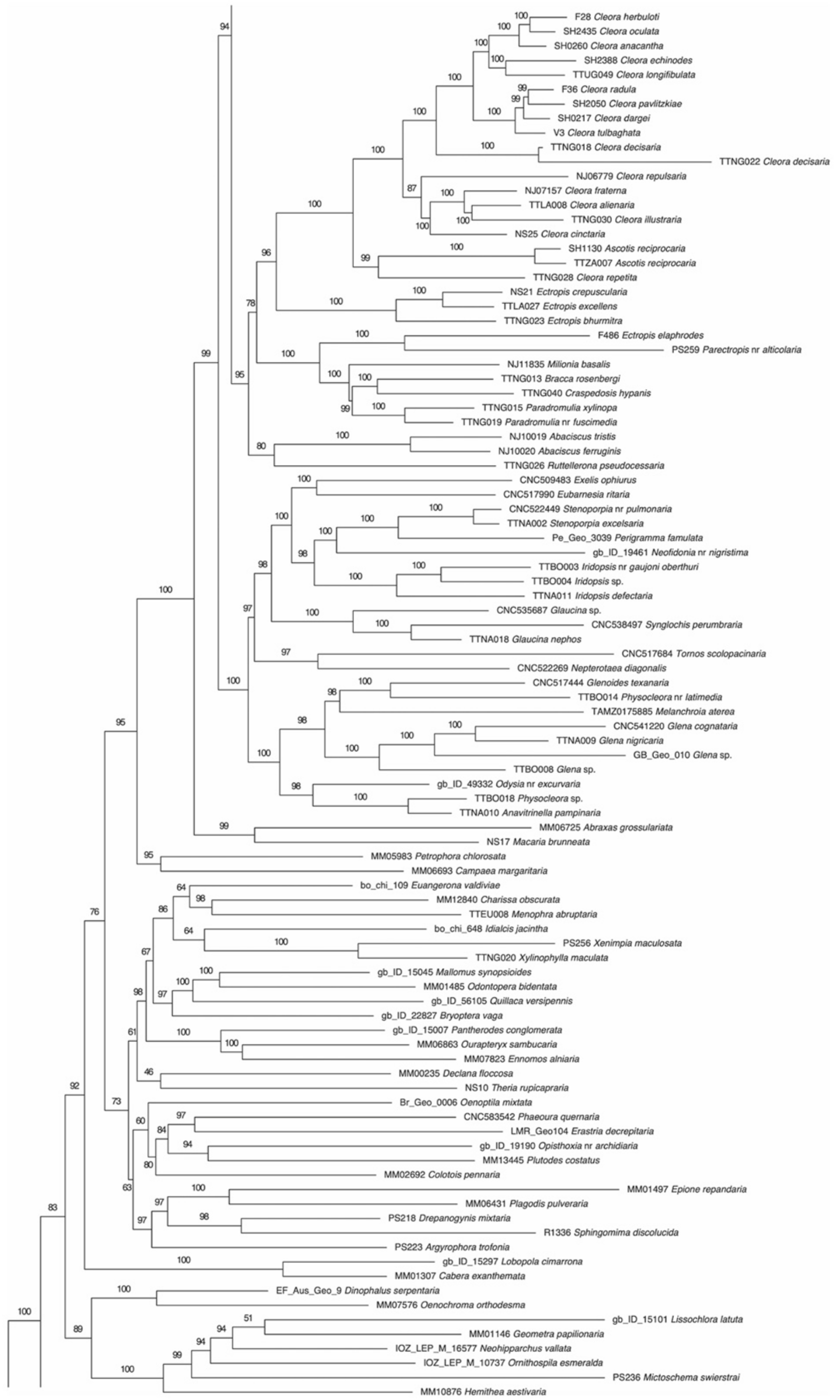

Figure A1. Continued.

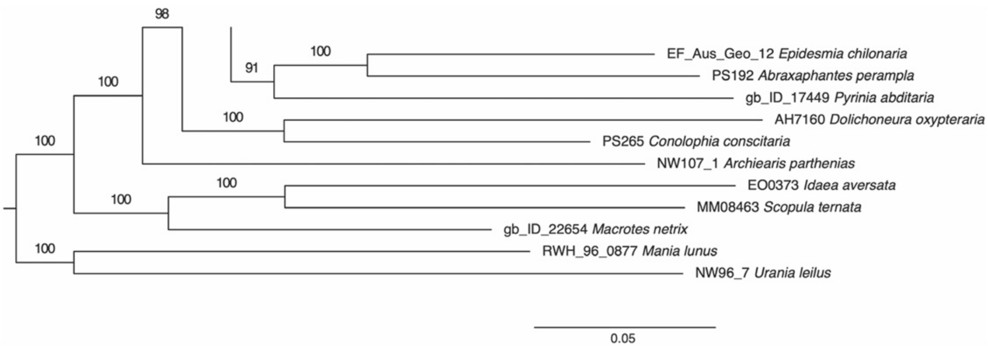

Figure A1. Continued.

Supplementary material 1

Taxa used in this study

Authors: Dominic Wanke, Axel Hausmann, David C. Lees, Kyung Min Lee, Geoff Martin, Pasi Sihvonen, Hermann Staude, Hossein Rajaei

Data type: table (excel file).

Explanation note: Taxa used in this study, with identification, process code, and GenBank accession numbers for each gene. Data from Murillo-Ramos et al. 2019 & Wanke et al. (current paper).

Link: https://doi.org/10.3897/nl.46.94940.suppl1

Original research paper 7

Integrative taxonomic review of the genus *Synopsia* Hübner, 1825 in the Middle East (Lepidoptera: Geometridae: Ennominae)

Dominic Wanke, Axel Hausmann, Pasi Sihvonen, Lars Krogmann, Hossein Rajaei

Published (2020) in Zootaxa 4885 (1): 27–50
https://doi.org/10.11646/zootaxa.4885.1.2

Painting of *Synopsia sociaria* by Valerio Caruso

Zootaxa 4885 (1): 027–050
https://www.mapress.com/j/zt/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

https://doi.org/10.11646/zootaxa.4885.1.2
http://zoobank.org/urn:lsid:zoobank.org:pub:3BFEB64C-FEA7-445F-AB3B-DFB3AECF9543

Integrative taxonomic review of the genus *Synopsia* Hübner, 1825 in the Middle East (Lepidoptera: Geometridae: Ennominae)

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Abstract

The geometrid genera *Synopsia* Hübner, 1825 and *Synopsidia* Djakonov, 1935 are revised, both being earlier validated at genus rank. Type specimens, original descriptions and additional specimens from different localities were examined. The revision is based on morphological characters, molecular data and distribution records. As a result, *Synopsidia* **syn. nov.** is regarded as junior synonym of the genus *Synopsia*. The synonymies of the species *Scodonia tekkearia* Christoph, 1883 and *Synopsia znojkoi* Djakonov, 1935 with *Synopsia phasidaria phasidaria* (Rogenhofer, 1873) **comb. nov.** are confirmed. Furthermore, *Synopsidia phasidaria alvandi* Wiltshire, 1966 **syn. nov.**, *Synopsidia phasidaria ardschira* Brandt, 1938 **syn. nov.**, *Synopsidia phasidaria chiraza* Brandt, 1938 **syn. nov.**, *Hashtaresia jodes* Wehrli, 1936 **syn. nov.** and *Synopsidia phasidaria mirabica* Wehrli, 1941 **syn. nov.** are regarded as synonyms of *Synopsia phasidaria phasidaria* (Rogenhofer, 1873) **comb. nov.**. *Synopsia phasidaria afghana* (Wiltshire, 1966) **comb. nov.** is tentatively validated at subspecific rank. *Synopsia centralis* (Wiltshire, 1966) **comb. nov.**, **bona sp.** is upgraded from subspecies to species level. Wing pattern, as well as male and female genitalia and diagnostic characters of examined genera and species are illustrated and analyzed. The distribution patterns of *Synopsia phasidaria* **comb. nov.** and *Synopsia centralis* **bona sp.**, as well as the type localities of all discussed taxa, are provided. A complete checklist of the genus is given.

Key words: *Angerona*, *Chariaspilates*, Gnophini, *Hypoxystis*, new combinations, new synonyms, *Phthonandria*, *Siona*, *Synopsidia*

Introduction

In current taxonomy, *Synopsia* Hübner, 1825 is a monotypic genus containing only the type species of the genus, *S. sociaria* (Hübner, 1899). Though, some authors also have placed the taxon *strictaria* Lederer, 1853 in *Synopsia* (e.g. Viidalepp 1996, Mironov *et al*. 2008, Beljaev & Mironov 2019), while others placed it in *Megalycinia* Wehrli, 1939 (e.g. Ahola *et al*. 1999, Scoble 1999, Hausmann *et al*. 2004, 2011). Müller *et al*. (2019) transferred the taxon *strictaria* to the genus *Phthonandria* Warren, 1894.

Synopsia sociaria is widely distributed from Portugal and Spain to the southern Ural Mountains, Turkey, Transcaucasia and Kazakhstan (Müller *et al*. 2019). Its polyphagous larvae feed on different species of e.g. Asteraceae, Fabaceae, Ranunculaceae or Rosaceae (see Müller *et al*. 2019).

Synopsidia Djakonov, 1935 was originally described as a subgenus of *Synopsia*, based on the type species *Synopsia znojkoi* Djakonov, 1935 from Azerbaijan: Paraga. Wehrli (1954) transferred *Nychiodes phasidaria* Rogenhofer, 1873 (described from Georgia: Akhaltsikhe) into *Synopsidia* and regarded it as the type species of *Synopsidia*. Subsequently he raised *Synopsidia* from subgenus to genus level and listed six subspecies for *Synopsidia phasidaria*. This classification has been followed later by Scoble (1999) and Hausmann & Scoble (2007), who listed

Accepted by R. Zahiri: 29 Sept. 2020; published: 24 Nov. 2020

eight subspecies under *Synopsidia phasidaria*, including the subspecies *znojkoi*. *Synopsidia* is a monotypic genus and occurs widely in the Middle East from Caucasus to Afghanistan.

Synopsidia phasidaria mirabica, originally described as a variation by Wehrli (1941), is not listed in both above-mentioned catalogues. According to article 45.6.4. of the International Code of Zoological Nomenclature (ICZN2000) this name should be regarded as a subspecies (Ride *et al*. 1999).

In current phylogenetic analyses *Synopsia* is classified in tribe Gnophini (Beljaev 2016), which has recently been supported by a multi-gene phylogenetic analysis (Murillo-Ramos *et al*. 2019), while *Synopsidia* is not included in either of these publications.

As the validity of all subspecies was still controversial and questioned by several authors (Viidalepp 1996, Lehmann & Zahiri 2011), the present study has two main aims: (1) investigation of the status of the genus *Synopsidia*; (2) a taxonomic review of the subspecies of *Synopsidia phasidaria*.

To achieve these goals, we mainly focused on morphological characters, combined with distribution data and DNA barcoding. Morphological characters (e.g. head, male and female genitalia and wing venation) of *Synopsia* and *Synopsidia*, as well as some of related Palearctic genera (see Material and Methods) were compared. Most type specimens were examined and original descriptions were critically reviewed. Large series of additional specimens from different localities were studied internally and externally to test the validity of the subspecies.

Material and methods

Type material and additional specimens, used in this study, were borrowed from the following collections (acronyms after Evenhuis 2007, as far as included):

NHMUK	Natural History Museum, London, United Kingdom
NHMV	Natural History Museum Vienna, Austria
NHRS	Naturhistoriska Riksmuseet, Stockholm, Sweden
PCJM	Private collection of Jörg-Uwe Meineke, Kippenheim, Germany
PCPS	Private collection of Peder Skou, Vester Skerninge, Denmark
SMNK	Staatliches Museum für Naturkunde Karlsruhe, Germany
SMNS	Staatliches Museum für Naturkunde Stuttgart, Germany
ZFMK	Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany
ZSM	Zoologische Staatssammlung München, Germany

Morphological examination. Morphological characters of the following genera were compared with those of *Synopsia* and *Synopsidia* to allow definition of diagnostic genus-level characters: *Siona* Duponchel, 1829; *Hypoxystis* Prout, 1915; *Angerona* Duponchel, 1829; *Phthonandria* Warren, 1894; and *Chariaspilates* Wehrli, 1953. These genera have been chosen based on close relationships with *Synopsia* as presented in Murillo-Ramos *et al*. (2019) as well as Müller *et al*. (2019). The structural comparisons against these genera are based on one male and female specimens per species. Therefore, the variation within these structures, for instance in wing venation, was not examined.

Type material of the investigated subspecies of *S. phasidaria* and original descriptions served for the identification and comparison of specimens. A Visionary Digital photography system (LK Imaging System, Dun. Inc., equipped with a Canon EOS 5DSR), as well as an Olympus E3 digital camera were used for the documentation of external characters. Genitalia preparations were carried out following standard techniques (e.g. Robinson 1976) and vesica evertion according to the method by Sihvonen (2001). For the photography of genitalia characters in their natural position before embedding, we followed the methods proposed by Wanke & Rajaei (2018) and Wanke *et al*. (2019). A Keyence VHX-5000 was used for their photography. Genitalia were finally embedded as permanent slides in Euparal and photographed with a Keyence VHX-5000.

The morphology of male and female antennae were studied using a Zeiss Scanning Electron Microscope (SEM, EVO-LS15). Before imaging with SEM, the antennae were mounted on holders and sputter-coated with 6 nm gold-palladium using a Leica coating system (EM ACE 200).

Distribution patterns. For tracing geographical coordinates, we used 'Google Earth Pro' (vers. 7.3.1.4507 for Mac) and distribution patterns were plotted and prepared in QGIS (vers. 2.18.15 for Mac). Preparation of the elevation profile in QGIS was conducted using Global Multi-resolution Terrain Elevation Data 2010 (GMTED2010) downloaded from https://earthexplorer.usgs.gov.

DNA barcoding. Extraction of DNA and amplification of the "barcode" fragment (658 base-pairs of the 5' terminus) of the mitochondrial Cytochrome-C Oxidase I were carried out using standard protocols (e.g. Ivanova *et al*. 2006). PCR amplification products were partly sent to Macrogen for sequencing and partly sequenced at the CCDB, Guelph. A specimen list used for DNA analysis is given in the appendix table along with their sampling site and process ID numbers. All sequences, photographs and metadata are accessible in the public dataset DS-SYNOPSIA on BOLD (Barcode of Life Datasystems; doi: dx.doi.org/10.5883/DS-SYNOPSIA). For the maximum likelihood analysis (with 1000 bootstrap replications) and calculation of genetic distances MEGA X (Kumar *et al*. 2018, Stecher *et al*. 2020) was used (using K2P model: Kimura 1980). The type species of the genera listed above for the morphological examination (except *Phthonandria*) served as outgroups in this analysis.

Results and discussion

Synopsia Hübner, 1825

Synopsia Hübner, [1825] 1816. Verzeichnis bekannter Schmetterlinge, 317. Type species: *Geometra sociaria* Hübner, 1799 [Europe].

Synopsidia Djakonov, 1935. Lambillionea 35, 147. Type species: *Synopsia znojkoi* Djakonov, 1935. Herewith regarded as **new synonym** of *Synopsia* based on morphological examination (see below).

Taxonomic remark. *Synopsidia* has been described as subgenus of *Synopsia* referring to the absence of a proboscis (which is also rudimentarily developed in *Synopsia* (see figs 1A–D)), a simplified wing pattern, a blunter and broader uncus, as well as a smaller number of cornuti on the vesica (Djakonov 1935). Also, within the diagnosis of *Synopsidia* (see Djakonov 1935), all characters and similarities with *Synopsia* were stated (e.g., the congruent wing venation (fig. 3) and details of the genitalia structures). Later, *Synopsidia* was raised to genus rank referring only to the absence of the proboscis (Brandt 1938, Wehrli 1954). Our investigation supports the view that *Synopsidia* needs to be regarded as a new synonym of *Synopsia* based on similar morphology (see diagnosis).

Description and diagnosis. *Wings and body*. Medium-sized moths (wingspan between 26–44 mm). Antennae bipectinate in males, filiform or bipectinate in females (if bipectinate, length of branches from 0.1 mm to 0.48 mm) (figs 1–2). Proboscis reduced or represented by barely visible rudimentary slats (Djakonov 1935) (see fig. 1A–D). Wings brown with light grey areas, bright beige or white to darker yellow with some brown spots (wings white with dark brown veins in *Siona*; wings light yellow, strongly intermixed with brown in *Hypoxystis*; varying combinations of yellow and orange in *Angerona*; varying shades of brown in *Phthonandria*; golden brown-yellow in *Chariaspilates*) (figs. 5–26; see Skou & Sihvonen 2015, pages 487, 495, 499 & Müller *et al*. 2019, page 587). Frons, thorax and abdomen concolorous with wings. Chaetosemata developed as two small separate patches.

Venation (figs 3–4). In the forewing Sc and R1 arising from a common stalk (similar condition in *Hypoxystis*, *Angerona, Phthonandria* and *Chariaspilates*; Sc arising separately from the wing base and continuing to the costal margin of the wing, R1 free, originating from the cell in *Siona*). In *Synopsia* R2 arising on a separate stalk; in its second half shortly anastomosing with common stalk of R3 and R4, (similar condition in *Chariaspilates*; *Phthonandria*; *Angerona*; *Hypoxystis*; R2 touching the common stalk of R3 and R4 without anastomosis in *Siona*) (fig. 4). R3–5 arising from a common stalk originating from the cell. R3–4 on common stalk distally of origin of R5. In the hindwing Sc+R1 fused, strongly curved in basal area, anastomosing with Rs and with vein M2 reduced.

Male genitalia (figs 27–36; Skou & Sihvonen 2015, pages 529, 537, 543 & Müller *et al*. 2019, page 651). Uncus strongly sclerotized and slightly to strongly bifurcate, sometimes tip only concave in the centre (uncus absent in *Siona*; short and stout in *Hypoxystis*; as a shallow plate in *Angerona*; small and bifid in *Phthonandria*; tapering in *Chariaspilates*). Gnathos strongly sclerotized, upturned, tongue-shaped, width of tongue differing (upturned and tapered in *Siona*; plate-shaped in *Hypoxystis*; upturned and tapered in *Angerona*; large and upturned in *Phthonandria*; as a large medial plate in *Chariaspilates*). Costa of valva with projection at the centre (similar condition in *Hypoxystis* and *Chariaspilates*; basal projection in *Siona*, *Angerona* and *Phthonandria*).

FIGURE 1. Structures of the head and antennae of *Synopsia sociaria* and *Synopsia phasidaria* **comb. nov.**. A male and C female head of *Synopsia sociaria* (proboscis rudimentary developed); B male and D female head of *Synopsia phasidaria* **comb. nov.** (proboscis strongly reduced, not reaching through the labial palps). E male bipectinate antennae and F female filiform antennae of *Synopsia sociaria*. G male bipectinate antennae and H, I female bipectinate antennae (slightly differing in specimens) of *Synopsia phasidaria* **comb. nov.**. Abbreviations: *lbp* – labial palps; *prb* – proboscis. Photos E-I in scale (scale-bar 1 mm).

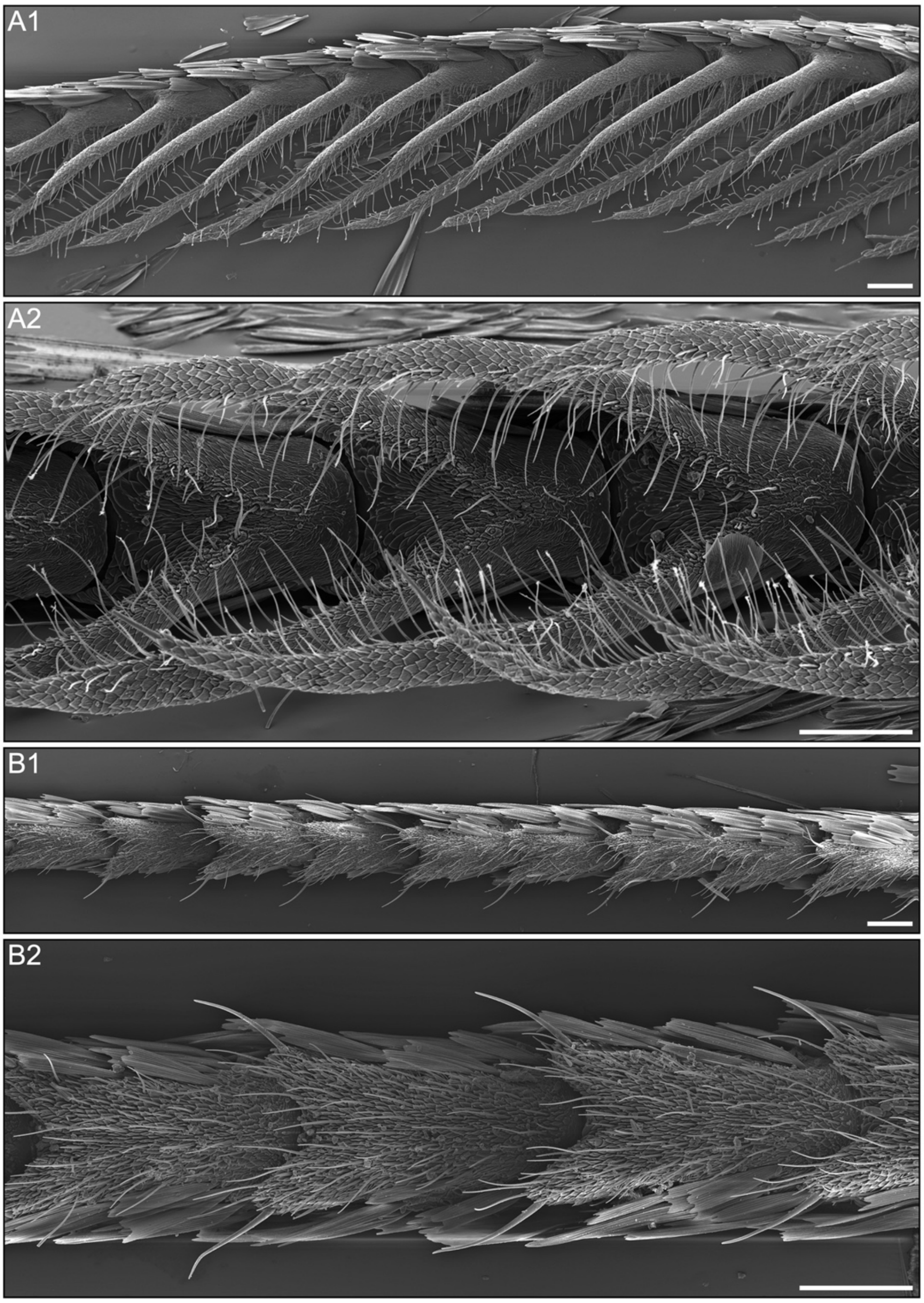


FIGURE 2. SEM close-up photos of the two different forms of bipectinate antennae in female of *Synopsia phasidaria* **comb. nov.**. Photos A strongly bipectinate (A1 lateral, A2 ventral); B weakly bipectinate (B1 lateral, B2 ventral). Scale-bar 100 µm.

Costal projection bearing one or more spines (only one spine in *Siona*; spines absent in *Hypoxystis*; spinose in *Angerona*; bearing spines in *Phthonandria* and *Chariaspilates*). Saccus wide and round, sometimes with extensions (without extensions in *Siona*, *Hypoxystis*, *Angerona*, *Phthonandria* and *Chariaspilates*).

Aedeagus with several strongly sclerotized cornuti on the vesica (a small row in *Siona*; small and dentate in *Hypoxystis*; one cornutus in *Angerona*; cornuti variable in number in *Phthonandria*; patch of microcornuti in *Chariaspilates*) (fig. 36).

Female genitalia (figs 37–40; Skou & Sihvonen 2015, pages 571, 579, 585; Müller *et al*. 2019, page 716). Ductus bursae sclerotized (short, laterally sclerotized in *Siona*; membranous short and wide in *Hypoxystis* and *Angerona*; short in *Phthonandria* and *Chariaspilates*). Corpus bursae anteriorly membranous (anterior part membranous in *Siona*; large and membranous in *Hypoxystis* and *Phthonandria*; anteriorly elongated in *Angerona*; anteriorly subtriangular in *Chariaspilates*). Signum present, serrated (elongated, with dentate margins in *Siona*; rectangular in *Hypoxystis*; rectangular with hollow centre in *Angerona*; oval with hollow centre in *Phthonandria*; elongated with sclerotized margins in *Chariaspilates*).

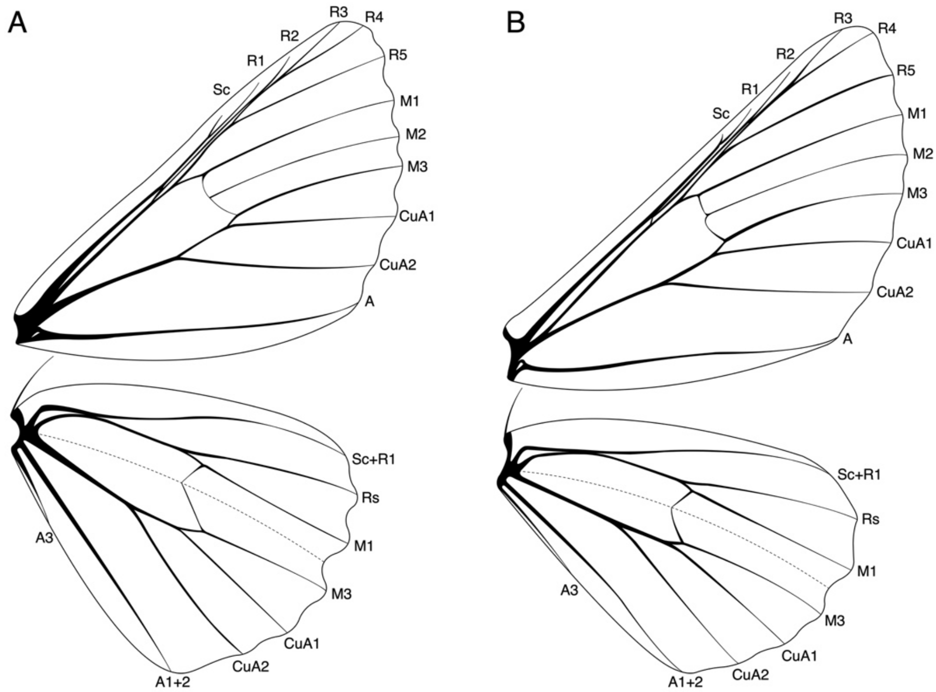


FIGURE 3. Wing venation of male specimens of A: *Synopsia* (*S. sociaria* type species for the genus) and B: *Synopsidia* (*S. phasidaria*) **syn. nov.** of *Synopsia*. Note that both wing venations do not show significant differences.

Species account

Synopsia phasidaria phasidaria **(Rogenhofer, 1873) comb. nov.**
(figs 8–22, 29–33, 36, 38–40, 42)

Nychiodes phasidaria Rogenhofer, 1873. Verhandlungen der Zoologisch-Botanischen Gesellschaft in Wien 23, 572. Syntypes (Caucasus, Achalzik [Akhaltsikhe]) (deposition of type specimen(s) unknown).

Scodonia tekkearia Christoph, 1883. In Romanoff, Mémoires sur les Lépidoptères 2, 123. Holotype ♂ ([Turkmenistan], near Nuchur [Nokhur]). According to Wehrli (1954) deposited in museum of St Petersburg. Wehrli (1941) combined this taxon with *Synopsidia*. This subspecies is regarded as a junior synonym of *Synopsidia phasidaria* by Viidalepp (1996). Here confirmed as junior synonym of *Synopsia phasidaria phasidaria* **comb. nov.**, based on morphological examination and sympatric occurrence of these forms.

Synopsia znojkoi Djakonov, 1935. Lambillionea 35 (7), 142. Syntypes ♂ (Transcaucasus: Paraga, NW of Ordubad). Deposition of type specimen(s) unknown. Examination after Djakonov´s description and illustration of the male genitalia. This subspecies is regarded as a junior synonym of *Synopsidia phasidaria* by Viidalepp (1996). Here confirmed as junior synonym of *Synopsia phasidaria phasidaria* **comb. nov.**, based on morphological examination and sympatric occurrence of these forms.

Hashtaresia jodes Wehrli, 1936. Lambillionea 36 (12), 276. Holotype ♂ (NHMUK, examined). Wehrli (1941) combined this taxon with *Synopsidia*. Hereby regarded as a **new synonym** of *Synopsia phasidaria phasidaria* based on morphological examination and sympatric occurrence of these forms.

Synopsidia phasidaria ardschira Brandt, 1938. Entomologische Rundschau 55 (51), 602. Holotype ♂ (NHRS examined). Hereby regarded as a **new synonym** of *Synopsia phasidaria phasidaria* based on morphological examination and sympatric occurrence of these forms.

Synopsidia phasidaria chiraza Brandt, 1938. Entomologische Rundschau 55 (51), 602. Syntypes (Iran, Sine-Sefid). (NHRS). Hereby regarded as a **new synonym** of *Synopsia phasidaria phasidaria* based on morphological examination and sympatric occurrence of these forms.

Synopsidia phasidaria mirabica Wehrli, 1941. In: Seitz, A. (Ed.), Die Großschmetterlinge der Erde. Supplement zu Band 4, 464. Syntypes ♂, ♀ (ZFMK, examined). Hereby regarded as a **new synonym** of *Synopsia phasidaria phasidaria* based on morphological examination and sympatric occurrence of these forms.

Synopsidia phasidaria alvandi Wiltshire, 1966. Zeitschrift der Wiener Entomologischen Gesellschaft, 51, 146. Holotype ♂ (NHMUK, examined). Hereby regarded as a **new synonym** of *Synopsia phasidaria phasidaria* based on morphological examination and sympatric occurrence of these forms.

Type material examined. *Synopsidia phasidaria alvandi*: Holotype, ♂, Iran, Mt. Alvand, 9000ft. [2743 m], 27.vii.1938, E.P. Wiltshire, g.prep. E.P. Wiltshire 1470; in NHMUK (fig. 9).

Synopsidia phasidaria ardschira: Paratype, 1 ♂, Iran, Fars, Straße Ardekan-Talochosroe, Comèe [Komehr] (Barm i Firus), ca 3750 m, 4. und 5.vi.1937, coll. Brandt, g.prep. 11026; in NHRS (fig. 8).

Synopsidia phasidaria jodes: Holotype, ♂, Iran, Hashtar, Demawend, 2500 m, viii.1935, F. Fusek, g.prep. 7100; in NHMUK (fig. 10).

Synopsidia phasidaria mirabica: Syntype, 1 ♂, Nordost-Iran, Kuh i Mirabi, Waldzone, 1600–1900 m, Juli, Exp. Wernicke, g.prep. 0501/2020 D. Wanke; Syntype, 1 ♀, Nord-Iran, Schahkuh, Westabhang, Geröllzone, 1800–2000 m Juni, Exp. Wernicke, g.prep. 0502/2020 D. Wanke; all in ZFMK (figs 11–12).

Additional material examined. 2 ♀, Iran, Mt. Alvand, 9000 ft. [2743 m], 27.vii.1938, E.P. Wiltshire; in NHMUK.

1 ♂, Iran, Fars, Straße Chiraz-Kazeroun, Fort Sine-Sefid, ca. 2200 m, Sept.1937, coll. Brandt, g.prep. 11027; 1 ♂, Iran, Fars, Strasse Ardecan-Talochosroe [Ardakan-Talle Khosrow], Comèe [Komehr] (Barm i Firus), ca. 3750 m, 4. und 5.vi.1937, Brandt, g.prep. 11028; in NHRS.

1 ♂, Iran, Kordestan, Baneh 15 km NE, Gharawol-Kaneh [Khaneh], 2000 m, 26./27.vi.2009, leg. A. Hofmann, J.-U. Meineke, H. Rayai [Rajaei], g.prep. 0213/2019 D. Wanke; in PCJM.

1 ♂, Türkei, Cukurca, Prov. Hakkari, 20.vi.1986, leg. Dittrich, Austria, 16273 coll. R. Wimmer, g.prep. 0382/2019 D. Wanke; 1 ♂, 2 ♀, Republic Armenia, Yeranos Mts. 1600 m, Dvin village suburbs, Arat district, 11.–13.vi.2009, leg. Yuriy Shevnin, g.prep. 0381/2019 D. Wanke; 1 ♂, 1 ♀, Republic Armenia, Yeranos Mts. 1600 m, Dvin village suburbs, Arat district, 14.–15.vi.2009, leg. Yuriy Shevnin, g.preps (♂) 0492/2019 D. Wanke, (♀) 0493/2019 D. Wanke; 2 ♂, Republic Armenia, Yeranos Mts. 1600 m, Dvin village suburbs, Ararat district, 11.vi.2009, leg. Yuriy Shevnin, coll Danny Nilsson, g.prep. 0494/2019 D. Wanke; 1 ♂, Republic Armenia, Aiotzdorsky range, 2000 m, Yeghegnadzor suburbs, 150 km to SE from Yerevan, Mozrov Village, Mountain steppes, 12.vii.2009, leg. Yuriy Shevnin; 2 ♂, Iran, Prov. Esfahan, Zagros Mts, Fereidun Shar, 3000 m, 15.–17.vi.2010, leg. B. Benedek & T. Hácz, g.preps 0383, 0495/2019 D. Wanke; 1 ♂, NW-Iran, Provinz Chahar Mahal, ca. 35 km SE Aligudarz Seitental SW Murak, Umg. Dorf Darreh Hoz, 1800–2000 m, 13.–15.vi.2001, leg. de Freina, g.prep. 0384/2019 D. Wanke; 1 ♂, [Iran], Azarbeijan-e Gharbi, Takab, Takht-e soleiman, N36°35'40.0", E047°19'43.5", 2528 m, 1.vii.2013, leg. M. Afsarian, g.prep. 0385/2019 D. Wanke; 1 ♂, Iran, Zanjan, Zanjan-Gilvan, Gargovol Dag, 2500 m, 26./27.vi.2001, leg. A. Hofmann, J.-U. Meineke, W.G. Tremewan, g.prep. 0386/2019 D. Wanke; all in PCPS.

1 ♂, W-Iran, Lorestan, Dorud, Paß S Darrya-che Gahar, Partsche Kabud, 2800 m, 1.–3.viii.1975, leg. Ebert & Falkner, g.prep. 0195/2018 D. Wanke; 2 ♂, 1 ♀, W-Iran, Kordestan, Straße Saghez-Baneh, 21 km NE Baneh, 1950 m, 30.[vi.]–2.vii.1975, leg. Ebert & Falkner, g.preps (♂) 0196/2018 D. Wanke, (♀) 0487/2019 D. Wanke; 2 ♂, 1 ♀, Nordiran, Elbursgebirge östl. Shemshak, 50 km nördl. Teheran, 2100–2500 m, 8.–24.vi.1973, leg. G. Junge, g.preps

(♂) 0209/2018, 0489/2019 D. Wanke; 1 ♂, NE-Iran, prov. Ostan-e Khorasan, Kopet Dagh, ca 50 km N Bojnurd, Sizmansufla, N 37°44'20", E 57°25'53", 10.v.2008, 1240 mNN, lux, leg. R. Trusch, M. Falkenberg & B. Müller, SMNK E-Lep. 247, g.prep. 0488/2019 D. Wanke; 1 ♂, N-Iran, Elburs-Mts., Prov. Tehran, 15km E Gatschsar, 2600 m, 5.viii.1972, leg. Ebert; 1 ♂, N-Iran, Elburs-Geb., 12 km v. Keregi, 1650 m, 27.v.1969, leg. G. Ebert, g.prep. 0490/2019 D. Wanke; 1 ♂, Persia s. [Iran], Elburs, Kendevan, ca. 3000 m, 3.–9.vii.[year missing], coll. Wagner, Wien; all in SMNK.

3 ♂, 1 ♀, [Turkey], Kleinasien, Prov. Hakkari, 20km E Uludere, Suvarihalil-Paß, 2300–2600 m, 14.–15.vii.[19]85, leg. de Freina, g.preps (♂) 0465, 0466/2019 D. Wanke, (♀) 0467/2019 D. Wanke; 2 ♀, [Turkey], Kleinasien, Prov. Hakkari, Tanin-Tanin-Paß, 2000–2300 m, 12.–13.vii.[19]85, leg. de Freina, g.preps 0468, 0480/2019 D. Wanke; 1 ♂,1 ♀, [Turkey], Kleinasien, Hakkari, Ö-Uludere, 1900 m, 28.–29.vi.1982, leg. W. Thomas, g.prep. (♀) 0469/2019 D. Wanke; 1 ♂, [Turkey], Kleinasien, Hakkari, Tanin-Tanin-Paß, 2000 m, 3.–5.vii.1983, leg. W. Thomas; 2 ♀, [Turkey], Kleinasien, Prov. Artvin, NO-Anatolisches Randgebirge SE Seite, Barhal Tal, 4 km NE Altiparmak, 1100 m, 31.vii.–03.viii.[19]83, leg. de Freina; 1 ♂, Türkei, Prov. Van, Kuzgun Kiran-Gecidi, 1900 m, 21.vi.–8.vii.[19]81, ex. coll. A. Hofmann; 1 ♂, Türkei, Prov. Agri, 2km S Dogubayasit, 2100 m, 25.vii.[19]92, leg. P. Kautt & V. Weiss, g.prep. 0470/2019 D. Wanke; 1 ♂, 2 ♀, Iran, Ostan Tehran, Reshteh Ye Alborz, Dizin Gardaneh, 2700–3000 m, 5.–8.vii. 1978, leg. W. L. Blom, g.preps (♂) 0471/2019 D. Wanke, (♀) 0472/2019 D. Wanke; 1 ♂, 1 ♀, Iran, Elburz-Geb., Dizin, 2600 m, vii.1976, leg. Czipka; 1 ♂, Iran, Elburs, Shemshak, 2700 m, 10.–11.viii.1978, leg. W. Thomas, g.prep. 0473/2019 D. Wanke; 1 ♂, Iran, Elburs, Kendevan, 8.–15.viii.1978, 2300–2800 m, leg. W. Thomas; 1 ♀, Iran, Elburs, vic. Kendevan, 7.–9.viii.1977, 2500–3000 m, leg. W. Thomas, g.prep. 0474/2019 D. Wanke; 9 ♂, 2 ♀, Iran, Zanjan prov., E Zanjan, road to Gilvan, Alt. 1889 m, N36°45'21.8", E48°49'20.7", 6.vii.2013, leg. H. Rajaei, J.-U. Meineke, B. Hafezi, g.preps (♂) 0105, 0106/2018, 0475, 0476/2019 D. Wanke, (♀) 0477/2019 D. Wanke; 5 ♂, 2 ♀, Iran, Kohkiluye va Boyerahmad, Yasuj, Sisakht, Dena, 2799 m, 30°57'23.6"N, 51°23'28.9"E, 30.vii.2016, leg. Sh. Feizpour, g.preps (♂) 0118/2018, 0484, 0485/2019 D. Wanke, (♀) 0486/2019 D. Wanke; 1 ♂, 4 ♀, Iran, Lorestan, Dorud, Astaneh door, 1801 m, 33°24'48.61"N, 49°08'42.5"E, 25.vii.2016, leg. Sh. Feizpour, g.preps (♂) 0123/2018 D. Wanke, (♀) 0478, 0496/2019 D. Wanke; 1 ♀, Iran, Azerbaijan-e Gharbi prov., Khoy to Ghotur road, Esteran vill., Alt. 1637 m, N 38°27'03.1", E 44°44'33.6", 1.vii.2013, leg. J.-U. Meineke, H. Rajaei, B. Hafezi, g.prep. 0299/2019 D. Wanke; 2 ♀, Iran, Shahrud, Shahkouh, Tash, Ayoub, Hosseini region, 2588 m, 36°37'18"N, 54°33'42.6"E, 11.vii.2016, leg. Sh. Feizpour, g.prep. 0481/2019 D. Wanke; 2 ♂, Iran, Prov. Golestan, Shahrud-Golestan road, Shahkuh, 2585 m, 36°38'36"N, 54°31'31"E, 16.vii.2015, leg. Sh. Feizpour, g.preps 0482, 0483/2019 D. Wanke; all in SMNS.

1 ♂, Iran, Khorassan, Kouh i Binaloud (Meched), 3000 m, 30.vii.1938, coll. Brandt, g.prep. 0503/2020 D. Wanke; in ZFMK.

1 ♂, 1 ♀, Iran, Fars, Straße Chiraz-Kazeroun, Fort Sine-Sefid, ca. 2200 m, 26.v.1937, coll. Brandt, both labelled as 'Paratypoid' ; 2 ♂, Iran, Fars, Strasse Ardekan-Talochosroe [Ardakan-Talle Khosrow], Comè [Komehr] ca. 2600 m, 2.viii.1937, coll. Brandt; all in ZSM.

Taxonomic remark on the subspecies. Based on the sympatric occurrence of the forms, absence of clear and constant morphological characters and evidence from the molecular data, most subspecies (except *Synopsia phasidaria afghana* **comb. nov.**) are treated as synonym to *Synopsia phasidaria phasidaria* **comb. nov.**. All subspecies and forms of *S. phasidaria* have been described based on small series of specimens, mainly referring to a different wing pattern and differences in the male genitalia (e.g. shape of the uncus, the number of cornuti and differences in the shape of the harpe). Nonetheless, in *S. phasidaria* all these characters are highly variable even within a single population, which has been stated also by different previous authors (Brandt 1938, Wiltshire 1966) and thus are inadequate as diagnostic characters (see fig. 36).

Furthermore, we observed two kinds of bipectinate antennae in females (short or long pectination) (figs 1H–I, 2), even in the same populations. However, these specimens with different shape of antennae do not show any correlated diagnostic differences in the wing pattern, genitalia characters, and DNA barcodes (fig. 41). All evidence therefore support the synonymy of these subspecies and lead us to conclude that the structurally different female antennae are intraspecific variation.

Diagnosis. *Wings and body* (figs 8–22). Wingspan ♂ 26–38 mm, ♀ 32–42 mm, female specimens rarely smaller (forewing length ♂ 15–20 mm, ♀ 17–23 mm). Wing pattern highly variable, ground colour of wings from bright beige or sandy yellow with some brown spots, to brown (sandy yellow with some brown and orange spots in *S. phasidaria afghana*; similar in *S. centralis*; beige to brown, spotted dark in *S. sociaria*). Transverse lines faint or slightly visible (brown in *S. phasidaria afghana* and *S. centralis*; black in *S. sociaria*) (figs 5–7, 23–26).

Male genitalia (figs 29–33, 36). Uncus sclerotized, slightly bifurcate or tip only concave in the centre (sclerotized tip concave in *S. centralis*; sclerotized and strongly bifurcate in *S. sociaria*). Gnathos well developed, arms fused, forming a tongue-shaped upturned plate, variable in shape (similar in *S. centralis*; almost similar in *S. phasidaria afghana* and *S. sociaria*). Costa of valva with central projection usually bearing one to three spines (similar in *S. phasidaria afghana*; without central projection in *S. centralis*; central projection bearing one to two spines in *S. sociaria*). Harpe sickle-shaped (similar in *S. phasidaria afghana*; thumb-shaped in *S. centralis*; without any harpe in *S. sociaria*). Aedeagus thick, bearing a small amount of cornuti, from 4 to 8 (5–6 cornuti in *S. phasidaria afghana*; 8 cornuti in *S. centralis*; vesica with two groups of cornuti, with a total amount of up to 25 spines in *S. sociaria*) (figs 27–28, 34–36). *Female genitalia* (figs 38–40). Apophyses anteriores about half the length of apophyses posteriores (similar in *S. sociaria*). Ductus bursae sclerotized, short and wide, with longitudinal foldings (wide and sclerotized, hardly any longitudinal foldings in *S. sociaria*). Corpus bursae, posteriorly sclerotized, anteriorly membranous (membranous in *S. sociaria*). Signum irregularly star-shaped (similar in *S. sociaria*, see fig. 37b).

Phenology. Investigated specimens collected from May to September, suggesting that this species has more than one generation per year.

Biology. Larva feeding on Apiaceae and Fabaceae (e.g. *Trifolium* sp.) (Wehrli 1954).

Habitat. In altitudes from 1100 up to 3750 m.

Distribution. Anatolian-Iranian, from eastern Turkey and southern Armenia, to western, northern and south-eastern Iran. In Afghanistan rarely recorded, occurrence so far restricted to the type locality of the subspecies *S. phasidaria afghana* (see fig. 42).

Genetic data. BIN: BOLD:AAC8929 (n=25). Nearest species: *S. sociaria* at a distance of only 3.5 %, which underpins the close phylogenetic relationship and thus the synonymy of *Synopsidia* with *Synopsia*.

Genetic distance of *Synopsia* (sensu lato) from species of Palearctic related genera is much larger, i.e. *Hypoxystis* (represented by *pluviaria*) (7.1 %), *Chariaspilates* (represented by *formosaria*) (8.8 %), *Angerona* (represented by *prunaria*) (8.9 %), *Siona* (represented by *lineata*) (8.9 %) (fig. 41).

Synopsia phasidaria afghana **(Wiltshire, 1966) comb. nov.**
(figs 23, 24, 34, 42)

Synopsidia phasidaria afghana Wiltshire, 1966. Zeitschrift der Wiener Entomologischen Gesellschaft, 51, 145. Holotype ♂ (NHMV). This subspecies is regarded valid at subspecific rank. Due to the lack of material from this region, a further examination in the present study is not possible, and we recommend a more detailed study with a larger series of specimens.

Type material examined. *Synopsidia phasidaria afghana*: Holotype, ♂, 17.vi.1965, 40km SW von Kabul, 2300 m, Afghanistan, Kasy & Vartian; Paratype, 1 ♂, same locality, Kasy & Vartian, g.prep. WW. 216; all in NHMV (fig. 23).

Diagnosis. *Wings and body* (figs 23, 24). Wingspan ♂ 27–35 mm, ♀ 36–41 mm (Wiltshire 1966). Ground colour of wings sandy yellow with some brown and orange spots (bright beige to brown and rarely similar forms in *S. phasidaria phasidaria* and *S. centralis*; beige to brown, spotted dark in *S. sociaria*). Transverse lines brown (faint or slightly visible in *S. phasidaria phasidaria*; brown in *S. centralis*; strongly black in *S. sociaria*) (figs 5–22, 25, 26).

Male genitalia (fig. 34). Uncus sclerotized, tip concave (sclerotized, slightly bifurcate or tip only concave in the centre in *S. phasidaria phasidaria* and *S. centralis*; sclerotized and strongly bifurcate in *S. sociaria*). Gnathos well developed, arms fused, forming a tongue-shaped upturned thin plate (similar but upturned plate variable in shape in *S. phasidaria phasidaria* and *S. centralis*; almost similar but upturned plate broad in *S. sociaria*). Costa of valva with central projection bearing one to three spines (similar in *S. phasidaria phasidaria*; without central projection in *S. centralis*; central projection bearing one or two spines in *S. sociaria*). Harpe sickle-shaped (similar in *S. phasidaria phasidaria*; thumb-shaped in *S. centralis*; without any harpe in *S. sociaria*). Aedeagus thick, bearing 5–6 cornuti (number of cornuti variable, from 4 to 8 in *S. phasidaria phasidaria*; 8 cornuti in *S. centralis*; vesica with two groups of cornuti, with a total amount of up to 25 spines in *S. sociaria*) (fig. 27–33, 35, 36).

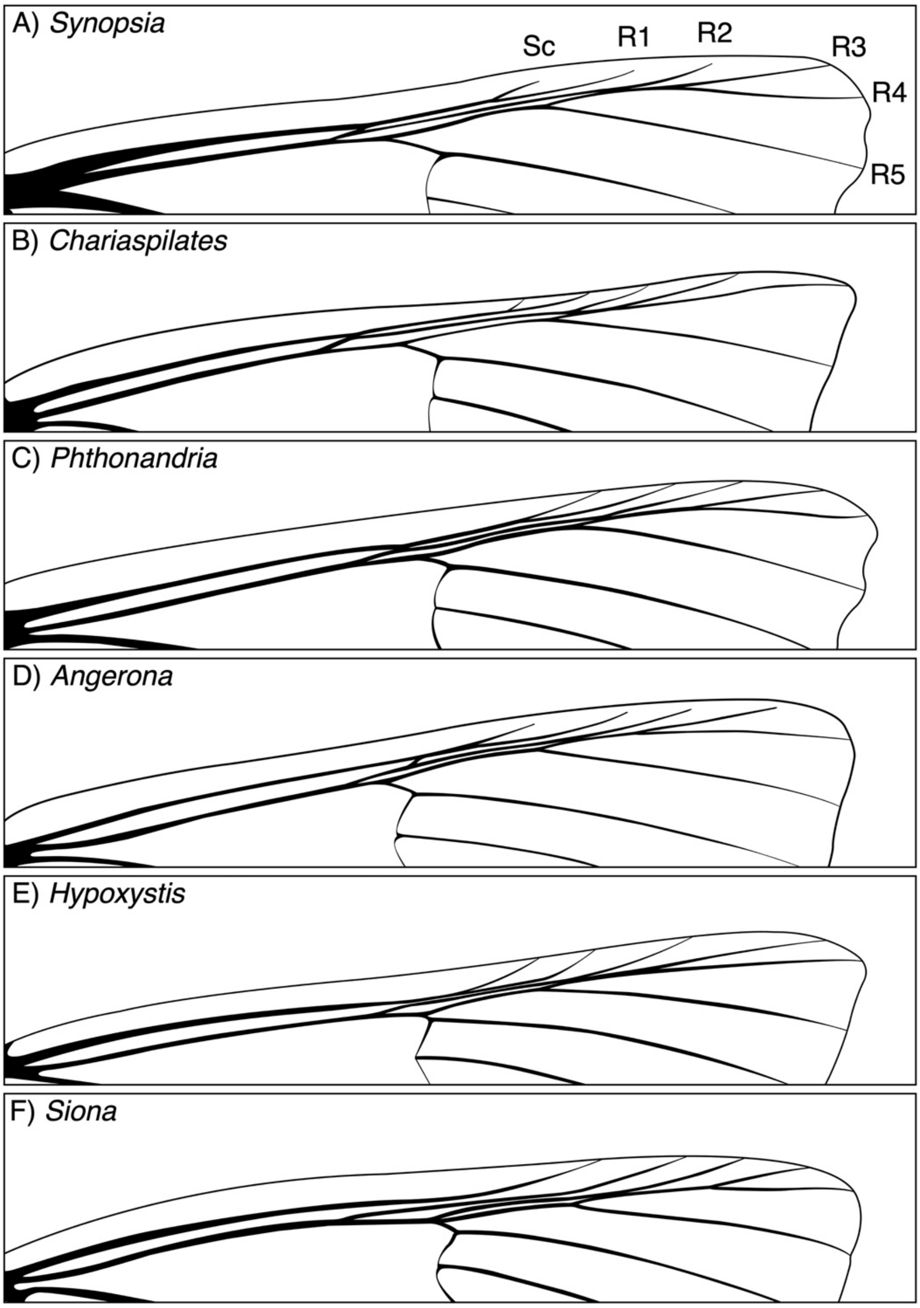
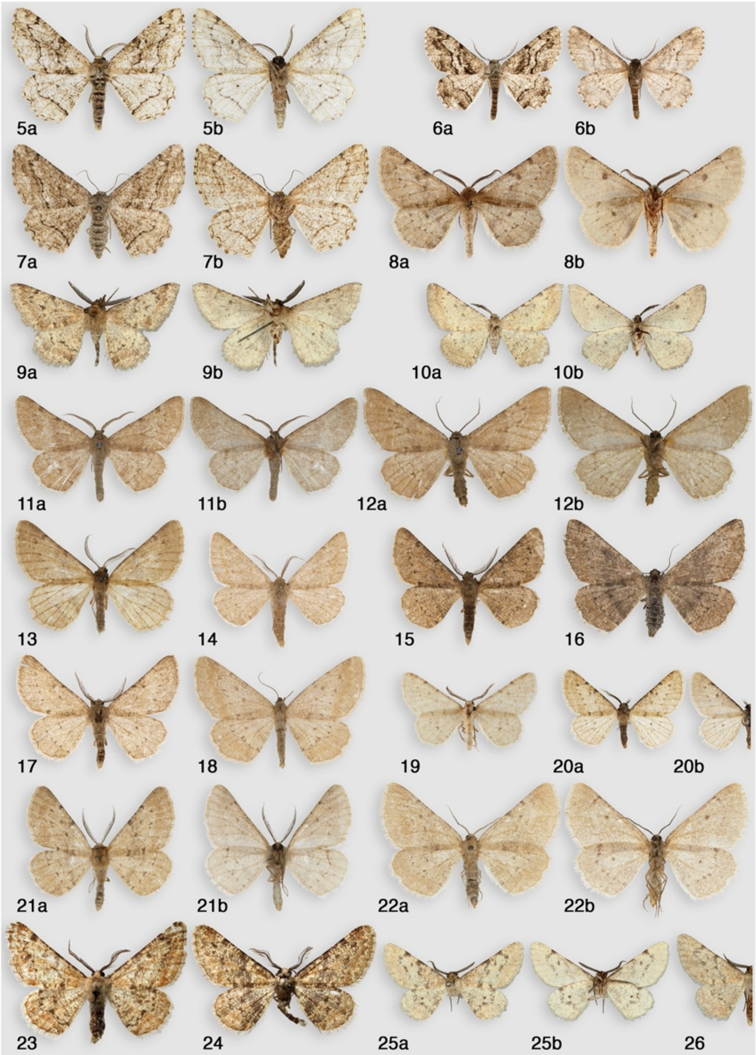
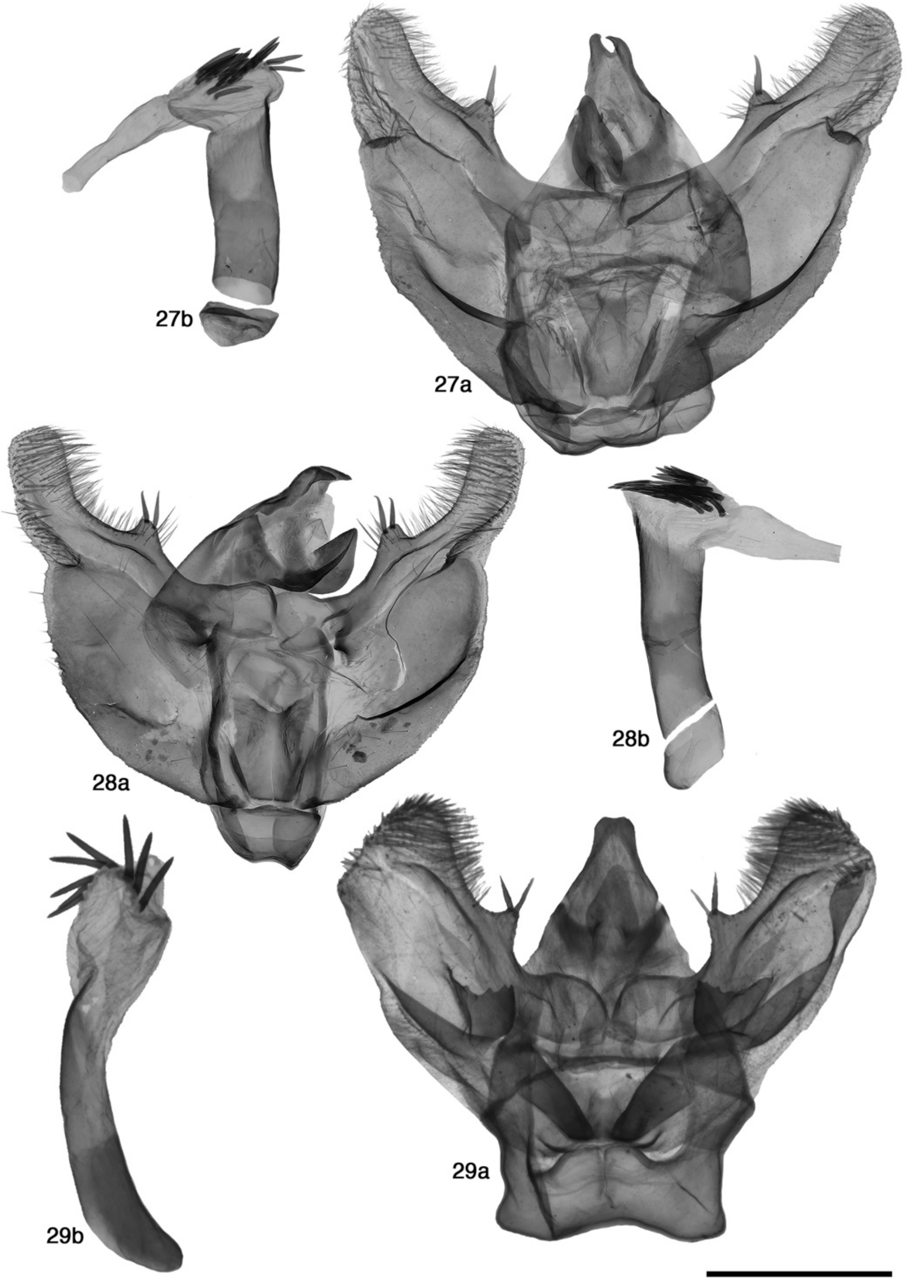


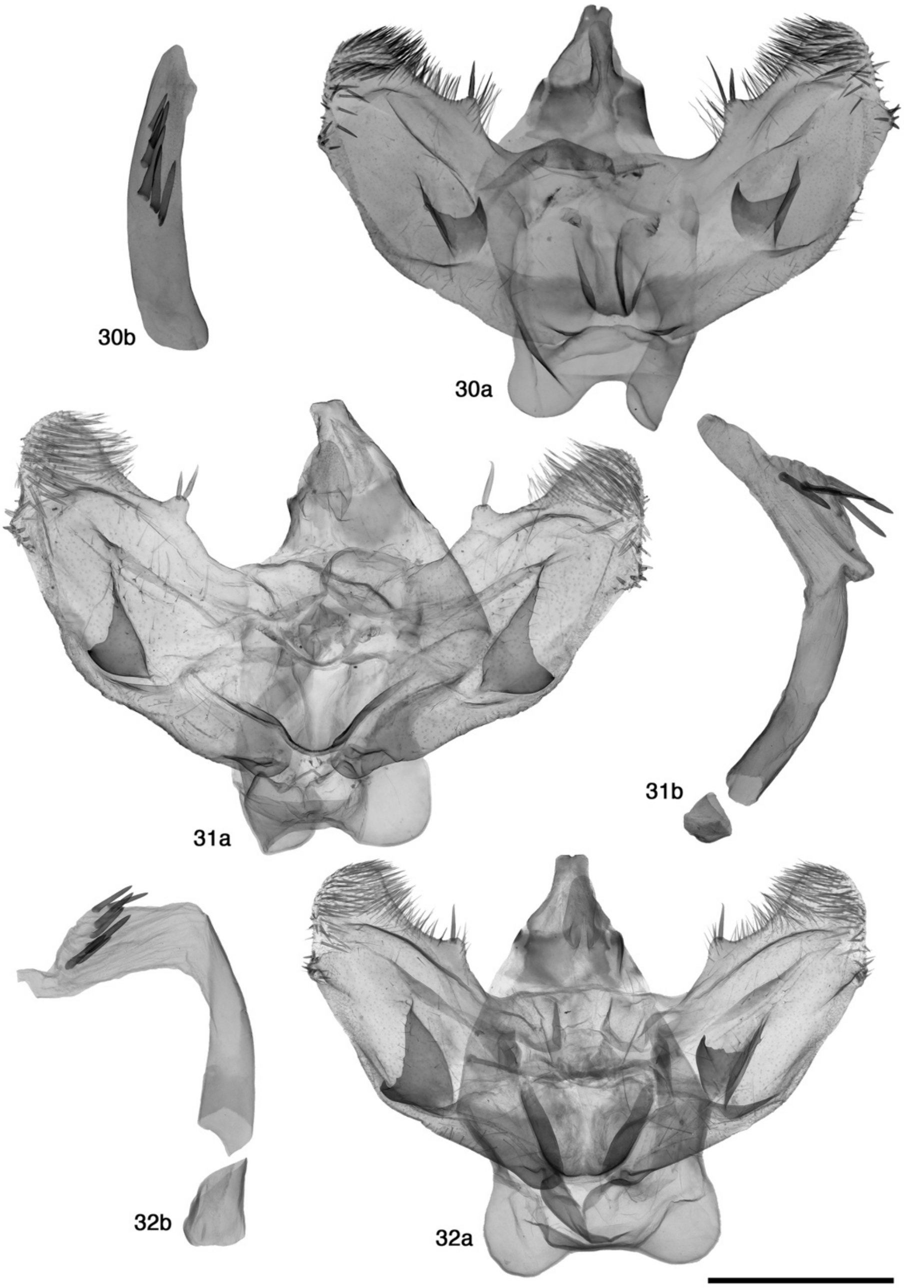
FIGURE 4. Comparison of the forewing venation of *Synopsia* and related genera. (Species taken for drawing: A: *Synopsia sociaria*; B: *Chariaspilates formosaria*; C: *Phthonandria atrilineata indica*; D: *Angerona prunaria*; E: *Hypoxystis pluviaria*; F: *Siona lineata*).



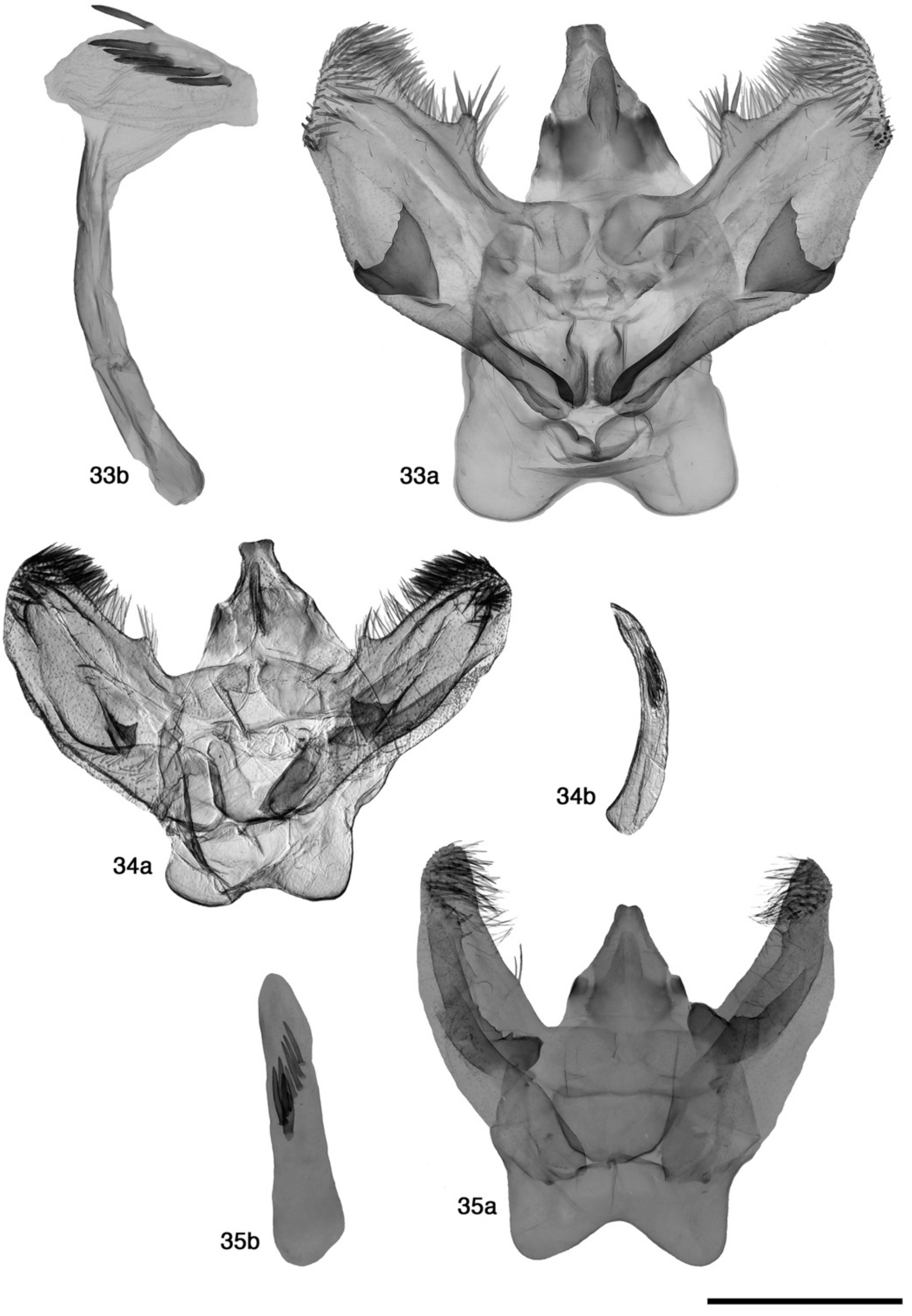
FIGURES 5–26. Wing pattern of *Synopsia* species. 5-7: *S. sociaria* (5: France, Le Meés; 6: Armenia, Syunik, g.prep. 0230/2019 D. Wanke; 7: Italy, Naturns, g.prep. 0497/2019 D. Wanke); 8-22: Nominotypical subspecies; 8: Paratype of *Synopsia phasidaria ardschira* **syn. nov.** of *Synopsia phasidaria phasidaria* (Iran, Fars, g.prep. 11026); 9: Holotype of *Synopsia phasidaria alvandi* **syn. nov.** of *Synopsia phasidaria phasidaria* (Iran, Alvand, g.prep. EP Wiltshire 1470, NHMUK 010920110); 10: Holotype of *Synopsia phasidaria jodes* **syn. nov.** of *Synopsia phasidaria phasidaria* (Iran, Demawend, g.prep. 7100, NHMUK 014172449); 11: Holotype of *Synopsia phasidaria mirabica* **syn. nov.** of *Synopsia phasidaria phasidaria* (Iran, Kuh i Mirabi, g.prep. 0501/2020 D. Wanke); 12: Paratype of *Synopsia phasidaria mirabica* **syn. nov.** of *Synopsia phasidaria phasidaria* (Iran, Kuh i Mirabi, g.prep. 0502/2020 D. Wanke); 13-22: *Synopsia phasidaria phasidaria* **comb. nov.** (13: Turkey, Hakkari, g.prep. 0466/2019 D. Wanke; 14: Armenia, Yeranos, g.prep. 0381/2019 D. Wanke; 15: Iran, Zanjan, g.prep. 0106/2018 D. Wanke; 16: Iran, Zanjan, g.prep. 0477/2019 D. Wanke; 17: Iran, Zanjan, g.prep. 0105/2018 D. Wanke; 18: Iran, Tehran, g.prep. 0472/2019 D. Wanke; 19: Iran, Fars, Sine Sefid, g.prep. 11027 [no type specimen of *Synopsidia phasidaria chiraza* was traced in the collection of Brandt, except this specimen labeled as *Synopsidia phasidaria chiraza* by Brandt]; 20: Iran, Yasuj, g.prep. 0485/2019 D. Wanke; 21: Iran, Golestan, g.prep. 0483/2019 D. Wanke; 22: Iran, Lorestan, g.prep. 0478/2019 D. Wanke); 23: Holotype of *Synopsia phasidaria afghana* **comb. nov.** (Afghanistan, Kabul); 24: Paratype of *Synopsia phasidaria afghana* **comb. nov.** (Afghanistan, Kabul, g.prep. WW216); 25: Holotype of *Synopsia centralis* **bona sp.** (Iran, Fars, g.prep. EP Wiltshire 1467, NHMUK 010920114); 26: *Synopsia centralis* **bona sp.** (Iran, Fars, NHMUK 014172450); a = upperside; b = underside. Scale-bar 1cm.



FIGURES 27–29. Male genitalia of *Synopsia* species. 27: *Synopsia sociaria* (Kazakhstan, NE Rudnichnyy, g.prep. 0103/2018 D. Wanke); 28: *Synopsia sociaria* (Armenia, Syunik, g.prep. 0230/2019 D. Wanke); 29: Paratype of *Synopsia phasidaria ardschira* **syn. nov.** of *Synopsia phasidaria phasidaria* (Iran, Fars, g.prep. 11026); a = genitalia capsule; b = aedeagus. Scale-bar 1 mm.



FIGURES 30–32. Male genitalia of *Synopsia* species. 30: Holotype of *Synopsia phasidaria alvandi* **syn. nov.** of *Synopsia phasidaria phasidaria* (Iran, Alvand, g.prep. EP Wiltshire 1470, NHMUK 010920110); 31: Holotype of *Synopsia phasidaria mirabica* **syn. nov.** of *Synopsia phasidaria phasidaria* (Iran, Kuh i Mirabi, g.prep. 0501/2020 D. Wanke); 32: *Synopsia phasidaria phasidaria* **comb. nov.** (Iran, Zanjan, g.prep. 0106/2018 D. Wanke); a = genitalia capsule; b = aedeagus. Scale-bar 1 mm.



FIGURES 33–35. Male genitalia of *Synopsia* species. 33: *Synopsia phasidaria phasidaria c***omb. nov.** (Turkey, Hakkari, g.prep. 0466/2019 D. Wanke); 34: Paratype of *Synopsia phasidaria afghana* **comb. nov.** (Afghanistan, Kabul, g.prep. WW216); 35: Holotype of *Synopsia centralis* **bona sp.** (Iran, Fars, g.prep. EP Wiltshire 1467); a = genitalia capsule; b = aedeagus. Scale-bar 1mm

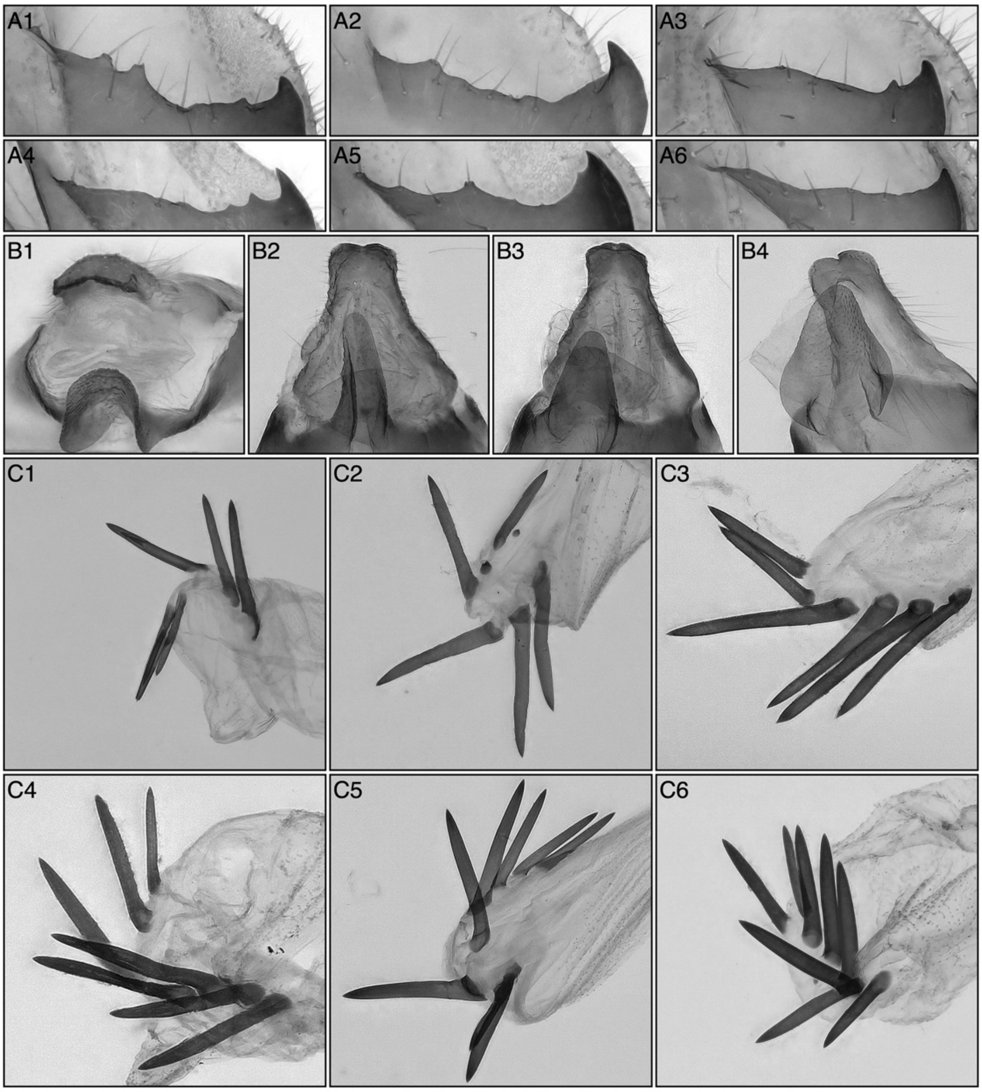


FIGURE 36. Details of the male genitalia capsule and the aedeagus of *Synopsia phasidaria phasidaria* **comb. nov.**, showing the intraspecific variation. A: distal margin of the harpe; B1: gnathos from posterior view; B2-3: gnathos from ventral view, C1-6: cornuti on the vesica.

Female genitalia. Unknown.

Phenology. Type specimens collected in June.

Biology. Unknown.

Habitat. Up to now recorded only at an altitude of 2300 m.

Distribution. So far only known from the type locality in Afghanistan (see fig. 42).

Genetic data. No data available.

***Synopsia centralis* (Wiltshire, 1966) comb nov., bona sp.**
(figs 25, 26, 35, 42)

Synopsidia phasidaria centralis Wiltshire, 1966. Zeitschrift der Wiener Entomologischen Gesellschaft, 51, 146. Holotype ♂ (NHMUK). Hereby combined with genus *Synopsia* and regarded as **bona species** based on morphological examination.

Type material examined. Holotype, ♂, Persia [Iran], N. Fars, Bavant, Kuh Taj Kirmani, 8500 feet [2591 m], 7.viii.[19]50, leg. E.P. Wiltshire, g.prep. E.P. Wiltshire 1467; in NHMUK (fig. 25). Paratype, 1 ♂, same data as Holotype; in NHMUK.

Diagnosis. *Wings and body.* Wingspan ♂ 32 mm (forewing length ♂ 15.5 mm). Ground colour of wings bright beige with some brown spots (similar forms in *S. phasidaria*; beige to brown, spotted dark in *S. sociaria*). Transverse lines present, brown (faint or slightly visible in *S. phasidaria*; strongly black in *S. sociaria*) (figs. 5–24).

Male genitalia (fig. 35). Uncus sclerotized, tip concave (sclerotized, slightly bifurcate or tip only concave in the centre in *S. phasidaria*; sclerotized and strongly bifurcate in *S. sociaria*). Gnathos well developed, arms fused, forming a tongue-shaped upturned plate, variable in shape (similar in *S. phasidaria*; almost similar in *S. sociaria*). Costa of valva without any central projection (central projection present, usually bearing one to three spines in *S. phasidaria*; central projection bearing one to two spines in *S. sociaria*). Harpe thumb-shaped (harpe sickle-shaped *S. phasidaria*; harpe absent in *S. sociaria*). Aedeagus thick, bearing 8 cornuti (number of cornuti variable, from 4 to 8 in *S. phasidaria*; vesica with two groups of cornuti, with a total amount of up to 25 spines in *S. sociaria*) (figs. 27–34, 36).

Female genitalia. Unknown.

Phenology. Specimens (n=2) collected in August.

Biology. Most likely similar to that of *Synopsia phasidaria*.

Habitat. In altitudes up to 2600 m.

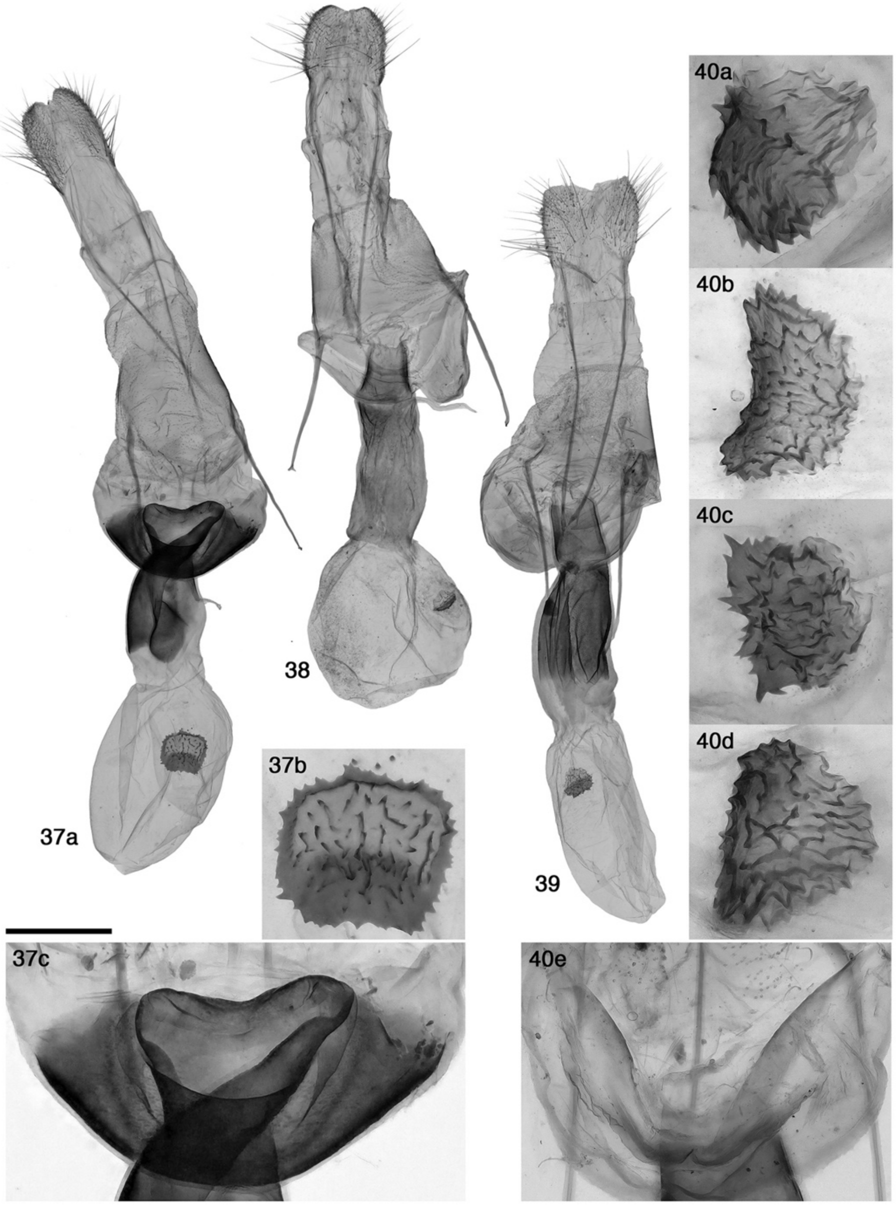
Distribution. So far only known from its type locality in southern Iran (see fig. 42).

Genetic data. No data available.

Taxonomic remarks. *S. centralis* shares similar external and internal character combinations with its sister species, *S. phasidaria*, like wing pattern, shape of the uncus, gnathos and the harpe. Nevertheless, on the costa of valva this species lacks the central projection, which is unique and does not occur in *S. phasidaria phasidaria*. We therefore suggest to treat this taxon as separate species and upgrade it therefore from subspecies to species level. This taxonomic decision needs further examination based on a larger series of specimens to be confirmed.

Complete checklist of the taxa of *Synopsia* with taxonomic changes in this paper
(Distribution data for European species taken from Müller *et al*. 2019):

Synopsia sociaria (from Europe to southern Ural Mountains, in Middle East and Central Asia)
Synopsia phasidaria phasidaria **comb. nov.** (eastern Turkey, southern Armenia, Azerbaijan, northern, western and southern Iran, southern Turkmenistan)
phasidaria tekkearia **syn. rev.**
phasidaria znojkoi **syn. rev.**
phasidaria alvandi **syn. nov.**
phasidaria ardschira **syn. nov.**
phasidaria chiraza **syn. nov.**
phasidaria jodes **syn. nov.**
phasidaria mirabica **syn. nov.**
Synopsia phasidaria afghana **comb. nov.** (Afghanistan: Kabul)
Synopsia centralis **comb. nov.**, **bona sp.** (Iran: Fars)



FIGURES 37–40. Female genitalia and details characters of *Synopsia* species. 37: *Synopsia sociaria* (Italy, Naturns, g.prep. 0497/2019 D. Wanke; a: genitalia; b: signum; c: lamella antevaginalis); 38: Paratype of *Synopsia phasidaria mirabica* **syn. nov.** of *Synopsia phasidaria phasidaria* (Iran, Kuh i Mirabi, g.prep. 0502/2020 D. Wanke); 39: *Synopsia phasidaria phasidaria* **comb. nov.** (Iran, Azerbaijan-e-Gharbi, g.prep. 0299/2019 D. Wanke); 40a-d: signum of *Synopsia phasidaria phasidaria* **comb. nov.** showing the intraspecific variation (a: Turkey, Hakkari, g.prep. 0468/2019 D. Wanke; b: Iran, Lorestan, g.prep. 0478/2019 D. Wanke; c: Iran, Zanjan, g.prep. 0477/2019 D. Wanke; d: Iran, Yasuj, g.prep. 0486/2019 D. Wanke); 40e: lamella antevaginalis of *Synopsia phasidaria phasidaria* **comb. nov.** (Iran, Kendevan, g.prep. 0474/2019 D. Wanke). 37b-c and 40 out of scale. Scale-bar 1mm

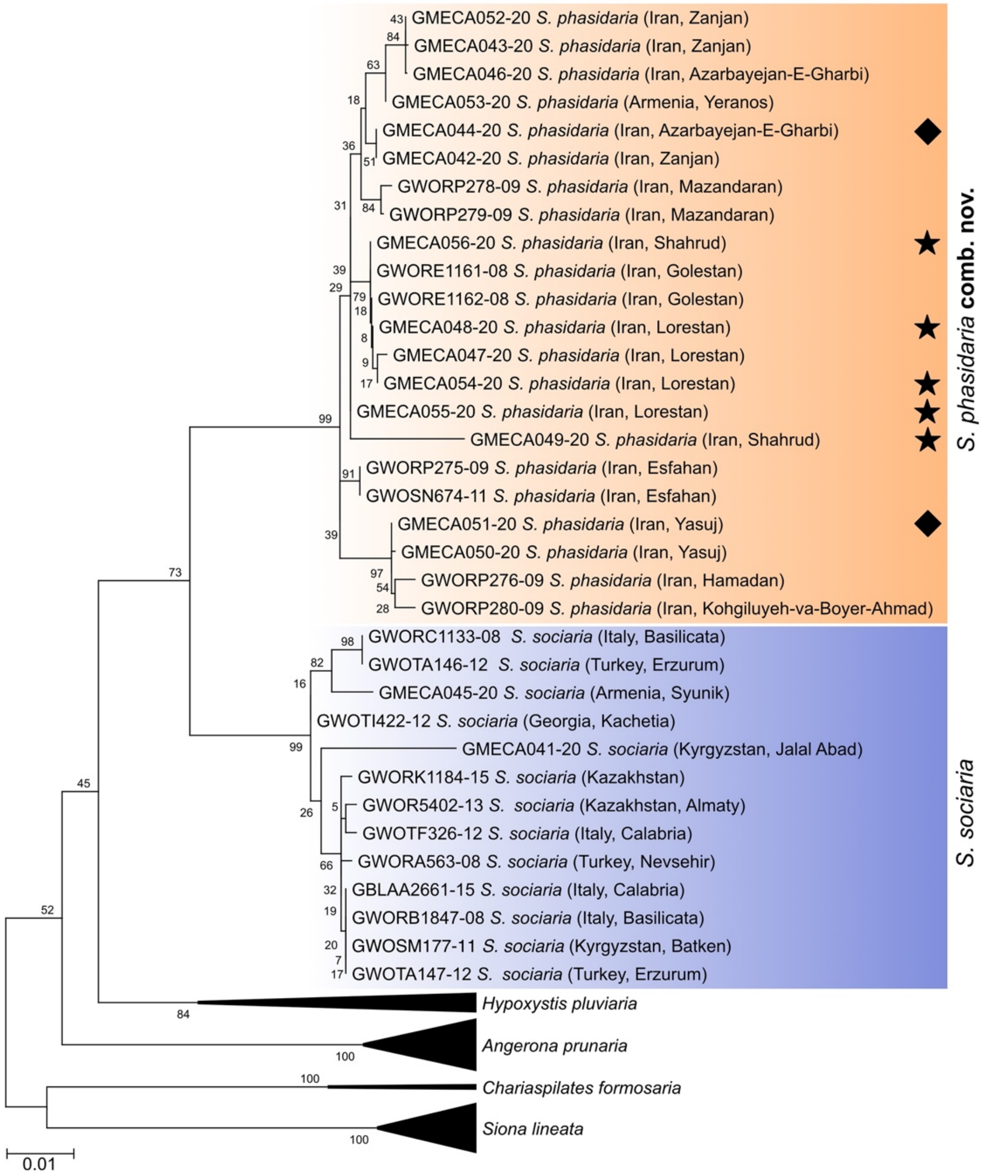


FIGURE 41. Maximum likelihood analysis of the two *Synopsia* species and 4 closely related genera (*Chariaspilates, Angerona, Hypoxystis, Siona*) based on COI 5' sequences (built with MEGA X; Kimura 2-parameter model; bootstrap method, 1000 replications). Symbols in *S. phasidaria*: Stars indicating on females with strongly bipectinate antennae; diamonds indicating on females with shortly bipectinate antennae.

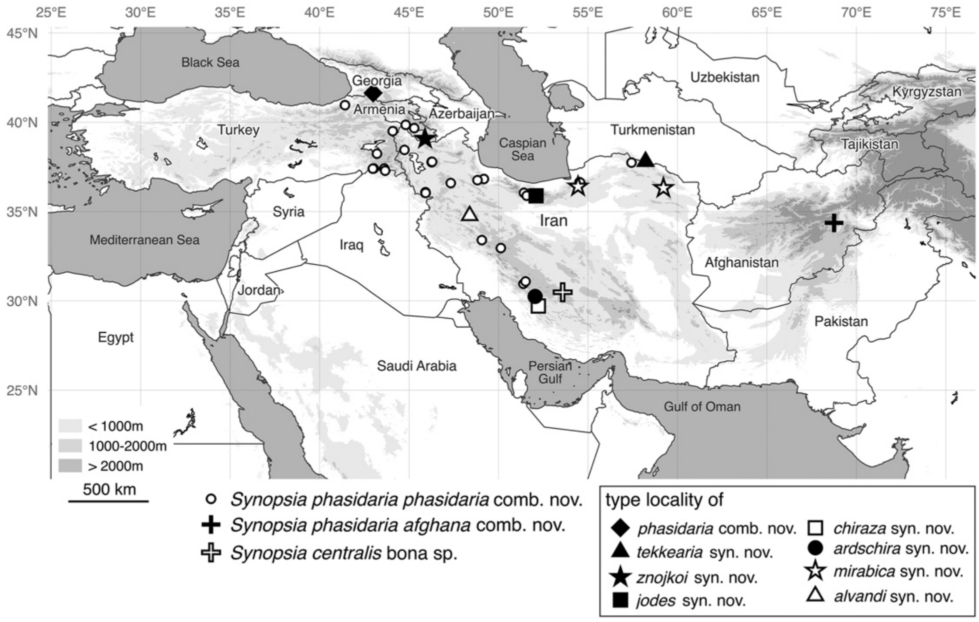


FIGURE 42. Map of *Synopsia phasidaria phasidaria* **comb. nov.**, *Synopsia phasidaria afghana* **comb. nov.** and *Synopsia centralis* **bona sp.** showing the distribution of these taxa. Different symbols illustrated in the rectangle indicating on the type localities of the subspecies of *Synopsia phasidaria phasidaria* **comb. nov.**.

Acknowledgements

We would like to express our sincere thanks to Peder Skou (Vester Skerninge, Denmark), Jörg-Uwe Meineke (Kippenheim, Germany), Michael Falkenberg and Robert Trusch (both Staatliches Museum für Naturkunde Karlsruhe, Germany) and Marianne Espeland (Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany) for the loan of valuable specimens from their collections. Many thanks to Geoff Martin, Phaedra Kokkini and David Lees (Natural History Museum London, UK) for the photography of detailed photos of *Synopsidia phasidaria alvandi*, *S. phasidaria centralis* and *S. phasidaria jodes* (the copyright of these images belong to the Trustees of the Natural History Museum, London, and made available under the Creative Commons License 4.0 (https://creativecommons.org/licenses/by/4.0/)). Also, we thank Sabine Gaal-Haszler (Natural History Museum Vienna) for the photography of the type material and genitalia slides of *S. phasidaria afghana*. Thanks to Antoine Leveque, Andreas Segerer, Xue Dayong, Marco Infusino, Iva Mihoci, Jörg Gelbrecht, Norbert Poell and Bernd Müller for sharing several barcodes used in this project. Many thanks to Christina Gasco Martin and Susanne Leidenroth for assisting the first author by the SEM-imaging. We deeply thank László Rákosy and a second anonymous reviewer, as well as Reza Zahiri (editor of Zootaxa) for their valuable comments on the submitted version of this paper. This project was partially supported by the Research Incentive Grant of State Museum of Natural History, Stuttgart, Germany. This paper is part of the PhD project of Dominic Wanke at the University of Hohenheim.

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APPENDIX TABLE. Sequenced specimens of *Angerona prunaria*, *Chariaspilates formosaria*, *Hypoxystis pluviaria*, *Siona lineata*, *Synopsia sociaria*, *Synopsia phasidaria* **comb. nov.** with identification, sampling site and process ID in the Barcode of Life Data Systems (BOLD). Tissue provided or data generated by: Axel Hausmann(1); Antoine Leveque(2); Andreas Segerer(3); Xue Dayong(4); Claude Herbulot(5); Marco Infusino(6); Iva Mihoci(7); Jörg Gelbrecht(8); Norbert Poell(9); Bernd Müller(10); Wanke *et al*. (current paper)(11).

Taxon Identification	**Sampling Site**	**Process ID**
***Angerona prunaria*(1)**	China, Hebei, Chongli, Baiqi, 23.vi.2006, C. Wang	GWORD877-08
***Angerona prunaria*(1)**	China, Hebei, Chongli, Baiqi, 22.vi.2006, C. Wang	GWORD941-08
***Angerona prunaria*(1)**	China, Hebei, Chongli, Shizigou, 16.vii.2007, C. Wang	GWORB2683-08
***Angerona prunaria*(1)**	China, Hebei, Chongli, Shizigou, 16.vi.2007, C. Wang	GWORB2705-08
***Angerona prunaria*(2)**	France, Hauts-de-France, Picardy, Oise, Marolles (Marais de Bourneville), 17.vi.2005, Jerome Barbut & Jeremy Lebrun	GWOAL011-08
***Angerona prunaria*(2)**	France, Hauts-de-France, Picardy, Oise, Verberie (Le Murger), 06.vii.2003, Jerome Barbut	GWOAL012-08
***Angerona prunaria*(2)**	France, Centre-Val de Loire, Centre, Loiret, Vitry-aux-Loges (Foret d Orleans, Carrefour du Sanglier), 10.vi.2006, Antoine Leveque	GWOAL013-08
***Angerona prunaria*(2)**	France, Centre-Val de Loire, Centre, Loiret, Vitry-aux-Loges (Foret d Orleans, Carrefour de Nestin), 27.v.2005, Antoine Leveque	GWOAL015-08
***Angerona prunaria*(3)**	Germany, Bavaria, south, Berchtesgadener Land, Melleck—Steinbach-tal, 13.vi.1998, A. Segerer	GWORB2980-08
***Angerona prunaria*(1)**	Germany, Bavaria, Upper Bavaria, Schlagenhofen a. Woerthsee, 31.iii.2007, Karl Ambil	GWOR4048-09
***Angerona prunaria*(3)**	Germany, Bavaria, Niederbayern, Landshut, Niederaichbach, 24.v.2009, Dr. Theo Gruenewald	FBLMT431-09
***Angerona prunaria*(1)**	Russia, Altayskiy Kray, Altai Shebalino, 30.vi.1993, Dirgela	GWOSK704-11
***Angerona prunaria*(1)**	Russia, Altayskiy Kray, Altai, Ulagan district, Chibit, 09.viii.2009, R. Yakovlev	GWOSU251-11
***Angerona prunaria*(1)**	Germany, Brandenburg, Dahme-Spreewald, Mittenwalde, Toepchin, 28.vi.2012, Franz Theimer	GBLAB088-13
***Angerona prunaria*(1)**	Germany, Saarland, Rubenheim, NSG Hanickel, 25.v.2012, A. Werno	GBLAB803-13
***Angerona prunaria*(4)**	China, Beijing Shi, Donglingshan, Xiaolongmen, 28.vi.2011, Y. Zou	GWOTL900-13
***Angerona prunaria*(1)**	Germany, Thuringia, Bad Blankenburg, Schwarzatal, Schieferbrueche, 07.vii.2013, S. Erlacher	GBLAC260-13
***Angerona prunaria*(1)**	Germany, Bavaria, Oberbayern, Haag, Schachenwald, 22.vii.2013, O. Hawlitschek	GBLAC640-13

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APPENDIX TABLE . (Continued)

Taxon Identification	**Sampling Site**	**Process ID**
Angerona prunaria[1]	Germany, Saxony, Koenigsbrueck, Altes Dorf, 16.vii.2013, S. Erlacher	GBLAD112-14
Angerona prunaria[1]	Germany, Brandenburg, Oberhavel, Kreuzbruch, Umgebung Roemerwegbruecke, 19.vi.2012, Rainer & Uljana Busse	GBLAF206-14
Angerona prunaria[1]	Germany, Rhineland-Palatinate, Fellerbachtal, 30.v.2011, V. Gayk	GBLAA857-14
Angerona prunaria[1]	Germany, Rhineland-Palatinate, Fellerbachtal, 31.v.2011, V. Gayk	GBLAA858-14
Chariaspilates formosaria[1]	Liechtenstein, Schaan, Aescher/Schwabbruennen, 14.vi.2000, U. Aistleitner	GWORK451-09
Chariaspilates formosaria[5]	Russia, Primorskiy Kray, Vladivostok dist.20, Nachodka, 31.vii.1994, Kuzneooy	GWOST761-11
Hypoxystis pluviaria[1]	Germany, Bavaria, Oberbayern, Isar-Muendungsdelta am Sylvensteinsee, 19.v.2004, Schacht	GWORL454-09
Hypoxystis pluviaria[1]	Germany, Bavaria, Oberbayern, Isar-Muendungsdelta am Sylvensteinsee, 19.v.2004, Schacht	GWORL455-09
Hypoxystis pluviaria[1]	Germany, Bavaria, Oberbayern, Berchtesgadener Land, Ramsau bei Berchtesgaden, Klausbachtal, 09.vi.2004, A. Haslberger	GWORE2199-09
Hypoxystis pluviaria[1]	Germany, Bavaria, Oberbayern, Bad Toelz-Wolfratshausen, Vorderriss, 24.v.2010, M. Seizmair	GWOSK877-11
Hypoxystis pluviaria[1]	Russia, Tyva Republic, Tuva, south, 12 km Khol-Oozku, 31.v.2010, R. Yakovlev	GWOSU274-11
Hypoxystis pluviaria[1]	Russia, Kemerovskaya Oblast, 35 km SW Mariinsk, 07.vi.2009, R. Yakovlev	GWOSU279-11
Hypoxystis pluviaria[1]	Romania, Transylvania, Voslabeni, 12.vii.2012, Z. Varga	GBLAC218-13
Siona lineata[3]	Germany, Bavaria, centr, Regensburg, Regensburg—Matting-Bhf, 26.v.2000, A. Segerer	GWORB2990-08
Siona lineata[1]	Germany, Bavaria, Oberbayern, Muenchen—Allach, 30.vi.2003, K. Ambil	GWORL467-09
Siona lineata[6]	Italy, Sicily, Bosco di Malabotta, 06.vi.2008, M. Infusino	GWORL909-09
Siona lineata[6]	Italy, Sicily, Bosco di Malabotta, 06.vi.2008, M. Infusino	GWORL910-09
Siona lineata[1]	Germany, Bavaria, Oberbayern, Muenchen—Allach, 25.v.2002, K. Ambil	GWORE2015-09
Siona lineata[1]	Croatia, Primorje-Gorski Kotar, Rijeka, Rijeka, Bribir, 10.vi.2001, A. Haslberger	GWORM213-09
Siona lineata[3]	Germany, Bavaria, Niederbayern, Kelheim, Kelheim, Lehnberg, 23.v.2009, Dr. Theo Gruenewald	FBLMT408-09
Siona lineata[7]	Croatia, Medjimurska, Medjimurje, Jurovcak, 20.v.2005, F. Perovic	GWOSI056-10
Siona lineata[1]	Russia, Altayskiy Kray, Altai Shebalino, 30.vi.1993, Dirgela	GWOSK702-11
Siona lineata[1]	Kazakhstan, Tarbagatai District, Zhagalbaily Mts., 18.v.2006, R.Yakovlev	GWOSQ460-11
Siona lineata[1]	Germany, Brandenburg, Spree-Neisse, Neuhausen/Spree, Kathlow/ Umgebung, 26.v.2012, Franz Theimer	GBLAB210-13
Siona lineata[1]	Germany, Saarland, Huettersdorf, 22.v.2011, N. Zahm	GBLAC090-13
Siona lineata[1]	Germany, Saarland, Huettersdorf, 24.v.2011, N. Zahm	GBLAC091-13
Siona lineata[1]	Germany, Thuringia, Koenigssee, Unterkoeditz, 08.vi.2013, B. Kirchner	GBLAD271-14

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APPENDIX TABLE . (Continued)

Taxon Identification	**Sampling Site**	**Process ID**
Siona lineata[(1)]	Germany, Brandenburg, Teltow-Flaeming, Ludwigsfelde, 07.vi.2013, F. Theimer	GBLAF717-14
Siona lineata[(1)]	Russia, Orenburgskaya Oblast, Kuvandyksky, South Ural Mountains, Kuvandyk town, 14.v.2012	GBLAD1070-14
Siona lineata[(1)]	Kyrgyzstan, Chuy, Kirghizsky Mts., Arashan settlement, 25.v.2014, S. Korb	GWOTO767-15
Siona lineata[(1)]	Germany, Brandenburg, Oberhavel, Roehmerwegbruecke, 08.vi.2014, R. Busse, U. Busse	GBLAA2317-15
Siona lineata[(1)]	Italy, Calabria, Cosenza, 6 km S Cosenza, Pianette di Dipignano, 01.vi.2015, G. Posa	GBLAA2676-15
Siona lineata[(1)]	Germany, Berlin, Marienfelde (Sued), NSG auf ehemaliger Deponie, 25.v.2014, J. Gelbrecht & E. Schwabe	GBLAA2780-15
Siona lineata[(1)]	Germany, Berlin, Marienfelde ehemaliger TUEP am suedlichen Stadtrand, 22.v.2014, J. Gelbrecht	GBLAA2781-15
Synopsia sociaria[(1)]	Italy, Basilicata, Valle Noce Trecchina, 29.viii.2001, A. Hausmann	GWORB1847-08
Synopsia sociaria[(1)]	Italy, Basilicata, Potenza, Valle Noce, Trecchina, 05.vi.1996, A. Hausmann	GWORC1133-08
Synopsia sociaria[(8)]	Turkey, Nevsehir, Ic Anadolu, Kapodokya, Uchisar, 18.vi.1996, J. Gelbrecht, S. Beshkov & T. Drechsel	GWORA563-08
Synopsia sociaria[(9)]	Kyrgyzstan, Prov. Batken, Distr. Batken, Turkestan-Range, Kara-Kol-Valley, 7 km W Kara-Bulak, 12.vi.2010, leg. N. Poell (A-Bad Ischl)	GWOSM177-11
Synopsia sociaria[(10)]	Turkey, Erzurum, Mescit Daglari, Ispir, Tshoru valley, 12.vi.2003, B. Mueller	GWOTA146-12
Synopsia sociaria[(10)]	Turkey, Erzurum, Mescit Daglari, Ispir, Tshoru valley, 13.vi.2003, B. Mueller	GWOTA147-12
Synopsia sociaria[(1)]	Italy, Calabria, M. Pollino, 3 km N Civita, 30.viii.2011, A. Hausmann	GWOTF326-12
Synopsia sociaria[(1)]	Georgia, Kachetia, David Gazeta, M. Franzen	GWOTI422-12
Synopsia sociaria[(1)]	Kazakhstan, Almaty, Tien Shan, Nurly, 27.iv.2010, G. Nazymbetova	GWOR5402-13
Synopsia sociaria[(1)]	Italy, Calabria, Cosenza, 6 km S Cosenza, Pianette di Dipignano, 01.v.2015, G. Posa	GBLAA2661-15
Synopsia sociaria[(1)]	Kazakhstan, Tarbagatai m.r.-S Urdzhar, 21.vii.1993, A. Berg	GWORK1184-15
Synopsia sociaria[(11)]	Kyrgyzstan, Jalal Abad, Chatkal Valley, Kanysh-Kija, 16.vi.2014, D. Bartsch	GMECA041-20
Synopsia sociaria[(11)]	Armenia, Sy Syunik prov, north of Shvanidzor, 17.vii.2013, D. Bartsch	GMECA045-20
***Synopsia phasidaria* comb. nov.**[(9)]	Iran, Golestan, Golestan National Park, Maghazy Valley, 25 km SW Gorgan, 13.vi.2007, N. Poell	GWORE1161-08
***Synopsia phasidaria* comb. nov.**[(9)]	Iran, Golestan, Golestan National Park, Maghazy Valley, 25 km SW Gorgan, 13.vi.2007, N. Poell	GWORE1162-08
***Synopsia phasidaria* comb. nov.**[(1)]	Iran, Esfahan, Kuhha-ye-Zagros, Fereidun Sahr, 27.vi.2005, Petranyi G.	GWORP275-09
***Synopsia phasidaria* comb. nov.**[(1)]	Iran, Hamadan, Kuhha-ye-Zagros, Nehavand, 26.vi.2005, Petranyi G.	GWORP276-09
***Synopsia phasidaria* comb. nov.**[(1)]	Iran, Mazandaran, Resteh-Ye-Elborz, Minokh, Baladeh Valley, 18.vi.2007, Hacz T.—Nadai L.	GWORP278-09

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APPENDIX TABLE . (Continued)

Taxon Identification	**Sampling Site**	**Process ID**
***Synopsia phasidaria* comb. nov.** [(1)]	Iran, Mazandaran, Resteh-Ye-Elborz, Minokh, Baladeh Valley, 18.vi.2007, Hacz T.—Nadai L.	GWORP279-09
***Synopsia phasidaria* comb. nov.** [(1)]	Iran, Boyer Ahmadi-e Kohkiluyeh, Kuhha-ye-Zagros, Kuh-e-Dinar, 15km N of Vazag, 12.vi.2007, Hacz T.—Nadai L.	GWORP280-09
***Synopsia phasidaria* comb. nov.** [(1)]	Iran, Esfahan, Zagros, Fergidun Shar, 17.vi.2010, B. Benedek, T. Hacz	GWOSN674-11
***Synopsia phasidaria* comb. nov.** [(11)]	Iran, Lorestan, Dorud, Astaneh door, 25.vii.2016, Sh. Feizpour	GMECA047-20
***Synopsia phasidaria* comb. nov.**[(11)]	Iran, Zanjan prov., E Zanjan, road to Gilvan, 6.vii.2013, H. Rajaei, J.-U. Meineke, B. Hafezi	GMECA042-20
***Synopsia phasidaria* comb. nov.**[(11)]	Iran, Azerbaijan-e Gharbi prov., Khoy to Ghotur road, Esteran vill., 1.vii.2013, J.-U. Meineke, H. Rajaei, B. Hafezi	GMECA044-20
***Synopsia phasidaria* comb. nov.** [(11)]	Republic Armenia, Yeranos Mts., Dvin village suburbs, Arat district, 11.vi.2009, Yuriy Shevnin	GMECA053-20
***Synopsia phasidaria* comb. nov.** [(11)]	Iran, Zanjan prov., E Zanjan, road to Gilvan, 6.vii.2013, H. Rajaei, J.-U. Meineke, B. Hafezi	GMECA052-20
***Synopsia phasidaria* comb. nov.** [(11)]	Iran, Zanjan prov., E Zanjan, road to Gilvan, 6.vii.2013, H. Rajaei, J.-U. Meineke, B. Hafezi	GMECA043-20
***Synopsia phasidaria* comb. nov.** [(11)]	[Iran], Azarbeijan-e Gharbi, Takab, Takht-e soleiman, 1.vii.2013, M. Afsarian	GMECA046-20
***Synopsia phasidaria* comb. nov.** [(11)]	Iran, Kohkiluye va Boyerahmad, yasuj, Sisakht, Dena, 30.vii.2016, Sh. Feizpour	GMECA051-20
***Synopsia phasidaria* comb. nov.** [(11)]	Iran, Kohkiluye va Boyerahmad, yasuj, Sisakht, Dena, 30.vii.2016, Sh. Feizpour	GMECA050-20
***Synopsia phasidaria* comb. nov.** [(11)]	Iran, Lorestan, Dorud, Astaneh door, 25.vii.2016, Sh. Feizpour	GMECA048-20
***Synopsia phasidaria* comb. nov.** [(11)]	Iran, Lorestan, Dorud, Astaneh door, 25.vii.2016, Sh. Feizpour	GMECA054-20
***Synopsia phasidaria* comb. nov.** [(11)]	Iran, Shahrud, Shahkouh, Tash, Ayoub, Hosseini region, 11.vii.2016, Sh. Feizpour	GMECA049-20
***Synopsia phasidaria* comb. nov.** [(11)]	Iran, Shahrud, Shahkouh, Tash, Ayoub, Hosseini region, 11.vii.2016, Sh. Feizpour	GMECA056-20
***Synopsia phasidaria* comb. nov.** [(11)]	Iran, Lorestan, Dorud, Astaneh door, 25.vii.2016, Sh. Feizpour	GMECA055-20

Original research paper 8

Taxonomic note on *Synopsia centralis* (Wiltshire, 1966) (Lepidoptera: Geometridae: Ennominae), and additional faunistic data on the genus *Synopsia* Hübner, 1825 in Iran

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Published (2022) in Integrative Systematics 5 (1): 105–108

https://doi.org/10.18476/2022.556903

Painting of *Synopsia centralis* by Lou Wanke (2 years and 8 months old), outline drawing by Maria Werner.

SHORT COMMUNICATION

Taxonomic note on *Synopsia centralis* (Wiltshire, 1966) (Lepidoptera: Geometridae: Ennominae), and additional faunistic data on the genus *Synopsia* Hübner, 1825 in Iran

Dominic Wanke[1,2] & Hossein Rajaei[1]

Abstract

The taxonomic rank of *Synopsia centralis* (Wiltshire, 1966), recently raised from subspecies to species, is validated through investigation of the paratype. The genitalia of the paratype are illustrated for the first time. Additional faunistic data are given for *Synopsia sociaria* (Hübner, 1899) and *Synopsia phasidaria phasidaria* (Rogenhofer, 1873), extending knowledge on their distribution in Iran.

Keywords: genitalia structure, Gnophini, Middle East, *Synopsidia*.

Zusammenfassung

Der taxonomische Rang von *Synopsia centralis* (Wiltshire, 1966), die kürzlich von Unterart auf Artebene erhoben wurde, wird durch die Untersuchung des Paratypus bestätigt. Die Genitalien des Paratypus werden zum ersten Mal abgebildet. Für *Synopsia sociaria* (Hübner, 1899) und *Synopsia phasidaria phasidaria* (Rogenhofer, 1873) werden zusätzliche faunistische Daten angegeben, die das Wissen über ihre Verbreitung im Iran erweitern.

Synopsia Hübner, 1825 is a small genus including three species, namely *S. sociaria* (Hübner, 1899), *S. phasidaria* (Rogenhofer, 1873)—including the nominotypical subspecies and the subspecies *S. phasidaria afghana* (Wiltshire, 1966)—and *S. centralis* (Wiltshire, 1966) (Scoble & Hausmann 2007; Müller et al. 2019; Wanke et al. 2020). The type species of the genus, *Synopsia sociaria*, is widespread from Portugal to Kazakhstan, whereas *S. phasidaria* is distributed from the Caucasus to Afghanistan and *S. centralis* is endemic to Iran (Müller et al. 2019; Wanke et al. 2020). *Synopsia* species are externally characterized by their beige to brown wings, with light white to grey areas and some brown spots on the wings (Müller et al. 2019; Wanke et al. 2020) (see Figs 1–4). Recently, the genus *Synopsidia* Djakonov, 1935 was synonymized with the genus *Synopsia* Hübner, 1825 by Wanke et al. (2020). Additionally, *Synopsia centralis*, which was originally described as a subspecies of *Synopsidia phasidaria* based on the male holotype and one male paratype collected in the southern Iranian province Fars (Wiltshire 1966), was tentatively raised from subspecies to species rank by Wanke et al. (2020) based on the genitalia morphology of the holotype, which was examined from photographs only. During a recent visit to the Natural History Museum in London, the genitalia preparation of the holotype of *S. phasidaria centralis* was examined together with the paratype, which was dissected to validate the previous decision to elevate this taxon to the rank of species. Furthermore, as distributional data for *S. sociaria* in Iran is only sparse (Barou 1967; Wieser et al. 2002; Lehmann & Zahiri 2011) and specimens from Iran are rather rare in collections, we report the species as new for some Iranian provinces. Finally, the distribution area of *S. phasidaria phasidaria* is extended further to include Southwest Iran.

Material and methods

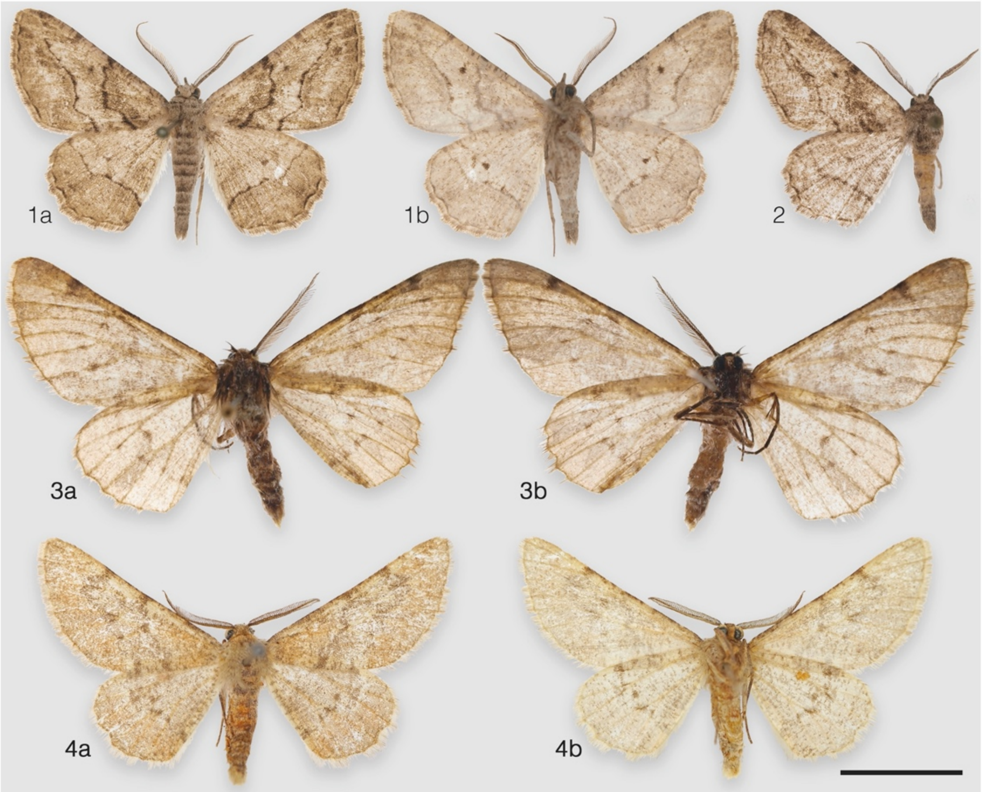
Specimens from the following collections were examined: NHMUK—Natural History Museum London, United Kingdom; PCJM—Private collection of Jörg-Uwe Meineke, Kippenheim, Germany; SMNS—Staatliches Museum für Naturkunde Stuttgart, Germany.

Documentation of external characters was carried out using an Olympus E3 digital camera. For genitalia preparation, standard techniques were followed and the dissected genitalia were embedded in Euparal on permanent microscope slides (Robinson 1976). A Keyence VHX-5000 photomicroscope was used for photography of the slides.

Synopsia sociaria (Hübner, 1899)
(Figs. 1, 2, 5)

Material examined

1 ♂, Iran, Masanderan, Tschamestan, 100 m, viii.1951, leg. F. Schäuffele, g. prep. 1265/2022 D. Wanke; 2 ♂, Nordpersien [Iran], Umg. Shahabad [Golestan] Nationalpark, 1300 m, 21.-



Figs. 1–4. Wing pattern of *Synopsia* Hübner, 1825 species (a = upperside; b = underside). – **1–2**. *S. sociaria* (Hübner, 1899) (1: Iran, Masanderan, g.prep. 1265/2022 D. Wanke; 2: Iran, Golestan, g.prep. 1266/2022 D. Wanke). **3**. *S. phasidaria phasidaria* (Rogenhofer, 1873) (Iran, Kerman, g.prep. 1258/2022 D. Wanke). **4**. Paratype of *Synopsia centralis* (Wiltshire, 1966) (Iran, Fars, NHMUK014172450). Scale bar: 1 cm.

22.viii.1977, [leg.] de Freina, g. prep. 1266/2022 D. Wanke; 1 ♂, NW-Iran, Kaleibar, 1700 m, 3.viii.1977, leg. W. Thomas, g. prep. 1267/2022 D. Wanke; 1 ♂, Iran, Elburs, Valiabad, 1700 m, 14. & 16.viii.1978, leg. W. Thomas; 2 ♂, Iran, Elburs, 15 km S Chalus, 1700 m, 15–18.v.1975, leg. W. Thomas; all in SMNS.

Distribution in Iran

Records of this species from Iran are scarce. So far it is known from three provinces, namely Azerbaijan-e-Sharqi (W Kaleibar, Arasbaran Forest, Al Hord), Esfahan (Esfahan) and Golestan (Tange Gol) (Barou 1967; Wieser et al. 2002; Lehmann & Zahiri 2011). We present additional records for the provinces Azerbaijan-e-Sharqi, Golestan, Mazandaran (first record) and Tehran (first record).

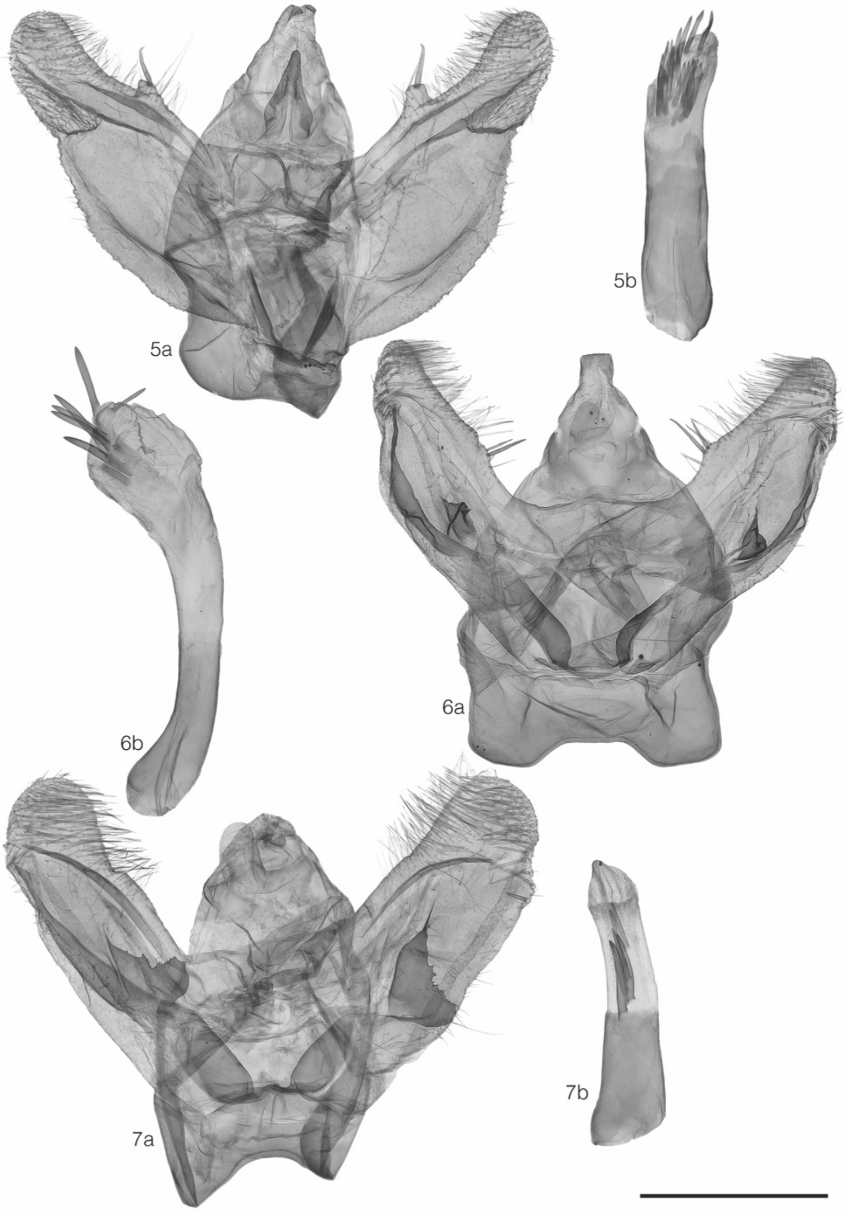
***Synopsia phasidaria phasidaria* (Rogenhofer, 1873)**
(Figs. 3, 6)

Material examined

1 ♂, Iran, Kerman, Rayen SW, Kuh-e Hesar, Abshar, 2700-3000 m, 24./25.v.2004, leg. A. Hofmann, J.-U. Meineke, G. Tremewan, g. prep. 1258/2022 D. Wanke; in PCJM.

Distribution in Iran

Wanke et al. (2020) reported on the distribution of this subspecies from northern Iran to the southern province Fars through the Zargos Mountains in the West. Here, we provide the first record for the southern province of Kerman.



Figs. 5–7. Male genitalia of *Synopsia* Hübner, 1825 species (a = genitalia capsule; b = aedeagus). – **5**. *S. sociaria* (Hübner, 1899) (Iran, Masanderan, g.prep. 1265/2022 D. Wanke). **6**. *S. phasidaria phasidaria* (Rogenhofer, 1873) (Iran, Kerman, g.prep. 1258/2022 D. Wanke). **7**. Paratype of *Synopsia centralis* (Wiltshire, 1966) (Iran, Fars, slide NHMUK010317480). Scale bar: 1 mm.

***Synopsia centralis* (Wiltshire, 1966)**
(Figs. 4, 7)

Material examined

Holotype, ♂, Persia [Iran], N. Fars, Bavant, Kuh Taj Kirmani, 8500 feet [2591 m], 7.viii.[19]50, leg. E. P. Wiltshire, NHMUK010920114, g.prep. E. P. Wiltshire 1467. Paratype, 1 ♂, same data as holotype, NHMUK014172450, slide NHMUK010317480; all in NHMUK.

Taxonomic note

Synopsia centralis was tentatively raised from the rank of subspecies of *S. phasidaria* to species rank by Wanke et al. (2020) based on the lack of a central projection on the costa of the valva of the male genitalia, a feature strongly developed in the other two species of this genus (Wanke et al. 2020) (see Figs. 5–7). At the time of that study, only habitus photos of the holotype and paratype and photos of the holotype's slide-mounted genitalia were available for examination. Therefore, we could not completely exclude that this character of the costa was not destroyed by the preparation or folded over during embedding, which led to the tentative elevation of this taxon from subspecies to species rank. During a recent visit to the Natural History Museum, London, we were able to check this character through genitalia dissection of the paratype. Our investigation confirmed the lack of a central projection on the costa also in the paratype, thus reinforcing our previous taxonomic decision to consider *S. centralis* a valid taxon at the species level (Fig. 7).

Acknowledgements

We are grateful to Geoff Martin, David Lees and Alberto Zilli (Natural History Museum, London, UK) for their support during our stay in London. Many thanks to Jörg-Uwe Meineke (Kippenheim, Germany) for the loan of valuable specimens from his collection. Copyright of images of the paratype of *Synopsia centralis* belong to the Trustees of the Natural History Museum, London, and they are published here under a Creative Commons License 4.0 (https://creativecommons.org/licenses/by/4.0/). We are thankful to two anonymous reviewers for their critical review and constructive comments to the submitted version of the paper. This research received support from the SYNTHESYS+ Project (http://www.synthesys.info/), which is financed by European Community Research Infrastructure Action under the H2020 Integrating Activities Programme, Project number 823827, and from the Research Incentive Grant of the State Museum of Natural History, Stuttgart, Germany.

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Wiltshire, E. P. (1966): Österreichische entomologische Iran-Afghanistan-Expeditionen, Beiträge zur Lepidopterenfauna, Teil 10, Subfamilien Larentiinae und Ennominae (sensu lato) (Lepidoptera, Geometridae). Middle East Lepidoptera XXIII. – Zeitschrift der Wiener Entomologischen Gesellschaft **51**: 138–152.

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ZooBank registration: https://zoobank.org/References/5B8D8EAE-7A9D-4130-A130-EC669649592F

Manuscript received: 13.V.2022; accepted: 9.VI.2022.

Original research paper 9

Tribal assignment of the genus *Eumera* Staudinger, 1892, using multi-gene analysis and description of a new species from the south Iranian province Kerman (Lepidoptera: Geometridae: Ennominae)

Dominic Wanke, Asghar Shirvani, Axel Hausmann, Leidys Murillo-Ramos, Pasi Sihvonen

Published (2023) in Zootaxa 5270 (1): 92–104
https://doi.org/10.11646/zootaxa.5270.1.4

Painting of *Eumera regina* by Marina Moser

Zootaxa 5270 (1): 092–104
https://www.mapress.com/zt/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

https://doi.org/10.11646/zootaxa.5270.1.4
http://zoobank.org/urn:lsid:zoobank.org:pub:AD854BA5-8A96-4E25-B481-313ECE7013FF

Tribal assignment of the genus *Eumera* Staudinger, 1892, using multi-gene analysis, with description of a new species from Iran (Lepidoptera: Geometridae: Ennominae)

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Abstract

The geometrid moth genus *Eumera* Staudinger, 1892 consists of five yellow-orange-pinkish species distributed in the western Palearctic, with uncertain tribal classification within the geometrid subfamily Ennominae. In this study, we explored the phylogenetic position of the genus *Eumera*. Therefore, a concatenated dataset was analyzed, which includes one mitochondrial and up to ten protein-coding genetic markers per taxa. Moreover, we compared some external and internal morphological traits to other closely related genera. Our phylogenetic inference and comparative morphology suggested that *Eumera* should be included in the tribe Prosopolophini. In addition, a new species, *Eumera rajaeii* **sp. nov.** Wanke & Shirvani is described from southern Iran, and diagnosed by molecular data and morphological features. The distribution of the Iranian species is shown on a map. We illustrate external characters and male genitalia of three closely related *Eumera* species.

Key words: *Colotois*, DNA barcoding, *Himeromima*, phylogeny, Prosopolophini, systematics, taxonomy, *Wilemania*

Introduction

In recent years, our knowledge of the classification of geometrid moths has been enhanced particularly by molecular phylogenetic studies (e.g., Sihvonen *et al.* 2011; Õunap *et al.* 2016; Jiang *et al.* 2017; Ban *et al.* 2018; Brehm *et al.* 2019; Murillo-Ramos *et al.* 2019). Despite this, we are just beginning to understand the relationships at the tribal- and genus levels, and this is a vast task in the family Geometridae, with about 24.000 known species (Müller *et al.* 2019; Rajaei *et al.* 2022). This is also true for the European Geometridae; for example, Müller *et al.* (2019) listed two genera for the subfamilies Larentiinae and 12 genera for Ennominae of uncertain tribal association. Ennominae include also the genus *Eumera* Staudinger, 1892, which is given special attention here in this study.

The genus *Eumera* was described in 1892 by Staudinger based on the type species *Eumera regina* Staudinger, 1892 from northern Turkey (Amasia, Zara). Later, a second species was added to this genus, when Prout (1929) described *E. mulier* based on a female holotype from Nicosia in the northern part of Cyprus. In 1932, Wehrli described the subspecies *E. regina turcosyrica* from Turkey (Marasch [Kahramanmaraş]; Akschehir) and Syria (Akbis [Maydan Ikbis]), which he later regarded as valid species (Wehrli 1934), followed by the description of *E.*

 Accepted by R. Zahiri: 28 Feb. 2023; published: 19 Apr. 2023

hoeferi Wehrli, 1934 from Turkey (Kurdistan, Malatia [Malatya]). Finally, Wehrli (1940), described the subspecies *E. hoeferi transcaucasica* from Nakhichevan, (Dzhuga (Arax River)). 68 years later, a further species was added to the genus *Eumera*, *E. lewandowskii*, from southwestern Jordan by Fischer (2008). Thus, today a total of five species are assigned to the genus *Eumera*, all distributed in the western Palearctic region but only one species has its distribution range in Iran (Skou & Sihvonen 2015; Müller *et al.* 2019; Hausmann *et al.* 2020; Rajaei *et al.* 2022; Rajaei *et al.* 2023).

Eumera species are large moths (wingspan 35–40 mm), with only limited information on their biology (Fischer 2008; Skou & Sihvonen 2015). Species of this genus are early autumnal, flying from August to early November (Skou & Sihvonen 2015). Caterpillars of *E. regina* have been found on *Acer monspessulanum* and were reared on *Prunus triloba* (Skou & Sihvonen 2015). Moths of this genus are characterized by their yellow to orange wing colouration, rarely with light pink elements of the wing pattern (Skou & Sihvonen 2015). The outer wing margins are slightly wavy with well-pronounced medial and postmedial lines. In the male genitalia, uncus and gnathos are absent, and the ventral margin of the valva bears a distinct hook. In the female genitalia large and broad ovipositor, short apophyses anteriores, lamella antevaginalis with a weakly sclerotized ridge, and weakly sclerotized signum are diagnostic. The genus *Eumera* is classified in the geometrid subfamily Ennominae but its tribal association is still uncertain (Skou & Sihvonen 2015; Müller *et al.* 2019). Earlier, *Eumera* was considered to be a member of the tribe Colotoini by Viidalepp (1996), whereas Hausmann *et al.* (2011) placed it in Ennomini. This study aims to clarify the systematic position of this genus using a multi-gene molecular phylogenetic analysis, including one mitochondrial and up to ten protein-coding nuclear gene regions, along with the examination of morphological characters. In addition, a new *Eumera* species is described from the southern Iranian province Kerman.

Material and methods

Examined type material and specimens are deposited in the following collections: CN-SHBUK—Collection of Noctuidae, Shahid Bahonar University of Kerman, Kerman, Iran; NHMUK—Natural History Museum London, United Kingdom; SMNK—Staatliches Museum für Naturkunde Karlsruhe, Germany; SMNS—Staatliches Museum für Naturkunde Stuttgart, Germany; SNSB/ZSM—Zoologische Staatssammlung München, Germany; ZFMK—Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany; ZMH—Finnish Museum of Natural History, University of Helsinki, Finland.

Examined material

Eumera regina: 1 ♂, Macedonia, Petrina, Planina, Ochrid, 1600 m, 20.viii.1955, leg. Dr. F. Kasy, g.prep. 1327/2022 D. Wanke; 1 ♂, Griechenland, Fokida Nom, Chrisso bei Delphi, 17.ix.2002, leg. M. Salmen, g.prep. 1328/2022 D. Wanke; 1 ♂, [Croatia], Sukosan, e.l., 1.ix.[19]65, leg. Czipka, g.prep. 1329/2022 D. Wanke; 1 ♂, 1♀, [Croatia], Dalmatien, ex coll. W. Pfitzenmeier Stuttgart, g.preps (♂) 1330 (♀) 1331/2022 D. Wanke; **all in SMNS.**

Eumera turcosyrica: Syntypes [both labeled with 'Typ'] 1 ♂, 1♀, Syr. sept. [Turkey], Taurus c. Marasch, 6–900 m, x.[19]30, leg. Einh. Slr., g.preps (♂) 5576 (♀) 1318/2022 D. Wanke; non-type specimens: 1 ♂, Syr. sept. [Turkey], Taurus c. Marasch, 6–900 m, x.[19]30, leg. Einh. Slr., g.prep. 1319/2022 D. Wanke; 1 ♂, Asia min. [Turkey], Akschehir, 10.-20.ix.[19]31, coll Wagner, Wien, g.prep. 1320/2022 D. Wanke; **all in ZFMK.**

1 ♂, Asia min. [Turkey], Aksehir, 25.viii.1966, leg. Czipka, g.prep. 1324/2022 D. Wanke; **in SMNS.**

Eumera hoeferi: Holotype ♂, Asia min. [Turkey], Malatya-Tecde, 20.ix., g.prep. 5570; Paratype [labelled as Allotype] 1 ♀, Asia min. [Turkey], Malatya-Tecde, 20.ix., g.prep. 1317/2022 D. Wanke; **all in ZFMK.**

Paratype 1 ♂, Asia min. [Turkey], Malatya-Tecde, 20.ix., NHMUK 014173742, g.prep. NHMUK 010317504; non-type specimens: 1 ♂, Iran, Fars, Straße Chiraz-Kazeroun, Fort Sine-Sefid, ca. 2200 m, 10.ix.1937, coll. Brandt, NHMUK 014173743, g.prep. NHMUK 010317503; 1 ♀, Iraq, Kurdistan, Rowanduz, 8.x.1936, E.P. Wiltshire, NHMUK 014173744, g.prep. NHMUK 010317505; 1 ♂, Iraq, Kurdistan, Rayat, 14.x.[19]36, E.P. Wiltshire, NHMUK 014173745, g.prep. NHMUK 010317506; **all in NHMUK.**

1 ♂, 1♀, Türkei, Kleinasien, Prov. Siirt, 3 km NE Baykan, 750 m, 14.x.1985, g.preps (♂) 1322 (♀) 1323/2022 D. Wanke; **all in SMNS.**

Morphological examination

Wing pattern and male genitalia were examined and original descriptions used for a critical review, as well as additional specimens from different localities were investigated. Documentation of external characters was carried out using an Olympus E3 digital camera. For the genitalia preparation, standard techniques were used (Robinson 1976) and if the vesica was everted, it was done following the protocol described in Sihvonen (2001). Genitalia was embedded in Euparal as permanent slides. A Keyence VHX-5000 microscope was used for their photography.

Distribution map preparation

Geographical coordinates were traced using 'Google Earth Pro' (vers. 7.3.6.9326 for Mac) and the distribution pattern was plotted and prepared in QGIS (vers. 3.22.8 for Mac). For the preparation of the elevation profile in QGIS, Global Multi-resolution Terrain Elevation Data 2010 (GMTED2010) downloaded from https://earthexplorer.usgs.gov, was used.

DNA extraction and amplification

Extraction of DNA of *Eumera rajaeii* **sp. nov.** Wanke & Shirvani was carried out at the molecular laboratory of the State Museum of Natural History Stuttgart. Therefore, prior to genitalia dissection, the whole abdomen of the holotype was used for lysis (details available in Hundsdoerfer & Kitching 2010), following the manufacturer's protocol of the DNeasy Blood and Tissue kits (Qiagen, Hilden, Germany).

Amplification of the "barcode" fragment (658 base-pairs of the 5' terminus) of the mitochondrial Cytochrome-*C* Oxidase I of *Eumera rajaeii* **sp. nov.** Wanke & Shirvani, was performed using standard protocols (Ivanova *et al.* 2006) and amplification of nuclear genes of *Eumera rajaeii* **sp. nov.** Wanke & Shirvani was conducted following the protocols of Wahlberg and Wheat (2008) and Wahlberg *et al.* (2016) at the molecular laboratory of the State Museum of Natural History Stuttgart. All PCR amplification products were sent to Macrogen for sequencing.

Extraction and amplification of the "barcode" fragment of all other *Eumera* and *Apocolotois* species used in barcoding analysis were performed at the Canadian Centre of DNA barcoding (CCDB, Guelph), in the framework of the Lepidoptera campaign of the International Barcode of Life program (iBOL; www.lepbarcoding.org).

Phylogenetic analysis

In addition to the data generated in this study, we retrieved up to ten sequences per species of 655 Ennominae taxa, as well as two Oenochrominae and three Geometrinae as outgroups from the dataset of Murillo-Ramos *et al.* (2019) (see Supplementary Table). The concatenated length of the alignment was 7,662 bp.

To reveal the phylogenetic position of *Eumera* within Geometridae, we conducted the phylogenetic analysis under a Maximum-likelihood (ML) approach in IQ-TREE2 V2.0.7 (Minh *et al.* 2020). The dataset was partitioned by genes. We evaluated support for nodes with 1000 ultrafast bootstrap (UFBoot2) approximations (Hoang *et al.* 2018), and SH-like approximate likelihood ratio test (Guindon *et al.* 2010). We selected the best substitution model with ModelFinder (Kalyaanamoorthy *et al.* 2017). To reduce the risk of overestimating branch supports in UFBoot2 test, we implemented the *-bnni* option. We visualized and edited the trees in FigTree v1.4.3.

TABLE 1. Interspecific genetic distances between six species of the genus *Eumera* and one species of the genus *Apocolotois* (in %), calculated with MEGA X. Note: The small genetic differences (< 2 %) of the species *E. lewandowskii*, *E. turcosyrica* relative to *E. regina* question their status on species level. However, this is beyond the scope of this study and needs further investigation.

	E. turcosyrica	*E. lewandowskii*	*E. regina*	*E. hoeferi*	*E. mulier*	***E. rajaeii* sp. nov. Wanke & Shirvani**
E. lewandowskii	1.72					
E. regina	1.90	1.76				
E. hoeferi	5.17	5.17	4.52			
E. mulier	6.52	6.28	5.80	7.18		
***E. rajaeii* sp. nov. Wanke & Shirvani**	6.44	6.39	6.20	6.12	6.67	
A. almatensis	9.78	9.78	9.09	10.92	11.35	9.81

Barcoding analysis

For the maximum likelihood analysis for *Eumera* species (with 1000 bootstrap replications), and calculation of genetic distances, MEGA X was used (Kumar *et al.* 2018, Stecher *et al.* 2020) (K2P model: Kimura 1980).

All specimens used for CO1 analysis are given in table 2 along with their sampling site, sample ID, and process ID numbers. Their sequences, photographs, and metadata are accessible in BOLD (Barcode of Life Datasystems) in the public dataset DS-EUMERA (doi: dx.doi.org/10.5883/DS- EUMERA).

TABLE 2. *Eumera* and *Apocolotois* specimens used in the COI maximum likelihood analysis, with identification, sampling site, sample ID and process ID in the Barcode of Life Data Systems (BOLD).

Taxon Identification	sampling site	Sample ID	Process ID
A. almatensis	China, Hebei, Chongli, Baiqi, 1350 m, 09.ix.2007, leg. C. Wang	BC ZSM Lep 12975	GWORD885-08
A. almatensis	China, Hebei, Chongli, Baiqi, 1350 m, 23.ix.2006, leg. C. Wang	BC ZSM Lep 13014	GWORD924-08
A. almatensis	China, Hebei, Chongli, Shizigou, 1650 m, 13.ix.2007, leg. C. Wang	BC ZSM Lep 13350	GWORB2670-08
A. almatensis	Kazakhstan, Almaty, Tien Shan, Turgen, 27.ix.2010, leg. G. Nazymbetova	BC ZSM Lep 80107	GWOR5397-13
E. hoeferi	Turkey, Malatya, Malatya, 2 km S Erkenek, Resadiye pass, 1550 m, 15.ix.2009, leg. R. Fiebig & S. Rothe	BMB Lep 00771	GWOTD1021-12
E. hoeferi	Turkey, Tunceli, 9.5 km NE Ovacik, 1400 m, 24.viii.2009, leg. R. & S. Fiebig	BMB Lep 00772	GWOTD1022-12
E. lewandowskii	Jordan, Ma'an, Al-Aqabah, Wadi Musa nr Petra, 1030 m, 12.x.2007, leg. S: Lewandowski & K. Tober	BC ZSM Lep 11461	GWORA593-08
E. mulier	Cyprus, Limassol, nr. Agios Joannis, 920 m, 03.x.2000, leg. H. Fischer	BC ZSM Lep+ 0020	GWOR3008-08
E. mulier	Cyprus, Larnaca, nr. Lefkara, 790 m, 01.x.2004, leg. S. Lewandowski	BC ZSM Lep 11478	GWORA610-08
E. mulier	Cyprus, Larnaca, nr. Lefkara, 790 m, 01.x.2004, leg. S. Lewandowski	BC ZSM Lep 11479	GWORA611-08
E. mulier	Cyprus, Larnaca, nr. Lefkara, 790 m, 01.x.2004, leg. S. Lewandowski	BC ZSM Lep 11480	GWORA612-08
E. regina	Turkey, Cankiri, Ic Anadolu, Ilgaz, 900 m, 09.ix.1997, leg. T. Drechsel & H. Loebel	BC ZSM Lep 09080	GWORA494-08
E. regina	Turkey, Cankiri, Ic Anadolu, Ilgaz, 900 m, 09.ix.1997, leg. T. Drechsel & H. Loebel	BC ZSM Lep 09081	GWORA495-08
E. regina	Turkey, Cankiri, Ic Anadolu, Ilgaz, 900 m, 09.ix.1997, leg. T. Drechsel & H. Loebel	BC ZSM Lep 09082	GWORA496-08
E. regina	Croatia, Splitsko-dalmatinska, Dalmatia, NP Mt. Biokovo, Rastovac, 221 m, 13.ix.2007, leg. I. Mihoci, M. Vajdic	RCIM 0017	GWOSI017-10
E. turcosyrica	Israel, Northern, Mt. Hermon, 2000 m, 30.xi.2003, leg. Mueller, Kravchenko	BC ZSM Lep 00250	GWOR250-07
E. turcosyrica	Jordan, Al Asimah, Jabal Ma uda, 100 m, 31.x.2002, leg. Li, Mueller	BC ZSM Lep 00334	GWOR334-07
E. turcosyrica	Lebanon, Mount Lebanon, Arab ei Laqlouq, 1600 m, 29.ix.2008, leg. Floriani, Saldaitis	BC ZSM Lep 19578	GWORP792-09
E. turcosyrica	Syria, Idlib, Al Barah, 659 m, 15.x.2010, leg. S. Lewandowski & K. Tober	BC ZSM Lep 52709	GWOSN598-11
E. rajaeii **sp. nov.** Wanke & Shirvani	Iran, prov. Kerman, Dalfard, waterfall, 2204 m, 16.ix.2021, leg. Asghar Shirvani	SMNS Lep 002347	GMECA086-23

Results

In total, eight genes (COI, ArgK, Ca-ATPase, EF-1α, GAPDH, IDH, MDH, RpS5) of the holotype of *Eumera rajaeii* **sp. nov.** Wanke & Shirvani were successfully amplified and sequenced. In molecular phylogenetic analysis, *Eumera rajaeii* **sp. nov.** Wanke & Shirvani clustered as sister to *Himeromima* near *aulis* (Druce, 1892) within the tribe Prosopolophini (fig. 1). Moreover, the results of our morphological examination support the assignment of *Eumera* to the tribe Prosopolophini (see figs 2–5 and Systematics part of Discussion).

Our results from the barcoding analysis revealed a genetic p-distance of *Eumera rajaeii* **sp. nov.** Wanke & Shirvani of 6.12 % difference from the nearest species *E. hoeferi*. Description of the new *Eumera* species is given in the taxonomy part of the Discussion.

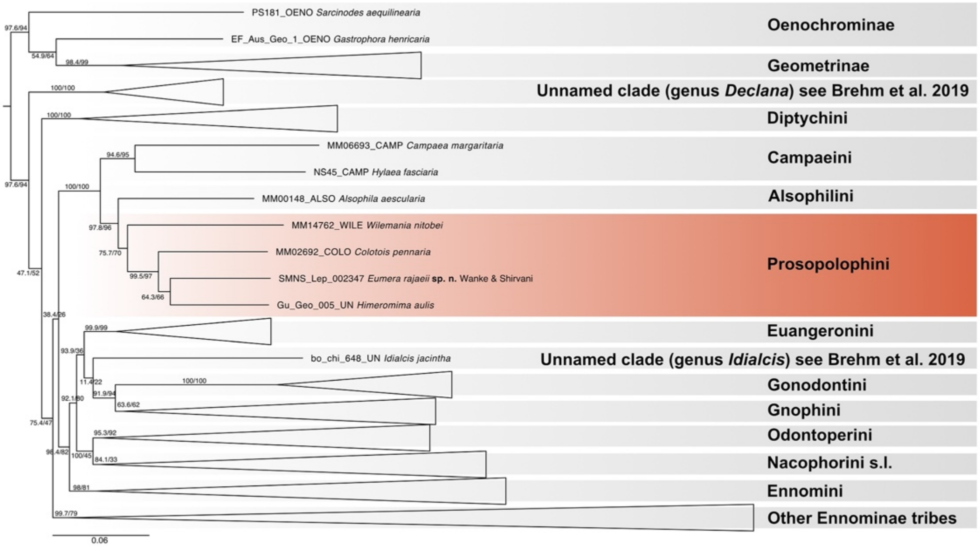


FIGURE 1. Phylogenetic position of *Eumera rajaeii* **sp. nov.** Wanke & Shirvani within Ennominae**,** supporting the classification of the genus *Eumera* in Prosopolophini. The maximum likelihood tree is based on up to ten genes, and the numbers above the branches are SH-aLRT support (%) / ultrafast bootstrap support (%). The dataset is based on Murillo-Ramos *et al.* (2019), supplemented with *Eumera rajaeii* **sp. nov.** Wanke & Shirvani (see Supplementary Table).

Discussion

Systematics

Eumera rajaeii **sp. nov.** Wanke & Shirvani, *Himeromima* near *aulis* (Druce, 1892), *Colotois pennaria* (Linnaeus, 1761), and *Wilemania nitobei* (Nitobe, 1907) grouped together in the multi-gene phylogeny (fig. 1) and those are morphologically similar (figs 2–5). In addition, *Dorsispina furcicornaria* Nupponen & Sihvonen, 2013, *Chondrosoma fiduciaria* Anker, 1854, *Apochima flabellaria* (Heeger, 1838), and *Dasycorsa modesta* (Staudinger, 1879), which have thus far not been included in molecular phylogeny, but the structures are well-known (Nupponen & Sihvonen 2013; Skou & Sihvonen 2015; Müller *et al.* 2019) are morphologically similar. Males share bipectinate antennae, often wings have pale spots in the terminal area, and the genitalia have diagnostic bilobed uncus (single in *D. modesta*; homology of dorsal structures in some Prosopolophini taxa is unclear, that of *E. regina* identified as scaphium in Skou & Sihvonen (2015)), which is either symmetrical or asymmetrical, valva is simple and relatively wide, sacculus sclerotized marginally and with a spine-shaped saccular process, the short and small aedeagus bears a simple vesica. Female genitalia are not known for all these species, but the examined taxa share large papillae anales, corpus bursae are simple and membranous, and signum is absent (small, weakly stellate signum is present in *W. nitobei*).

Many of the above-mentioned taxa have earlier been assigned to the tribes Colotoini (e.g., Viidalepp 1996), or Gonodontini Forbes, 1948 (Pohl *et al.* 2016), while Beljaev (2016) considered Colotoini Wehrli, 1940, Wilemanini Wehrli, 1941 and Compsopterini Herbulot, 1963 junior synonyms of Prosopolophini Warren, 1894. The type genus of Prosopolophini is *Compsoptera* Blanchard, 1845, which has thus far not been included in molecular phylogeny. The morphology of *Compsoptera* is illustrated in Skou and Sihvonen (2015). *Alsophila aescularia* (Denis &

Schiffermüller, 1775), currently classified in Alsophilini Herbulot, 1962, is sister to Prosopolophini in the molecular phylogeny (fig. 1). It is morphologically different from Prosopolophini lineage (see e.g., Hausmann 2001), therefore, we consider Alsophilini valid on tribe level.

The disjunct biogeography of Prosopolophini is striking. In the phylogenetic tree, *Eumera* and *Himeromima* are sister taxa, the former occurring from southern Europe across the Near East to Iran in the Palearctic (Skou & Sihvonen 2015), the latter from Mexico to the northern parts of South America (Pitkin 2002). All other Prosopolophini species are found in the Palearctic, except *C. pennaria*, which shows a Holarctic distribution. It is not excluded that this disjunct zoogeographical pattern will become supplemented and modified when additional genera will be included in the molecular phylogenetic analysis, which may turn out to be closer relatives to *Eumera*.

Taxonomy

Eumera rajaeii sp. nov. Wanke & Shirvani

(figs 4, 16, 21)

Material examined. Holotype ♂, Iran, prov. Kerman, Dalfard, waterfall, 28°59′58″N, 57°35′15″E, 2204 m, 16.ix.2021, leg. Asghar Shirvani, g.prep. 1321/2022 D. Wanke; **in SMNS.**

Paratypes 2 ♂, Iran, prov. Kerman, Baft, Khabr, 2360 m, 28°51′0″N, 56°22′22″E, 7–8.x.2021, leg. Asghar Shirvani; **all in SMNS.**

2 ♂, Iran, prov. Kerman, Sarbizhan, Shingera, 2850 m, 29°5′8″N 57°32′50″E, 25.viii.2022, leg. Asghar Shirvani, g.prep. AS880m A. Shirvani; 1 ♂, Iran, prov. Kerman, Baft, Dehsard, 15.viii.2022, leg. Mehrabi, g.prep. AS882m A. Shirvani; 1 ♂, Iran, prov. Kerman, Baft, Khabr, 2522 m., 28°45′34″N 56°29′5″E, 2.ix.2022, leg. Kamyab & Shirvani, g.prep. AS881m A. Shirvani; **all in CN-SHBUK.**

1 ♂, Iran, prov. Kerman, Baft, Khabr, 2360 m, 28°51′0″N, 56°22′22″E, 7–8.x.2021, leg. Asghar Shirvani; **in SMNK.**

2 ♂, Iran, prov. Kerman, Baft, Khabr, 2360 m, 28°51′0″N, 56°22′22″E, 7–8.x.2021, leg. Asghar Shirvani; **all in SNSB/ZSM.**

1 ♂, Iran, prov. Kerman, Baft, Khabr, 2522 m., 28°45′34″N 56°29′5″E, 2.ix.2022, leg. Kamyab & Shirvani; 1 ♂, Iran, prov. Kerman, Sarbizhan, Shingera, 2850 m, 29°5′8″N 57°32′50″E, 25.viii.2022, leg. Asghar Shirvani; **all in ZMH.**

Description. *Wings and body* (figs 4, 16). Wingspan ♂ 30–37 mm (forewing length ♂ 17–20 mm). Antennae bipectinate. Frons protruding, prominently yellow scaled. Chaetosemata present as two small patches, located between eyes' margin and antennal bases. Labial palpi strongly reduced, about one-fifth eye diameter. Proboscis reduced. Head, thorax and abdomen concolorous with wings. Forewing basal area, terminal area, and costa brownish-yellow pink with some olive green, terminal area olive green. Terminal line and fringes pink with some brown spots. Medial and postmedial lines brown, pink highlighted. Medial line weakly pronounced. Postmedial line neatly curved. Hindwing brownish-pink, basal and medial area pink, terminal area olive-green. Medial line absent. Postmedial line narrow, brown.

Male genitalia (figs 4, 21). Uncus (homology tentative) triangular. Gnathos absent. Valva long and thin. Costa of valva and and ventral margin of sacculus strongly sclerotized. Sacculus with spine-shaped process. Juxta large, posteriorly narrowing. Saccus large and elongated. Aedeagus strongly s-shaped. Vesica without cornuti.

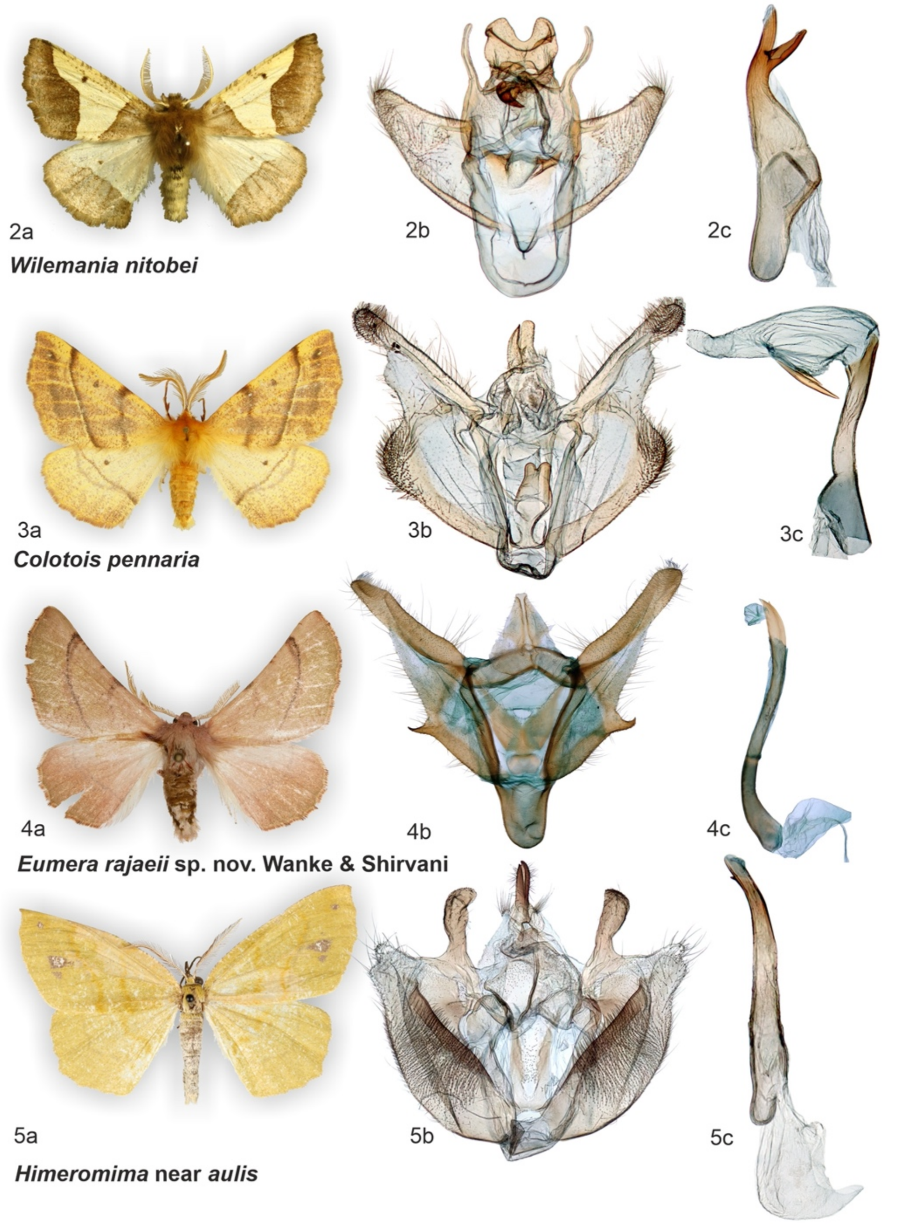
Female genitalia. Unknown.

Diagnosis. In Iran, only *E. hoeferi* is reported from the southern province Fars (Brandt 1939, Viidalepp 1996), which we can confirm here as a specimen was available from this province in the collection of the NHMUK (see examined material). Nevertheless, the new species is - in addition to *E. hoeferi* - also compared with *E. regina* and *E. turcosyrica*. In the forewing postmedial line neatly curved (rather straight in *E. regina*, *E. turcosyrica* and *E. hoeferi*) (figs 6–16). Two white spots in the terminal area of the forewing absent (similar in *E. hoeferi*; two white spots present in *E. regina* and *E. turcosyrica*). In the male genitalia differences are minute and quantitative: saccus more elongated and aedeagus strongly s-shaped compared to *E. regina*, *E. turcosyrica* and *E. hoeferi* (figs 17–21). See also DNA barcoding.

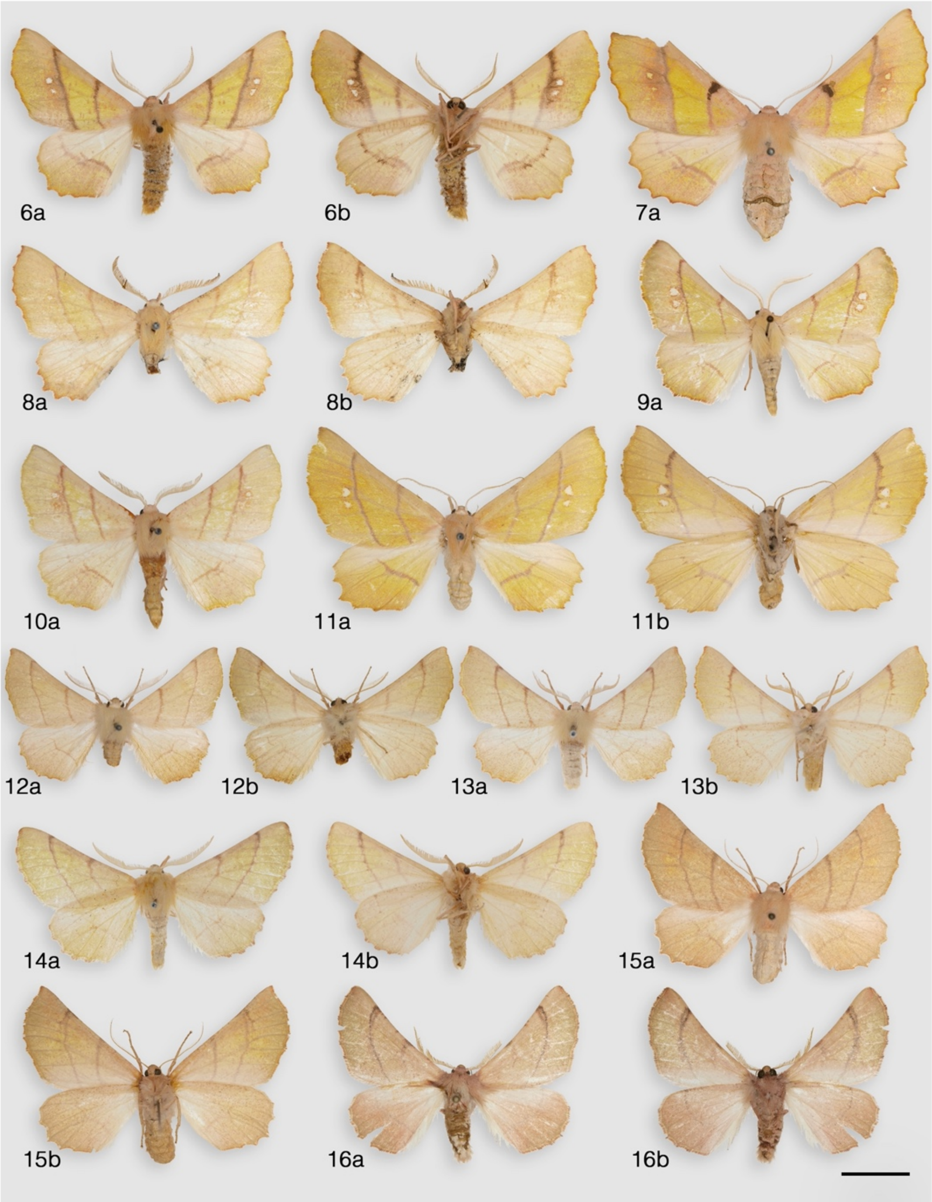
Phenology. Type specimens collected from August to October.

Biology. Unknown.

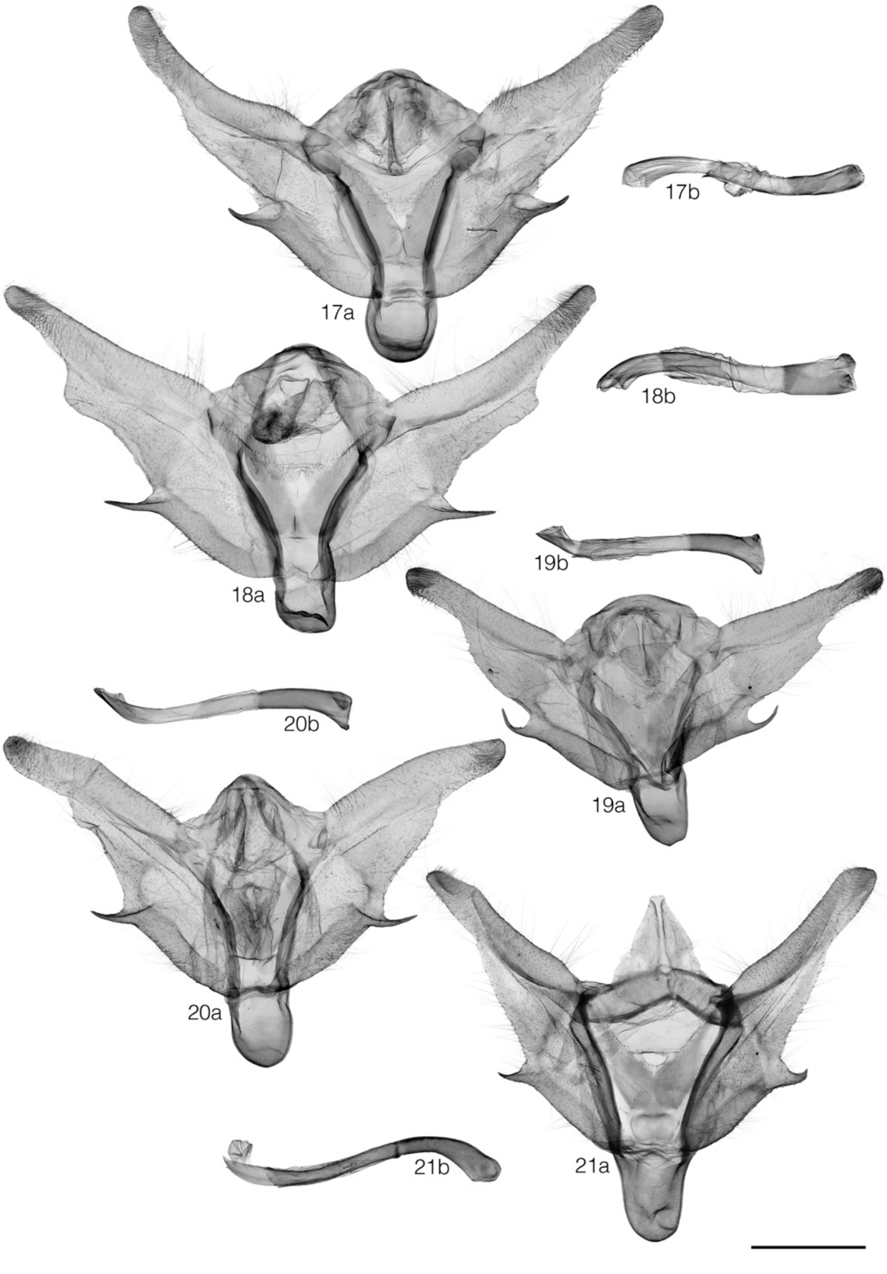
Habitat. Type specimens were collected from rocky mountainous regions covered with shrubs and trees at altitudes from 2204 m up to 2850 m.



FIGURES 2–5. Adults, male genitalia and aedeagus of *Eumera rajaeii* **sp. nov.** Wanke & Shirvani and related genera based on the molecular phylogeny shown in Figure 1. We classify these genera and several other (see text for details), in tribe Prosopolophini. 2: *Wilemania nitobei* (Japan, Bushi, Iruma, Saitama-kea, 24.xi.1973, coll. NHMUK, g.prep. Sihvonen 1867); 3: *Colotois pennaria* (a: Sweden, Södermanland, Ågeta, 21.ix.1973, coll. Skou; b–c. Finland: Vantaa, Königstedt, 2–9.ix.1995, coll. Sihvonen, g.prep. Sihvonen 1862); 4: *Eumera rajaeii* **sp. nov.** Wanke & Shirvani (Iran, Kerman, Dalfard, 16.ix.2021, coll. SMNS, g.prep. 1321/2022 D. Wanke); 5: *Himeromima* near *aulis* (Mexico, Orizaba, May 1896, coll. NHMUK, g.prep. Sihvonen 2873). Figures are not to scale.



FIGURES 6–16. Wing colouration and pattern of *Eumera* species. 6–7: *E. regina* (6: Macedonia, Petrina, g.prep. 1327/2022 D. Wanke; 7: [Croatia], Dalmatien, g.prep. 1331/2022 D. Wanke); 8–11: *E. turcosyrica* (8: Syntype, [Turkey], Taurus c. Marasch, g.prep. 5576; 9: [Turkey], Aksehir, g.prep. 1324/2022 D. Wanke; 10: [Turkey], Taurus c. Marasch, g.prep. 1319/2022 D. Wanke; 11: Syntype, [Turkey], Taurus c. Marasch, g.prep. 1318/2022 D. Wanke); 12–15: *E. hoeferi* (12: Holotype, [Turkey], Malatya-Tecde, g.prep. 5570; 13: Paratype, [Turkey], Malatya-Tecde, g.prep. NHMUK 010317504; 14: Iran, Fars, Fort Sine-Sefid, g.prep. NHMUK 010317503; 15: Paratype [Turkey], Malatya-Tecde, g.prep. 1317/2022 D. Wanke); 16: *E. rajaeii* **sp. nov.** Wanke & Shirvani (Iran, Kerman, Dalfard, g.prep. 1321/2022 D. Wanke). a = upperside; b = underside. Scale-bar 1 cm.



FIGURES 17–21. Male genitalia of *Eumera* species. 17: *E. regina* (Griechenland, Fokida Nom, Chrisso, g.prep. 1328/2022 D. Wanke); 18: *E. turcosyrica* ([Turkey], Taurus c. Marasch, g.prep. 1319/2022 D. Wanke); 19–20: *E. hoeferi* (3: Paratype, [Turkey], Malatya-Tecde, g.prep. NHMUK 010317504; 4: Iran, Fars, Fort Sine-Sefid, g.prep. NHMUK 010317503); 21: *E. rajaeii* **sp. nov.** Wanke & Shirvani (Iran, Kerman, Dalfard, g.prep. 1321/2022 D. Wanke). a = genitalia capsule; b = aedeagus. Scale-bar 1 mm.

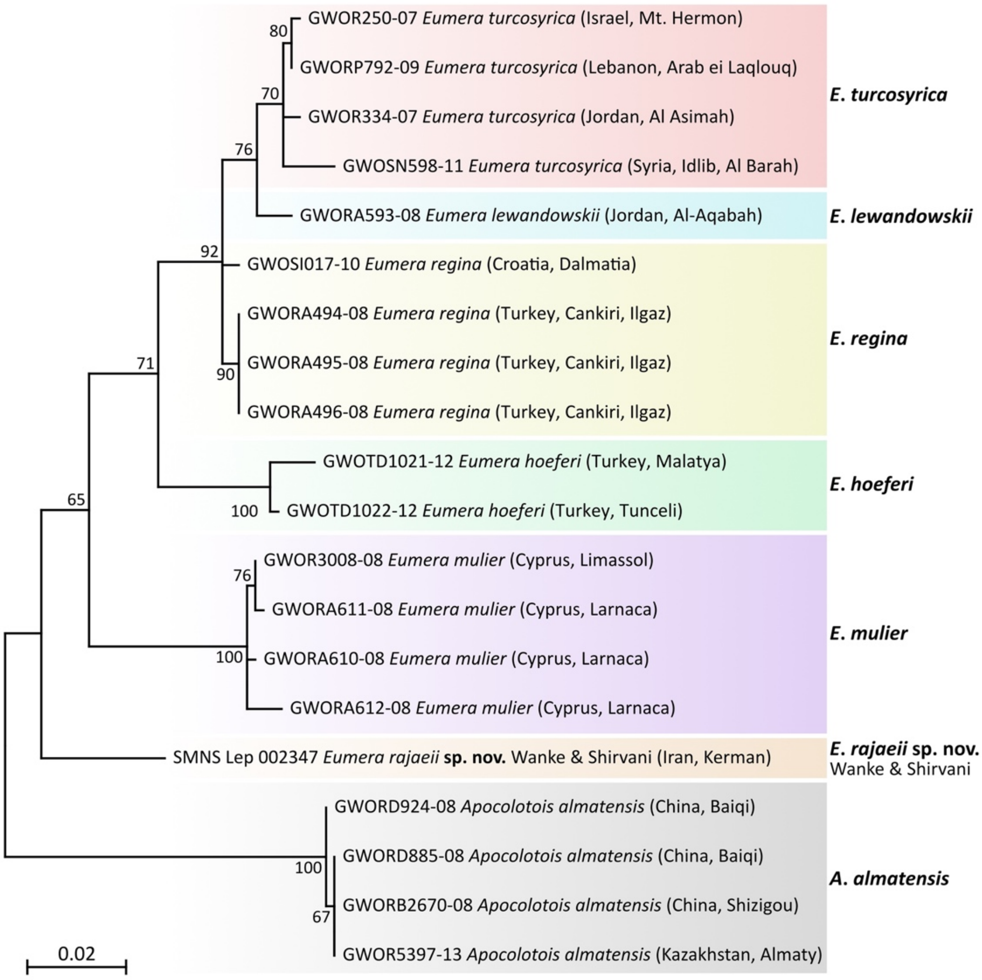


FIGURE 22. Maximum likelihood analysis including all known *Eumera* species and *Apocolotois almatensis* based on COI 5' sequences (built with MEGA X; Kimura 2-parameter model; bootstrap method, 1000 replications).

Distribution. Only known from the southern Iranian province Kerman (fig. 23)

DNA barcoding. The new species shows more than 6 % genetic p-distance from all other *Eumera* species. The genetically nearest species is *E. hoeferi* with 6.12 % difference (fig. 22, tab. 1).

Etymology. The new species is dedicated to our friend and mentor of the first author, Hossein Rajaei (SMNS, Germany), for his encouraging and always enjoyable collaboration and his exceptional contribution to the knowledge of Iranian Lepidoptera.

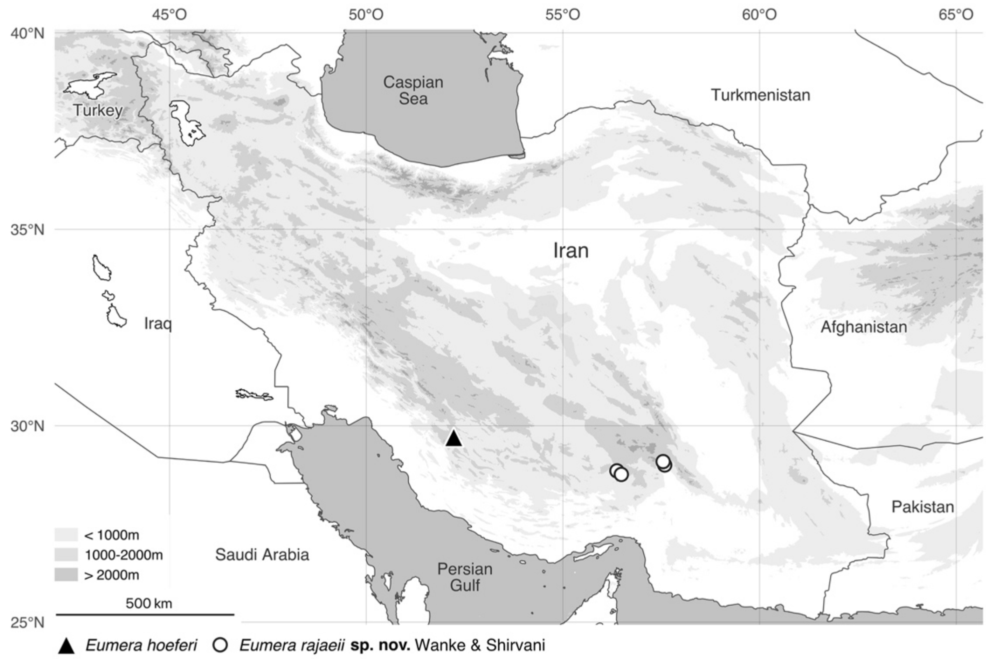


FIGURE 23. Distribution map of *Eumera* species in Iran.

Acknowledgements

We would like to express our sincere thanks to Marianne Espeland (Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany), Geoff Martin, David Lees and Alberto Zilli (Natural History Museum, London, UK) for their support during the stay in their collections and the loan of valuable specimens. We sincerely thank the subject editor of Zootaxa, Reza Zahiri (Ottawa, Canada), and two anonymous reviewers, for their critical review, constructive comments and helpful suggestions. This research received support from the SYNTHESYS+ Project (http://www.synthesys.info/), which is financed by European Community Research Infrastructure Action under the H2020 Integrating Activities Programme, Project number 823827.

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Original research paper 10

Network-based bioregionalization analysis of the geometrid moths of Iran

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Unpublished manuscript

Painting of *Problepsis cinerea* by Maria Werner

Network-based bioregionalization analysis of the geometrid moths of Iran

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Abstract

Three of the six zoogeographical realms defined by Wallace meet in the southern part of Iran. The high environmental heterogeneity of this country is reflected in the complex communities of plants and animals. Geometridae is one of the most diverse groups of Lepidoptera, with hitherto 539 species and a high rate of endemism in Iran. Using a network-based method, we identify bioregions based on the known distributions of all geometrid moths occurring in Iran, with the aim to uncover areas with unique faunal elements, and shed light on regions with significant species richness and endemism. Our results revealed an outstanding species richness along the mountain ranges, particularly the Zagros Mts. in the west and south and the Alborz Mts. in the north. Regarding endemic species, the southern mountainous areas are the most diverse. The bioregionalization analysis identified six main bioregions, some of which reflect the specific local faunal composition. These bioregions are in line with previous biogeographic studies on the biodiversity of the country and highlight its complex species composition, particularly in the transition zone between zoogeographical realms. Our results confirmed the presence of two melting points between the Palearctic and Saharo-Arabian realms along the southwestern and southern foothills of the Zagros Mts. and between the Palearctic and Oriental realms in the south-east.

Keywords. Bioregions, Insects, Lepidoptera, Network-based method, Oriental, Palearctic, Saharo-Arabian

Introduction

Defining regions structured as significant ecological and geographical units is a crucial step in biogeography, ecology, evolution, and conservation biology (Vilhena & Antonelli 2015). At a large-scale, fauna on Earth can be subdivided into unique regions based on the similarity and dissimilarity of their species composition and underlying patterns, e.g., zoogeographical realms

(Wallace 1876; Holt et al. 2013; Ficetola et al. 2017). Historically, these units have been developed via different drivers, like continental drifts, mountain orogeneses, and past climate fluctuations (Antonelli 2017). Although these realms can be useful for studying the distribution of different species globally, finer resolution units are necessary at national or local levels.

Iran is located at the intersection of three of Wallace's six zoogeographical realms: Palearctic, Saharo-Arabian, and Oriental (Holt et al. 2013), which is reflected in its species composition (Rajaei et al. in prep). In addition, two of the 36 global hotspots extend to the north and western half of the country, namely the Iranian-Anatolian region and the Caucasus (Myers et al. 2000; www.conservation.org). The country exhibits a complex topology and steep climatic gradient, which have been suggested as the main explanatory variables for the highly diverse fauna and flora and high rate of endemism of Iran (Noroozi et al. 2019; Noori et al. 2021; Rajaei & Karsholt 2023).

The country has been subdivided into various bioregions based on different taxa (e.g., Yusefi et al. 2019). Although there is agreement on the number of bioregions in Iran based on plant species, which approximately represent macrobioclimatic zones in the country (White & Léonard, 1991; Djamali et al. 2011), the number of bioregions varies for different animal groups (Rajaei et al. in prep.). Different numbers of bioregions have been suggested according to the studied taxa: e.g., thirteen for reptiles (Anderson 1968); eight for birds (Scott et al. 1975); nineteen main basins for freshwater fishes (Coad 1987), and eight bioregions for mammals (Yusefi et al. 2019).

In the case of invertebrates, studies are limited to only a few insect taxa at the family and genus levels. For instance, Naumann (1987) suggested three eco-geographical types for the genus *Zygaena* (Zygaenidae), while Dubatolov & Zahiri (2005) clustered Iran into three main territories based on 36 species of the subfamily Arctiinae (Erebidae): a) the western, northern, and central regions with Palearctic faunal elements; b) the plain of Khuzestan in the southwest and the northern seashore of the Persian Gulf in Bushehr province; and c) the southern and south-eastern areas, with Oriental and the Paleotropical faunal elements (Dubatolov & Zahiri 2005). Matov et al. (2008) used 19 species of the subfamily Heliothinae (Insecta: Lepidoptera: Noctuidae) and divided Iran into three main territories. Mozaffarian (2013) divided the country into 13 primary zones and identified six endemic zones for the suborder Fulgoromorpha (Insecta: Hemiptera).

According to Rajaei et al. (2023a), the insect order Lepidoptera accounts for 4,812 recorded species in Iran, with a high rate of endemism (19.7%) and possibly the same number of species still to be discovered. Although species distribution patterns have been studied for few lepidopteran taxa (e.g., Zygaenidae, Arctiinae, Heliothinae), there are no comprehensive studies regarding those of the most diverse and well-studied groups, such as butterflies (Rhopalocera) and many Heterocera (e.g., Geometridae and Noctuidae).

Geometrid moths are distributed worldwide and are the second-largest family of Lepidoptera, with about 24,000 known species (Nieukerken et al. 2011; Sihvonen et al. 2020; Rajaei et al. 2022). Based on Rajaei et al. (2023b), a total of 539 geometrid species have been recorded for the country, 65 of which remain unconfirmed. Six out of the nine currently recognized subfamilies (Murillo-Ramos 2021; Rajaei et al. 2023b) are represented in Iran. With the 1,000 European geometrid species as a comparison (Müller et al. 2019), Landry et al. (2023) estimated that Iran has over 950 geometrid species, including those already recorded, that have not yet been fully explored, due to the still incomplete knowledge of this family, and of Lepidoptera in general, in the country.

Of the 539 Geometridae species hitherto recorded in Iran, 109 (20%) are endemic, and little to no biological or ecological data are available for most of them (Rajaei et al. 2023b). Biodiversity in Iran is under intense threat from climate change and, more especially, from human-related activities such as agriculture, overgrazing, and habitat fragmentation (Jowkar et al. 2016; Karimi & Jones 2020). As only approximately half of Iran's geometrid fauna is known, and because data on the distribution and biology of the recorded species is still lacking or incomplete, protecting unique areas is paramount and further research on these moths in Iran is of utmost importance.

The present study aims to identify the areas of Iran with a high richness of Geometridae species and identify bioregions based on analysis of this insect group in Iran, in order to improve our knowledge regarding unique species assemblages and reveal small areas with very special faunal elements. With this study, our goal is to provide information on areas of Iran in need of priority protection and to shed light on hitherto poorly-studied areas.

Material and Methods

Occurrence dataset

The distribution data for the geometrid moths of Iran used in the analyses were collected from the same sources used for the compilation of the "Lepidoptera Iranica" project (Rajaei et al. 2023b), which included all research papers, monographs, conference abstracts, short communications, etc. with data on the lepidopteran fauna of Iran. Additionally, unpublished data from 48 institutional and private collections [for a full list, see Rajaei & Karsholt (2023)], as well as unpublished data from the Ph.D. projects of S. Feizpour, H. Rajaei (2013) and D.

Wanke. These resulted in a total of 4,586 data points after cleaning and removing duplicate records using the R programming environment (version 4.2.1; R Core Team 2022).

Species richness analysis

To map the species richness and endemic species we used the FSC plugin (version 3) for QGIS (3.24.2-Tisler; QGIS Development Team 2022). Species richness was generated once for all occurring species and once for the endemic species, in a grid of 1 degree size (approx. 90 × 110 km^2 for the study area) (Figs 1–2). This size of grid (1 degree) was used to reduce as much as possible the effect of sampling bias in our dataset.

In the next step, the elevation values for each occurrence data were extracted from the Global Digital Elevation Model (version 3; www.nasa.gov) in R and were used to generate a density graph of endemic and non-endemic species based on elevation, using the *ggplot2* package (Fig. 3).

Bioregionalization analysis

To define the bioregions with unique species composition, we used the network-based method embedded in "*Infomap Bioregions*", which has been shown to be a useful tool to delimit biodiversity patterns (Edler et al. 2017; Yusefi et al. 2019; https://www.mapequation.org/bioregions/). *Infomap* is an online interactive application to define bioregions based on species occurrence data using a network clustering algorithm. It clusters the bioregions using a bipartite network of both species occurrence and grid cells in which the species are present (Vilhena & Antonelli 2015; Edler et al. 2017). We tuned the application as follows: max and min cell size to 1 degree, max cell capacity to 200 and min cell capacity to 5, respectively, with the rest of the variables set as default. To reduce sensitivity to bias in the dataset, unweighted clustering with 10 trials was used. Finally, the bioregionalization map was plotted in QGIS. *Infomap* also generates a report that shows the common and indicator species that were considered to delimit the bioregions (Tab. 1).

Results

Species richness and distribution of endemic species

Most geometrid species have been recorded along the mountain ranges in the north, west, and south of Iran (Fig. 1). The two major mountain ranges, the Alborz Mts. in the north and the Zagros Mts. from northwestern to southern Iran, were recognized as areas with the most species diversity and a high number of endemic species. Moreover, there is a significant richness of species in the Kopet-Dagh mountains in the northeast of Iran, as well as in high-elevation mountain areas in the southern part of the central basin and southeast. The richness of species decreases towards the central basin desert plains. Additionally, as shown in Fig. 3, endemic species are restricted to regions with higher elevation compared to non-endemic species. While the species richness is much higher in the central Alborz Mts., the areas with higher endemism are located in the southern half across the central and southern parts of Zagros Mts., the mountains of Kerman and Hormozgan, and high elevation regions in the southeast, across the Taftan and Makran mountains.

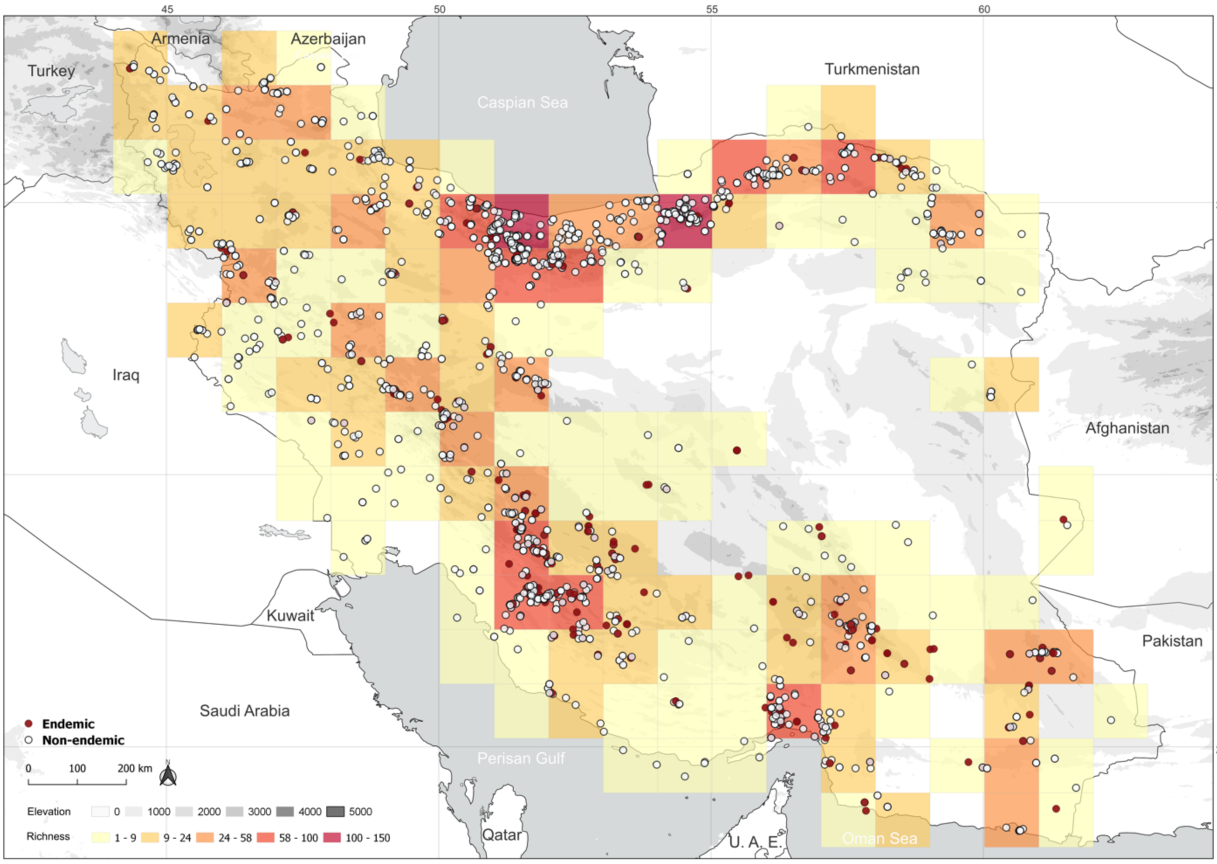

Figure 1. Species richness map for Geometridae of Iran. The map shows the species richness of the species across 1-degree grids and distribution of the occurrence for endemic (red) and non-endemic (white) species.

Bioregions

The bioregionalization analysis was able to recognize 12 bioregions according to the dataset for all species (Fig. 4). Although six of these bioregions are limited to a very small area, six major regions can be recognized across the country. For the most common species (MCS) and the main indicator species (MIS) for each bioregion, see Table 1.

Bioregion 1 is the largest bioregion and covers a vast area from northwestern to central Iran, extending almost throughout the Zagros Mts. and touching the southern regions of the Alborz mountains. Most of the Alborz Mts. and the southern shore of the Caspian Sea fall into bioregion 2, which stretches from southwestern Iran to south-east of the Caspian Sea. Bioregion 3 is mainly delineated by the mountainous area of Kopet-Dagh in the north-east.

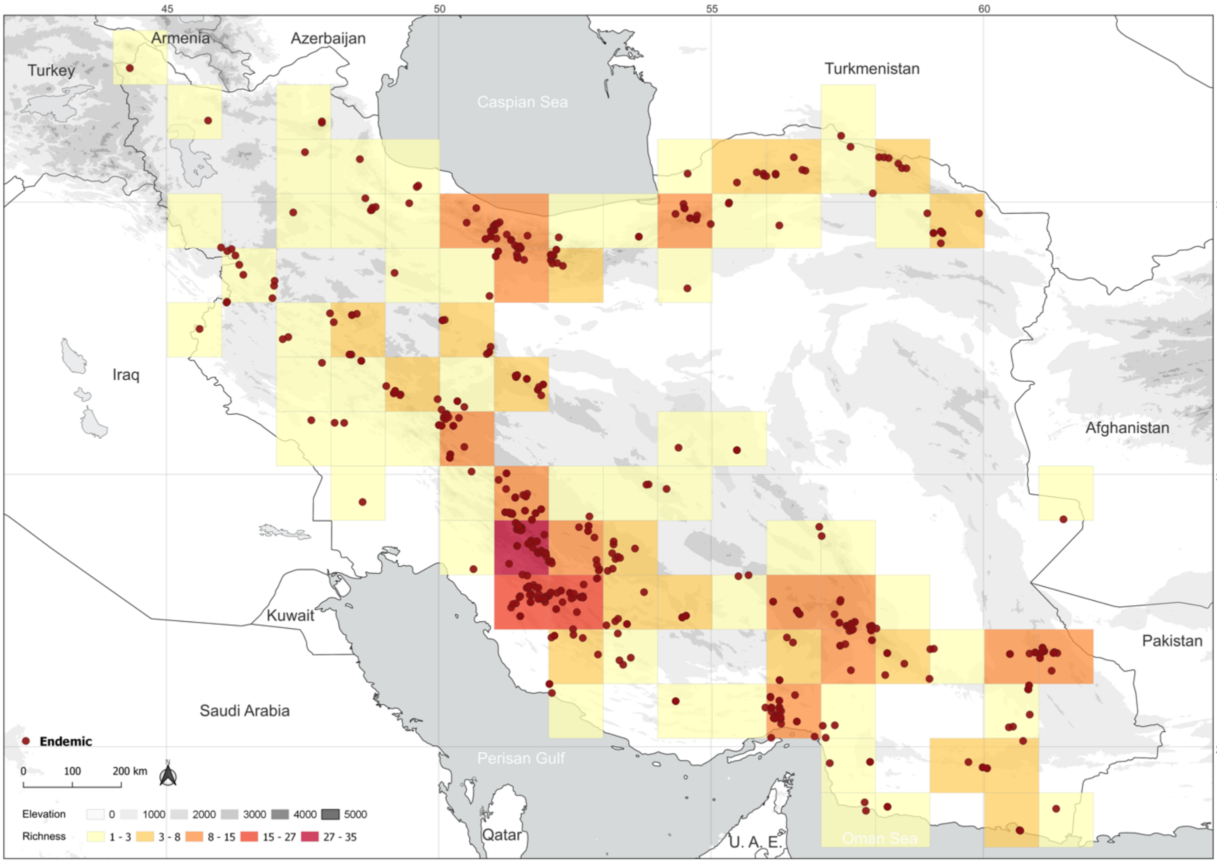

Figure 2. Species richness map for endemic Geometridae of Iran. The map shows the species richness of the species across 1-degree grids.

The Makran mountains, the coastal areas of the Oman Sea as well as parts of Khuzestan are covered by bioregion 4. Bioregion 5 mainly covers parts of the southern provinces in Kerman and Sistan-o-Baluchestan, extending over mountainous areas across the central basin. Bioregion 6 is fragmented along the western parts of Iran in Kermanshah, Bushehr, and Fars. Located in northern Iran, bioregion 7 is a unique region at the border with Armenia and Azerbaijan in the southern parts of the Caucasus. Bioregion 8 includes fragmented grid cells along with the western and southern slopes of Zagros Mts. and covering areas in Khuzestan, Ilam, and Fars. Bioregion 9 is also located in northern Iran, at the border with Armenia and Azerbaijan. The remaining three bioregions (10–12) have been identified as exceptionally unique regions. Bioregion 10 covers a small area in northeastern Fars, whereas bioregion 11 is located in Hamadan. Bioregion 12 is bordered by Turkmenistan and the Caspian Sea. According to our analysis, the southern and central parts of the Zagros Mts. can be considered as the region with the most complicated species structure for Geometridae, as at least five distinct bioregions meet in that mountain range.

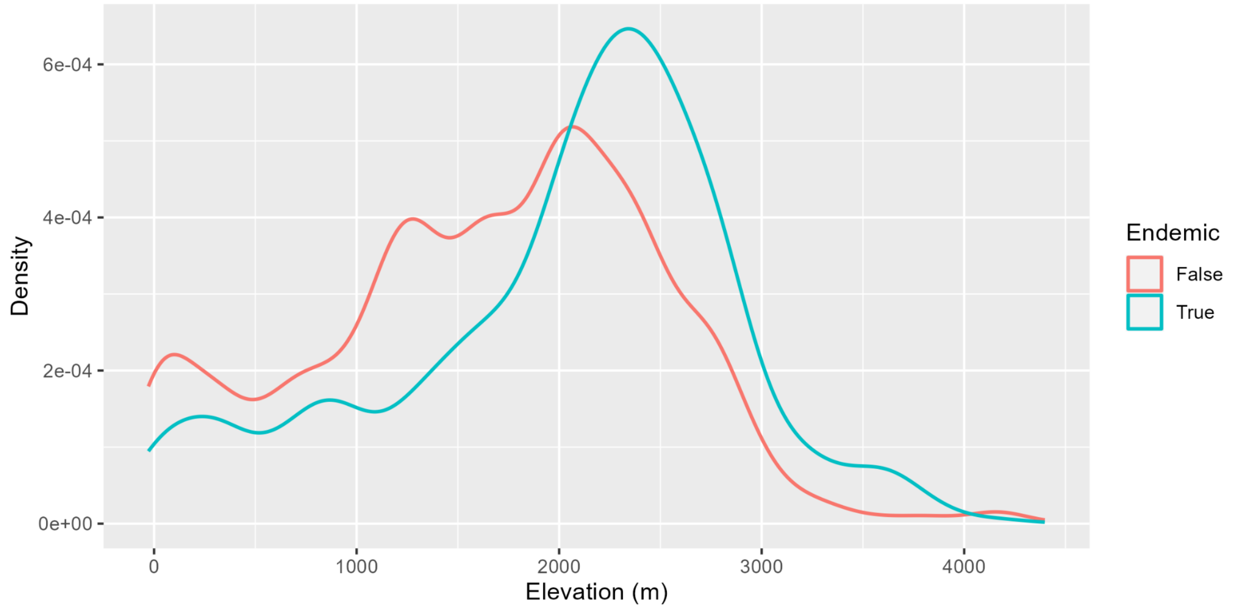

Figure 3. Preferences of altitudinal distribution of endemic (blue) and non-endemic species (red) in Iran.

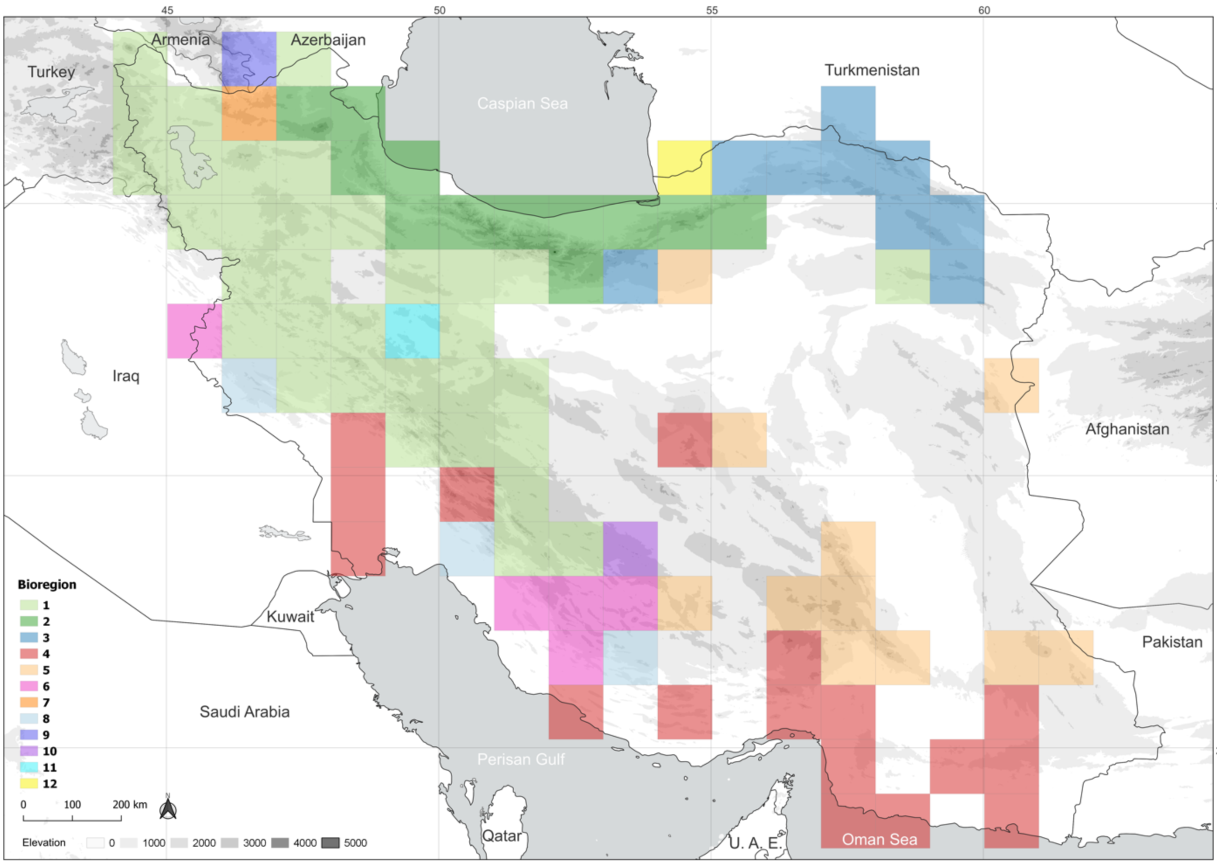

Figure 4. The map of bioregions for the Geometridae of Iran. The Infomap algorithm was able to recognize 12 bioregions in the country based on species occurrence. **1**: Azerbaijan – Zagros; Bioregion; **2**: Alborz; Bioregion **3**: Kopet-Dagh; Bioregion **4**: Makran– Khuzestan; Bioregion **5**: Baluchestan – Kerman – Khorasan; Bioregion **6**: Bushehr – Fars – Kermanshah; Bioregion **7**: Azerbaijan-e Sharghi; Bioregion **8**: Fars – Khuzestan – Ilam; **9**: Northern Azerbaijan; **10**: Northern Fars; **11**: Hamadan; **12**: Turkmen Plain.

Discussion

High species richness and endemism along with mountainous areas

Our results revealed a high species richness in the Alborz Mts. in the north, the Kopet Dagh mountains along the border with Turkmenistan, as well as the Zagros Mts. in the western half (Fig. 1–2). These mountain ranges have also been found as the most species rich areas for various species of plants (Noroozi et al. 2018 & 2019), animals, e.g, reptiles (Safaei-Mahroo et al. 2015; Kafash et al. 2020; Noori et al. 2021), mammals (Yusefi et al. 2019), and arthropods, e.g., ants, spiders, and burnet moths (Paknia et al. 2008; Keil 2014; Hofmann & Tremewan 2017; Zamani et al. 2018). These main mountain ranges fall within the Irano-Anatolian biodiversity hotspot, an area with high rates of endemism (Mittermeier et al. 1999; Noroozi et al. 2018). Moreover, the southeastern province Sistan-o-Baluchestan, along the border with Pakistan and Afghanistan, has been reported as a region with a high rate of species richness and endemism for various species groups (Hosseinzadeh et al. 2014; Dubatolov & Zahiri 2005; Hofmann & Tremewan 2017). For geometrids, similar findings were made by us for the Sistan-o-Baluchestan province, where the number of species is rather high along the Taftan and Makran Mts. In contrast to species richness, the regions with a high rate of endemism for Geometridae are more concentrated in the south of the country (Fig 2). Our results are in line with other studies showing a preference of the endemic species for higher elevations (Fig. 3; Noori et al. in prep; Noroozi et al. 2019). Some of the regions with high endemism are distributed across the high elevation regions of Alborz, Kopet-Dagh, and Zagros Mountains. However, most endemic species are found in the central and southern parts of the Zagros Mountains, in the high mountains of Kerman and Hormozgan, and in the eastern mountain regions of Taftan and Makran. One of the main reasons for this difference between areas with high species richness and areas with high rates of endemism could be the sampling bias towards the central Alborz regions near the country's capital, Tehran, where most of the entomological research centers are also located. Moreover, the Alborz Mts. have been and still are a classic destination for many European lepidopterists, due to the similarity of its fauna with that of Europe (Rajaei et al. 2023c). As shown in Fig. 3, the altitudinal distribution of the endemic species is also different from that of the non-endemic species. Most endemic geometrids are distributed at higher elevations (above 2000 m), as documented also for plants (Noroozi et al. 2018 & 2019) and Zygaenidae moths (Hofmann & Tremewan 2017). These higher elevations of the Iranian mountain ranges act as a barrier and corridor for biodiversity and provide a wide range of microhabitats (Ghaedi et al. 2021). However, there is some evidence that in the face of climate change and human activities such as habitat fragmentation, agricultural activities, overgrazing and fires, species common at high elevations will experience a decline in their current habitat suitability and shift to even higher elevations (Karimi & Jones 2020; Rödder et al. 2021).

Bioregionalization of the Geometridae fauna in Iran

Our analysis revealed six main bioregions (Fig. 4; bioregions 1–6), in which the common species count (CSC) is high and the indicator species score (ISS) is low due to the higher frequency of indicator species in other bioregions. In the remaining six scattered bioregions (Fig. 4; bioregions 7–12), the common species count (CSC) is low and rarely exceeds one record, but the indicator species score (ISS) is higher due to rare records and to the local distribution of indicator species. This is not surprising, as some provinces in Iran have been better studied than others in the past (Rajaei et al. 2023a). Furthermore, taxonomically well-studied genera (e.g., *Gnopharmia* Staudinger, 1892, *Nychiodes* Lederer, 1853, *Rhodostrophia* Hübner, 1823, *Scopula* Schrank, 1802) often include the most common species in a bioregion, but this pattern could change as most, and ideally all, genera are revised in the future. Rajaei et al. (2023a) highlighted the lack of data in understudied groups as a general problem for all Iranian Lepidoptera.

Bioregionalization analyses using high resolution data on the fauna of Iran have rarely been carried out due to insufficient data (Yusefi et al. 2019). For mammals, Yusefi et al. (2019) used almost 14,000 records of 188 species and identified seven bioregions using a network-based analysis. Our results are more or less in agreement with those of Yusefi et al. (2019), although a greater division into small bioregions is still evident for geometrids. Especially in the north of Iran along the Alborz, Zagros, and Kopet-Dagh mountain ranges, three main bioregions can be identified for geometrid moths, whereas this was not the case for mammals, as their bioregion 1 traverses the entire north of Iran. This reveals a complex pattern of species distribution for Geometridae (Fig. 4). Surprisingly, in our analysis, most bioregions are defined by non-endemic species and only bioregions 1, 2 and 5 are well defined by endemic species (Tab. 1). The three bioregions (10–12) we identified as unique are mostly inhabited by species in need of further investigation (Tab. 1). This pattern could change when more data are added to the dataset. However, the Turkmen plain in northeastern Iran had already been pointed out by Yusefi et al. (2019) as a small area with a high level of unique diversity.

Melting point of zoogeographical realms and species richness/bioregions

Iran, due to its position, is located where three zoogeographical realms, the Palearctic, Saharo-Arabian, and Oriental realms, meet (Holt et al. 2013). This result stemmed from analysis of distribution data for mammals, amphibians, and birds. It revealed that both the Zagros and Alborz Mountain ranges and the highlands of northwestern Iran fall within the Palearctic realm, whereas most of the remaining country falls within the Saharo-Arabian realm. Only a small area in the southeastern part of the country, on the border with Pakistan, may fall within the Oriental realm (Holt et al. 2013). Yusefi et al. (2019) followed this classification. However, according to our understanding, for geometrid moths most parts of the north and the central basin fall within the Palearctic realm and the Saharo-Arabian realm is restricted to the area from the Persian Gulf to the Oman Sea, towards the province Hormozgan. This area had been previously suggested as having a distinctive fauna (Dubatolov & Zahiri 2005) and flora (White & Léonard, 1991). Theoretically, two main intersection zones in southern Iran may be present. First, the melting point of the Palearctic and Saharo-Arabian realms in the southwestern part of the Zagros Mts. in Khuzestan and Fars provinces and, second, the melting point of all three realms in the Kerman, Hormozgan, and Sistan-o-Baluchestan provinces.

The lowland region of Khuzestan, with hot and moist weather, is separated by the high elevation mountains of the Zagros range from the central basin. The fauna of this region is similar to that of the provinces north of the Persian Gulf, Bushehr, and Hormozgan, and has an affiliation with the Mesopotamian fauna of Iraq, which is represented by multiple geometrid species, e.g., *Lithostege dissocyma* Prout, 1938, *Neromia pulvereisparsa* (Hampson, 1896) and *Scopula adelpharia* (Püngeler, 1894). These regions are mainly grouped together in bioregion 4 and have been suggested as constituting a unique area with a distinct fauna based on other species (Dubatolov & Zahiri 2005). For example, in the most pioneering work on the bioregionalization of animals in Iran, Blanford (1876) considered the region as Mesopotamian and Persian Gulf shore area. Paknia and Pfeiffer (2011) suggested this region as one of four distinct ecoregions for Iranian ants (Nubo-Sindian), and Mozaffarian (2013) reported it as the Baluchistan and Persian Gulf coast biogeographic region for Fulgoromorpha (Auchenorrhyncha). This region is more or less compatible with the Saharo-Sindian phytogeographic subdivision of the flora (White & Léonard 1991).

The southeastern area of the Sistan-o Baluchestan province represents the westernmost are of distribution of some Oriental species of mammals, such as the Asiatic black bear (*Ursus thibetanus* Cuvier, 1823), the palm squirrel (*Funambulus pennanti* Wroughton, 1905), and the Indian crested porcupine (*Hystrix indica* Kerr, 1792; Yusefil et al. 2019). In the case of

Geometridae, this is the case for *Gonodontis clelia* (Cramer, [1780]), *Hemithea punctifimbria* Warren, 1896, *Hyperythra swinhoei* Butler, 1880, *Microloxia indecretata* (Walker, 1963), *Pseudosterrha paulula* (Swinhoe, 1887), *Zamarada minimaria* Swinhoe, 1895, and *Zygophyxia relictata* (Walker, 1866). These seven species represent the Oriental fauna present in Iran, as their origin and main distribution area lie in Pakistan and India (Rajaei et al. 2022).

Conclusion

The results of the bioregionalization analysis for Geometridae imply the presence of melting points between three zoogeographical realms in southern Iran. The faunal elements of Geometridae are very specific here, which is visible from the subdivision into a wide variety of bioregions. Still, finding the buffer area between these realms requires further investigation.
The outcomes of our analysis help to explain the outstanding heterogeneity of biodiversity in southern Iran and illustrate the importance of these transition zones, in which many different faunal elements come together creating a biodiversity hotspot. Thus, making the transition zones important regions for conservation efforts. Nevertheless, further studies are needed to substantiate our results, and an analysis for all Iranian Lepidoptera, and ideally other groups, would be a valuable and interesting addition to support our findings.

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Table 1. Bioregions identified by a network-based method using Infomap with most common species and indicator species in each bioregion. Abbreviations: CSC = common species count; ISS = indicator species score. Note. Indicator species score shows how frequent a species is in a bioregion compared with the other bioregions. For example, a score of 2 means the species is twice frequent in its bioregions compared to other bioregions. Endemic species are indicated with a star (*).

Bioregion	Most common species	CSC	Indicator Species	ISS
Bioregion 1 **Azerbaijan – Zagros**	*Scopula beckeraria* (Lederer, 1853)	70	*Holoterpna pruinosata* (Staudinger, 1898)	1.94
	Gnopharmia colchidaria (Lederer, 1870)	60	*Eupithecia truschi* Mironov & Ratzel, 2012 *	1.94
	Scopula transcaspica Prout, 1935	45	*Gypsochroa renitidata* (Hübner, 1817)	1.94
	Nychiodes divergaria Staudinger, 1892	44	*Euphyia scopulata* Brandt, 1938 *	1.94
	Scopula marginepunctata (Goeze, 1781)	42	*Euphyia farsica* Brandt, 1941 *	1.94
	Rhodostrophia auctata (Staudinger, 1879)	40	*Dicrognophos culminata* (Brandt, 1938) *	1.94
	Scopula sacraria (Bang-Haas, 1910)	36	*Lithostege stadiei* Lehmann, 2011 *	1.94
	Gnopharmia irakensis Wehrli, 1938	36	*Ennomos fuscantaria* (Haworth, 1809)	1.94
	Thetidia persica Hausmann, 1996	34	*Kresnaia beschkovi* (Ganev, 1987)	1.94
	Rhodostrophia tumulosa Brandt, 1938	34	*Eupithecia zagrosata* Mironov & Ratzel, 2012 *	1.94
Bioregion 2 **Alborz**	*Euphyia frustata* (Treitschke, 1828)	39	*Hydria montivagata* (Duponchel, 1830)	3.49
	Scopula marginepunctata	37	*Hydrelia chionata* (Lederer, [1871])	3.49
	Xanthorhoe rectifasciaria (Lederer, 1853)	34	*Opisthograptis luteolata* (Linnaeus, 1758)	3.49
	Ourapteryx persica (Ménétries, 1832)	27	*Macaria notata* (Linnaeus, 1758)	3.49
	Hydria montivagata	26	*Scopula nigropunctata* (Hufnagel, 1767)	3.49
	Thetidia persica	24	*Selenia forsteri* Wehrli, 1941	3.49
	Scotopteryx sterilis (Prout, 1938)	23	*Charissa annubilata* (Christoph, 1885)	3.49
	Rhodostrophia terrestraria (Lederer, 1869)	23	*Eupithecia extraversaria* Herrich-Schäffer, 1848	3.49
	Aplocera plagiata (Linnaeus, 1758)	21	*Cabera pusaria* (Linnaeus, 1758)	3.49
	Scotopteryx vicinaria (Duponchel, 1830)	20	*Nebula approximata* (Staudinger, 1879)	3.49
Bioregion 3 **Kopet-Dagh**	*Scopula beckeraria*	20	*Idaea laszloi* Hausmann, 1997	6.80
	Scopula marginepunctata	20	*Charissa stachyphorus* (Wehrli, 1936)	6.80
	Thetidia fulminaria (Lederer, 1871)	17	*Cinglis eurata* (Prout, 1913)	6.80
	Gnopharmia colchidaria	17	*Scotopteryx kurmanjiana* Rajaei & László, 2014 *	6.80
	Phaselia pithana Wehrli, 1941	15	*Nebula longipennis* (Brandt, 1941) *	6.80
	Aplocera plagiata	12	*Stegania dalmataria* Guenée, [1858]	6.80
	Scopula transcaspica	12	*Scopula subtilata* (Christoph, 1867)	6.80
	Cataclysme riguata (Hübner, [1813])	11	*Phyllometra culminaria* (Eversmann, 1843)	6.80
	Rhodostrophia abscisaria Brandt, 1941	10	*Menophra lederi* (Christoph, 1887)	6.80
	Camptogramma bilineata (Linnaeus, 1758)	10	*Lycia necessaria* (Zeller, 1849)	6.80
Bioregion 4 **Makran–Khuzestan**	*Pingasa lahayei* (Oberthür, 1887)	35	*Coenina collenettei* Prout, 1931	3.89
	Xanthorhoe wiltshirei (Brandt, 1941)	21	*Microloxia indecretata* (Walker, 1963)	3.89
	Hemidromodes sabulifera Prout, 1922	18	*Isturgia disputaria* (Guenée, 1858)	3.89
	Gnopharmia kasrunensis Wehrli, 1939	17	*Pseudosterrha paulula* (Swinhoe, 1887)	3.89
	Scopula gracilis (Brandt, 1941)	16	*Nebula saidabadi* (Brandt, 1941) *	3.89
	Scopula chalcographata (Brandt, 1938)	14	*Idaea sanctaria* (Staudinger, 1900)	3.89
	Gnopharmia colchidaria	12	*Gonodontis clelia* (Cramer, [1780])	3.89

	Gnophosema isometra (Warren, 1888)	11	*Idaea mimetes* (Brandt, 1941)	3.89
	Phaselia erika Ebert, 1965	10	*Isturgia hedemanni* (Christoph 1885)	3.89
	Pasiphila palaearctica	10	*Scopula luridata* (Zeller, 1847)	3.89
Bioregion 5 **Baluchestan – Kerman – Khorasan**	*Nychiodes subvirida* Brandt, 1938	14	*Rhodostrophia vahabzadehi* Rajaei, Hausmann & Trusch, 2022*	9.71
	Rhodostrophia phaenicearia (Hampson, 1907)	13	*Eupithecia aradjouna* Brandt, 1938 *	9.71
	Scopula transcaspica	13	*Thetidia recta* (Brandt, 1941) *	9.71
	Nychiodes divergaria	12	*Charissa taftana* (Brandt, 1941) *	9.71
	Gnopharmia colchidaria	12	*Gnophosema palumba* Brandt, 1938 *	9.71
	Rhodostrophia nesam Brandt, 1938	12	*Isturgia sengana* (Brandt, 1940) *	9.71
	Scotopteryx fuscofasciata (Brandt, 1938)	11	*Eupithecia nachadira* Brandt, 1941	9.71
	Rhodostrophia terrestraria	9	*Lithostege samandooki* Rajaei, 2011 *	9.71
	Dyscia malatyana Wehrli, 1934	9	*Thetidia persica*	9.71
	Scopula chalcographata	9	*Rhoptria mardinata* (Staudinger, 1900)	9.71
Bioregion 6 **Bushehr – Fars – Kermanshah**	*Gnopharmia colchidaria*	23	*Dicrognophos sartata* (Treitschke, 1827)	5.91
	Gnopharmia kasrunensis	20	*Crocallis tusciaria* (Borkhausen, 1793)	5.91
	Pingasa lahayei	17	*Idaea palaestinensis* (Sterneck, 1933)	5.91
	Nychiodes divergaria	16	*Heterobapta plumellata* Wiltshire, 1943 *	5.91
	Scopula beckeraria	16	*Eupithecia cheituna* Brandt, 1938 *	5.91
	Nychiodes subvirida	15	*Eupithecia brandti* Mironov & Ratzel, 2012 *	5.91
	Protorhoe centralisata (Staudinger, 1892)	14	*Ramitia ghirshmani* (Wiltshire, 1944)	5.91
	Rhodostrophia nesam	11	*Costaconvexa polygrammata* (Borkhausen, 1794)	5.91
	Scopula chalcographata	10	*Isturgia hopfferaria* (Staudinger, 1879)	5.91
	Catarhoe rubidata ([Denis & Schiffermüller], 1775)	10	*Eupithecia sectila* Brandt, 1938 *	5.91
Bioregion 7 **Azerbaijan-e Sharghi**	*Rhodostrophia sieversi* (Christoph, 1882)	2	*Synopsia sociaria* (Hübner, 1799)	68.00
	Gymnoscelis rufifasciata (Haworth, 1809)	2	*Scopula rubiginata* (Hufnagel, 1767)	68.00
	Philereme transversata (Hufnagel, 1767)	2	*Eupithecia linariata* ([Denis & Schiffermüller], 1775)	68.00
	Xanthorhoe fluctuata (Linnaeus, 1758)	2	*Ematurga atomaria* (Linnaeus, 1758)	68.00
	Euphyia frustata	1	*Idaea straminata* (Borkhausen, 1794)	34.00
	Cyclophora annularia (Fabricius, 1775)	1	*Charissa ciscaucasica* (Rjabov, 1964)	34.00
	Camptogramma bilineata	1	*Abraxas grossulariata* (Linnaeus, 1758)	34.00
	Eupithecia icterata (Villers, 1789)	1	*Triphosa dubitata* (Linnaeus, 1758)	22.67
	Dyscia negrama Wehrli, 1953	1	*Idaea ochrata* (Scopoli, 1763)	22.67
	Ematurga atomaria	1	*Gnopharmia colchidaria*	22.67
Bioregion 8 **Fars – Khuzestan – Ilam**	*Scopula marginepunctata*	3	*Ascotis selenaria* ([Denis & Schiffer-müller], 1775)	45.33
	Ascotis selenaria	3	*Chlorissa cloraria*	45.33
	Phaiogramma etruscaria	3	*Idaea mancipiata* (Staudinger, 1871)	30.22
	Protorhoe unicata (Guenée, [1858])	2	*Protorhoe unicata*	15.11
	Isturgia arenacearia ([Denis & Schiffermüller], 1775)	2	*Ochodontia adustaria* (Fischer de Waldheim, 1840)	15.11
	Ochodontia adustaria	2	*Isturgia arenacearia*	15.11
	Scopula turbulentaria (Staudinger, 1870)	2	*Idaea elongaria* (Rambur, 1833)	15.11
	Idaea mancipiata	2	*Cinglis humifusaria* (Eversmann, 1837)	15.11
	Digrammia rippertaria (Duponchel, 1830)	1	*Chiasmia clathrata* (Linnaeus, 1758)	15.11

	Eilicrinia subcordaria Herrich-Schäffer, 1852	1	*Eilicrinia subcordaria*	11.33
Bioregion 9 **Northern Azerbaijan**	*Chiasmia aestimaria* (Hübner, [1809])	1	*Idaea inquinata* (Scopoli, 1763)	34.00
	Gymnoscelis rufifasciata	1	*Timandra comae* Schmidt, 1931	27.20
	Idaea inquinata	1	*Scopula minorata* (Boisduval, 1833)	22.67
	Idaea persidis (Wiltshire, 1966)	1	*Idaea persidis* *	12.36
	Microloxia herbaria (Hübner, 1813)	1	*Microloxia herbaria*	6.80
	Scopula beckeraria	1	*Chiasmia aestimaria*	6.18
	Scopula minorata	1	*Gymnoscelis rufifasciata*	4.12
	Timandra comae	1	*Scopula beckeraria*	1.00
Bioregion 10 **Northern Fars**	*Gnopharmia kasrunensis* Wehrli, 1939	5	*Synopsia centralis* (Wiltshire, 1966) *	27.20
	Gnopharmia irakensis	3	*Nyssiodes rhodopolitis* Wehrli, 1939 *	27.20
	Nychiodes divergaria	2	*Dicrognophos orthogonia* (Wehrli, 1939)	27.20
	Gnopharmia colchidaria	2	*Cinglis benigna* (Brandt, 1941) *	27.20
	Casilda consecraria (Staudinger, 1871)	1	*Casilda consecraria*	4.53
	Cinglis benigna	1	*Scopula orientalis* (Alphéraky, 1876)	3.40
	Dicrognophos orthogonia	1	*Gnopharmia kasrunensis* *	2.47
	Oulobophora externaria (Herrich-Schäffer, 1848)	1	*Oulobophora externaria*	1.94
	Nyssiodes rhodopolitis	1	*Gnopharmia irakensis*	1.36
Bioregion 11 **Hamadan**	*Gnopharmia irakensis* Wehrli, 1938	2	*Dicrognophos euryticHes* (Brandt, 1941) *	68.00
	Aplocera fraternata (Herrich-Schäffer, 1861)	1	*Aplocera fraternata*	68.00
	Dicrognophos eurytiches	1	*Eupithecia silenicolata* Mabille, 1867	34.00
	Eilicrinia subcordaria	1	*Eupithecia adjemica* Brandt, 1941	34.00
	Eupithecia adjemica	1	*Eilicrinia subcordaria*	17.00
	Eupithecia silenicolata	1	*Thetidia crucigerata* (Christoph, 1887)	2.43
	Scopula sacraria	1	*Gnopharmia irakensis*	2.27
	Scopula transcaspica	1	*Scopula sacraria*	1.15
	Thetidia crucigerata	1	*Scopula transcaspica*	0.67
Bioregion 12 **Turkmen Plain**	*Catarhoe arachne* Wiltshire, 1967	2	*Brachyglossina staudingeri* (Prout, 1932)	68.00
	Agriopis bajaria ([Denis & Schiffermüller], 1775)	1	*Catarhoe arachne*	13.60
	Apochima flabellaria (Heeger, 1838)	1	*Dicrognophos brandtorum* (Wehrli, 1941)	11.33
	Brachyglossina staudingeri	1	*Apochima flabellaria*	11.33
	Dicrognophos brandtorum	1	*Agriopis bajaria*	9.71
	Dyscia malatyana	1	*Dyscia malatyana*	3.24
	Thetidia crucigerata	1	*Thetidia crucigerata*	2.43

III Discussion

In the following section, the results of all research papers on the biodiversity of Iranian Geometridae are discussed. The discussion is divided into three parts, each covering one aspect of this research, respectively taxonomy, systematics and biogeography.

Integrative taxonomic revisions of Iranian geometrid moths

Taxonomic revisions are essential for the understanding of species concepts, as they deal with misinterpretations and errors and contribute to establishing the identity of taxa (Bolton 2007; Lastrucci et al. 2014). Moreover, by conducting revisions, researchers collect label data to plot the distribution ranges of species, and these data can be a valuable resource crucial to further research and species conservation (Meier & Dikow 2004).

For the fauna of Iran, taxonomic revisions of many lepidopteran genera, including geometrid moths, are urgently needed (Rajaei et al. 2023c). Before 2010, research on the family Geometridae in Iran was limited to faunistic data or sporadic descriptions of new taxa (see the historical part of the Introduction), but complete genus revisions were rare (Ebert 1968; Hausmann 1994a, 1994b). This changed as more researchers began to study the geometrid faunas of Middle Eastern countries in the course of taxonomic revisions of various genera of the subfamilies Larentiinae (Mironov & Ratzel 2012a; Rajaei 2012; Rajaei et al. 2011; 2017; Wanke et al. 2019), Ennominae (Rajaei et al. 2012) and Geometrinae (Feizpour et al., in prep.). In the course of the present thesis, important contributions to the subfamilies Sterrhinae, Geometrinae and Ennominae were made, which are presented in the following section, with open questions highlighted.

The subfamily Sterrhinae was the focus of research papers 1 and 2. It includes two of the most species-rich genera, *Scopula* (tribe Scopulini) and *Idaea* Treitschke, 1825 (tribe Sterrhini) (Rajaei et al. 2022a), which are also hard to identify, leading to misidentifications and misinterpretations in the past.

Research papers 1 and 2 highlight the Scopulini tribe through revision of the whole tribe and provide tools for their unambiguous identification as well as an understanding of the distribution patterns of its species in Iran. According to these two studies, the Scopulini are now represented by 33 confirmed species in Iran (30% of the biodiversity of the subfamily Sterrhinae in Iran). Eight species are still unconfirmed and their distribution in Iran requires further investigation.

Two other large genera of the subfamily Sterrhinae are *Rhodostrophia* Hübner, 1823, which was recently revised by Rajaei et al. (2022b) and *Idaea*. The genus *Idaea*, with 43 known species, represents 35% of the species of this subfamily in Iran and is the only genus left within Sterrhinae that needs revision. In the course of this work, research on Iranian *Idaea* has already begun, which could not be avoided because some *Scopula* species can be confused with *Idaea* species and vice versa (Hausmann 2004).

Research Paper 3 deals with the first emerald moth (Geometrinae) ever described from Iran, and the second Geometridae ever mentioned for the country (see history part of the Introduction). Described by Kollar (1850) as *Phorodesma graminaria*, this endemic species was assigned to the genus *Xenochlorodes* (Scoble 1999; Scoble & Hausmann 2007). During this study, morphological dissimilarities with the genus *Xenochlorodes* were observed, which was confirmed by an intense survey. As none of the known genera of the subfamily shared the characters of this taxon, a new genus (*Sabzia*) was established. The tribal assignment of the genus *Sabzia* is not yet clear, as no fresh material was available during this project. This will have to be solved in the future by a multi-gene molecular phylogeny including the species of this genus. Since the remaining Geometrinae of Iran have already been successfully processed (Feizpour et al., in prep.), the assignment of this taxon to a new genus provided the last piece of the puzzle towards a more complete understanding of the subfamily.

The subfamily Ennominae was the target of research papers 4–9, with a special focus on three genera: *Nychiodes*, *Synopsia* and *Eumera*.

Most species of the genus *Nychiodes* are found in the Middle East, making this region a hotspot for this group. Although the European fauna of this genus was recently revised (Müller et al. 2019), the fauna of this genus in the Middle East and Central Asia was still in need of urgent revision. Research papers 4–6 provide a revision of the genus *Nychiodes* in these regions. The intensive study of external and internal characters uncovered a strikingly high intraspecific variation in these characters in some of the species (e.g., *N. divergaria* Staudinger, 1892). These variations made greatly confused species identification in the past and led to the unnecessary description of several taxa. Most of those taxa are considered as synonyms here. The illustration of these character variations allows a reliable species identification. Additionally, new data were added to their biology, such as for *N. divergaria*, which shows an incredibly broad intraspecific variation and can be a pest in plantations of cultivated *Prunus* species, such as apricot, peach and plum (Wiltshire 1957; Bolu 2019).

A similar case of high intraspecific variation was observed in the genus *Synopsia*, which received special attention in research papers 7 and 8. In these two research papers, after understanding the intraspecific variation in external and internal characters, seven subspecies were synonymized or confirmed as synonyms of the nominotypical subspecies *Synopsia* *phasidaria phasidaria*. The species *Synopsia phasidaria* was assigned to the genus *Synopsidia* in earlier classifications. This genus was synonymized with *Synopsia* in research paper 6 and the species was combined with the genus *Synopsia*.

Research paper 9 provides insights on the genus *Eumera*, which has its main area of distribution in south-eastern Europe, the Middle East and Central Asia (Skou & Sihvonen 2015). This paper highlights the characters of Iranian species in this genus and describes a new species from Iran. For the Ennominae, most Iranian genera have now been revised or are only represented by one or two species in Iran (Rajaei et al. 2023c). Just a few genera (e.g., *Charissa* Curtis, 1826, *Dicrognophos* Wehrli, 1951, *Isturgia* Hübner, 1823) still await further investigation (Rajaei et al. 2023c). Until recently, this was also true for the genus *Phaselia* Guenée, [1858], but this genus was recently the subject of an elaborate revision by Werner et al. (2023).

In conclusion, these taxonomic publications have contributed greatly to our understanding of the family Geometridae in Iran. They provide a helpful tool and an important basis for further research in the Middle East and Central Asia, as several of the treated species are also distributed in Iran's neighboring countries.

In the course of the research listed above, one new genus and four new species were described, several new taxonomic changes were made, and three new faunistic records were provided for various countries, as summarized hereafter:

List of new taxa, taxonomic changes and new records introduced in this work

Sabzia Wanke & Rajaei, 2022 **new genus**

Nychiodes convergata Hausmann, Wanke & Rajaei, 2020 **new species**
Nychiodes mirzayansi Wanke, Hausmann & Rajaei, 2020 **new species**
Nychiodes eberti Wanke, Hausmann & Rajaei, 2020 **new species**
Eumera rajaeii Wanke & Shirvani, 2023 **new species**

Cinglis Guenée, 1858 **re-validated at genus level**
    = *Pseudocinglis* Hausmann, 1994 **new synonym**
Scopuloides Hausmann, 1994 **re-validated at genus level**
Scopula Schrank, 1802
    = *Glossotrophia* **new synonym**
Synopsia Hübner, 1825
    = *Synopsidia* Djakonov, 1935 **new synonym**

Problepsis wiltshirei (Prout, 1938) **new combination**
Cinglis benigna benigna (Brandt, 1941) **new combination**
    Cinglis benigna amseli (Wiltshire, 1967) **new synonym**
C. benigna nigromaculata (Hausmann, 1994) **new combination**

Cinglis eurata (Prout, 1913) **new combination**
Scopula adulteraria (Erschov, 1874) **new status**
S. flaccidaria (Zeller, 1852)
= *Scopula iranaria* Bytinski-Salz & Brandt, 1937 **new synonym**
S. transcaspica Prout, 1935
= *S. transcaspica taftanica* Brandt, 1941 **new synonym**
S. diffinaria (Prout, 1913)
= *S. diffinaria asiatica* (Brandt, 1938) **new synonym**
Scopula sacraria ariana (Ebert, 1965)
= *Glossotrophia bullata* Vojnits, 1986 **new synonym**
Sabzia graminaria (Kollar, 1850) **new combination**
= *Xenochlorodes albicostaria* Brandt, 1938, **new synonym**
Nychiodes waltheri Wagner, 1919;
= *Nychiodes waltheri saerdabica* Wehrli, 1938 **new synonym**
Nychiodes palaestinensis Wagner, 1919
= *N. palaestinensis libanotica* Zerny, 1933 **new synonym**
Nychiodes admirabila Brandt, 1938;
= *N. admirabila safidaria* Wiltshire, 1943 **new synonym**
Nychiodes subvirida Brandt, 1938
= *N. agatcha* Brandt, 1938 **new synonym**
= *N. subvirida disjuncta* Wehrli, 1941 **new synonym**
= *N. subvirida taftana* Brandt, 1941 **new synonym**
Nychiodes divergaria Staudinger, 1892
= *N. variabila variabila* Brandt, 1938 **new synonym**
= *N. variabila opulenta* Brandt, 1941 **new synonym**
= *N. divergaria elbursica* Wehrli, 1937 **new synonym**
= *N. divergaria fallax* Wehrli, 1939 **new synonym**
= *N. divergaria achtyca* Wehrli, 1939 **new synonym**
Aphilopota tyttha (Prout, 1915) **new combination**
Synopsia phasidaria phasidaria (Rogenhofer, 1873) **new combination**
= *S. phasidaria alvandi* Wiltshire, 1966 **new synonym**
= *S. phasidaria ardschira* Brandt, 1938 **new synonym**
= *S. phasidaria chiraza* Brandt, 1938 **new synonym**
= *Hashtaresia jodes* Wehrli, 1936 **new synonym**
= *S. phasidaria mirabica* Wehrli, 1941 **new synonym**
= *S. phasidaria phasidaria* (Rogenhofer, 1873) **new synonym**
Synopsia phasidaria afghana (Wiltshire, 1966) **new combination**
Synopsia centralis (Wiltshire, 1966) **new combination, raised to species rank**

Problepsis wiltshirei (Prout, 1938) **new for the fauna of Turkey**
Nychiodes antiquaria Staudinger, 1892 **new for the fauna of Pakistan**
Nychiodes rayatica Wiltshire, 1957 **new for the fauna of Iran**

Contributions to the systematics of Sterrhinae and Ennominae

In this part, with special focus on the two subfamilies Sterrhinae and Ennominae, the phylogenetic placement of several genera with distribution in Iran was studied. The phylogenetic relationships of the family Geometridae have been the subject of molecular studies in recent years (Murillo-Ramos et al. 2019; Sihvonen et al. 2020), but many genera in little-studied regions (like Iran) are still missing from many of those studies (Rajaei et al. 2022a).

The subfamily Sterrhinae is a highly diverse group, and past classifications were based on morphological characters (e.g., Holloway 1997; Hausmann 2004; Sihvonen 2005) and later on molecular phylogenetic studies (Sihvonen et al. 2011, 2020). The dataset of Sihvonen et al. (2020), including 1,192 taxa of Geometridae, provided the basis for this part of the thesis. Within the Sterrhinae, taxa of the tribe Scopulini were the target in research papers 1 & 2.

Prior to this study, the genera *Somatina* Guenée, [1858] and *Problepsis* were both represented by one species in Iran (*S. wiltshirei* (Prout, 1938) and *P. cinerea* (Butler, 1886)), which were the focus of research paper 1. The morphological character used in traditional classifications within the Scopulini was the number of areoles on the forewing: the genera *Problepsis* and *Scopula* with one areole, and the genus *Somatina* with two areoles (Sihvonen 2005). This character was found to be homoplastic and not diagnostic by Sihvonen (2005), as two areoles also are present in *Problepsis* and *Scopula* species. Since then, various studies have been done to reclassify the erroneously placed species in the genus *Somatina* (Sihvonen 2005; Xue et al. 2018; Sihvonen et al. 2020). Here, the type species of the genus *Somatina* (*S. anthophilata* Guenée, [1858]) and the two taxa also distributed in Iran were added to the Sterrhinae dataset (Sihvonen et al. 2020), which provided clear evidence to reclassify the taxon *Somatina wiltshirei* as *Problepsis wiltshirei*.

Research paper 2 deals with the genera *Cinglis*, *Glossotrophia*, *Pseudocinglis* and *Scopuloides*, whose status had been repeatedly questioned by several authors (Hausmann 1993, 2004; Sihvonen 2005; Õunap 2010; Müller et al. 2019). Hausmann (1993, 2004) treated *Cinglis*, *Glossotrophia*, *Pseudocinglis* and *Scopuloides* as valid at the genus level, while Sihvonen (2005) regarded them as synonyms of *Scopula*. *Glossotrophia* was treated at the genus level by Õunap (2010) and as a subgenus of *Scopula* by Müller et al. (2019). Among the different available classifications resulting from the analysis in research paper 2, a treatment of *Cinglis* and *Scopuloides* at the genus level was supported. *Pseudocinglis* was regarded as a synonym of the genus *Cinglis*, and the synonymy of *Glossotrophia* with the genus *Scopula* was confirmed.

The Ennominae subfamily includes almost half (47%) of all Geometridae and its systematics has been targeted in various morphological (e.g., Holloway 1994; Pitkin 2002; Beljaev 2006) or molecular (e.g., Young 2006; Õunap et al. 2011; Sihvonen et al. 2011; Murillo-Ramos et al. 2019) studies. To clarify questions concerning the systematics of two genera of Ennominae in research papers 6 and 9, the dataset published by Murillo-Ramos et al. (2019) was used, which included 1,206 geometrid taxa.

Research paper 6 clarifies the classification of the taxon '*Nychiodes tyttha*', whose generic assignment was questioned during the taxonomic revision of the genus *Nychiodes* (see research paper 4). During the investigation of the genus *Nychiodes*, this taxon showed strong morphological differences in genitalia characters which did not fit with those of the genus *Nychiodes*. During the taxonomic revision of the genus *Nychiodes*, an assignment of the taxon '*Nychiodes tyttha*' to another genus was not possible based only on morphology. The results of the multi-gene analysis supported a reclassification of this species within the genus *Aphilopota* Warren, 1899, which was supported by morphology. For the genus *Aphilopota*, Rajaei et al. (2022a) listed 44 species and seven subspecies, all in need of urgent revision in order to understand the concept of this genus. The assignment of t*yttha* to the genus *Aphilopota* provided additional molecular and morphological data for further research on this genus.

In research paper 9, the tribal assignment of the genus *Eumera*, which was still uncertain, was investigated (Müller et al. 2019). In earlier studies it was placed in the tribe Colotoini by Viidalepp (1996) and assigned to the Ennomini by Hausmann et al. (2011).

As the newly-collected specimens of *Eumera* species from southern Iran were suitable for molecular analyses, mitochondrial and nuclear genes could be successfully amplified from them. The results allowed to include this genus in the tribe Prosopolophini, which was also supported by morphology.

In summary, the inclusion of the Sterrhinae and Ennominae genera in multi-gene phylogenies contributed to producing a more stable classification and is a step forward to establishing monophyletic groups within those subfamilies. The results allow a better understanding of the evolutionary history of geometrid moths and provide a basis for the study of character evolution.

A network-based method to classify Iran into bioregions using geometrid moths

The identification of regions consisting of specific assemblages of species, so-called bioregions, provides important insights for conservation efforts, biogeography, evolution and ecology (Vilhena & Antonelli 2015; Edler et al. 2017). The discovery that the biota of the world can be divided into regions with special species compositions was already made in the 19th century by naturalists such as Wallace, who divided the world into zoogeographical realms (Wallace 1876; Holt et al. 2013; Vilhena & Antonelli 2015; Edler et al. 2017). However, there is no universal approach for the bioregionalization of taxa, as they are tied to specific factors such as the interaction of butterflies and moths with their food plants, which impacts their distribution (Scoble 1992; Edler et al. 2017).

Regarding Iran, bioregions for different taxa of terrestrial (e.g., Anderson 1968; Scott et al. 1975) and aquatic vertebrates (Coad 1987) have been defined. The most recent and best dataset was used by Yusefi et al. (2019) and contained more than 14,000 distribution records of 188 mammal species. As a result of their analysis, Yusefi et al. (2019) divided Iran into eight bioregions, some of which are very local and unique, with very special species compositions.

For invertebrates, bioregionalization studies are rare and only a few studies have been done on very few taxa of the order Lepidoptera (Naumann 1987; Dubatolov & Zahiri 2005; Matov et al. 2008) or the order Hemiptera (Mozaffarian 2013).

In research paper 10, Iran was divided into bioregions using the largest data set for geometrid moths to date and a network-based method implemented in "Infomap Bioregions" (Edler et al. 2017).

"Infomap Bioregions" has been shown to be a useful tool for the bioregionalization of biota worldwide (e.g., Droissart et al. 2018; Hazzi et al. 2018; Chan & Grismer 2021).

In the present study, the Geometridae dataset contained 4,586 distribution records for 539 species, which revealed a high species richness in the two main mountain ranges (Zagros Mts. and Alborz Mts.) and an occurrence of endemic species in the higher altitudinal zones of these mountain ranges. Moreover, it divided Iran into six main bioregions, which largely coincides with the results of Yusefi et al. (2019).

Nevertheless, one should keep in mind that taxon sampling of distribution data can be biased (Vilhena & Antonelli 2015); therefore, more sampling is needed to confirm these results. An analysis of all Iranian Lepidoptera would be of great interest, to see if this division into bioregions is also valid when all families of this order are included.

Significance

The present study contributes significantly to our understanding of the species diversity of Geometridae in Iran and adjacent countries. Taxonomic revisions provide information on species identification and distribution and provide data on their habitat preferences. Thus, the available data have a broader significance, as they can be used to prioritize management actions for the conservation of the entire Iranian fauna. They are also an important tool for neighboring countries, as some of the species may also be distributed there and thus serve as a first point of reference for research in those countries. The results also highlight research gaps in Iranian Geometridae and points out where future studies should be focused. In addition, the results of this study have been used to compile the Geometridae section of the first comprehensive catalog of Iranian Lepidoptera (Rajaei et al. 2023c). Last but not least, this study led to the confident identification of a large number of already-collected specimens stored in numerous natural history and private collections.

The use of multi-gene phylogenetic analyses helped to classify genera with an unclear systematic position, thereby contributing to creating a more established classification based on monophyletic groups and making available important molecular data for future analyses. These results give us a better understanding of the evolutionary history of geometrid moths and provide a basis for the of character evolution, which goes hand in hand with the taxonomic part of this study.

By using distribution data collected for the groups worked on during this project, available from previous projects or collected during the preparation of the catalog of Iranian geometrids (see Rajaei et al. 2023), it was possible to uncover biodiversity hotspots for these moths in Iran and divide the country into unique bioregions. These data thus provide the basis for possible species conservation projects and for the establishment of nature reserves, and indicate gaps in knowledge where more sampling is essential.

In a nutshell, this work shows that integrative taxonomy is essential for our understanding of species and their needs, and that with intensive taxonomic research we can create a basis for the protection of species and the conservation of their habitats.

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Author's contributions

Systematics of *Problepsis wiltshirei* (Prout, 1938), comb. nov. (Lepidoptera, Geometridae, Sterrhinae) – an endemic species to the Zagros Mountains in the Middle East

Wanke, D., Krogmann, L., Murillo-Ramos, L., Sihvonen, P. & Rajaei, H.

Nota Lepidopterologica 44, (2021): 175–192. https://doi.org/10.3897/nl.44.67345

I contributed to the study design, conducted morphological and molecular (mitochondrial and nuclear genes) investigations, prepared the scientific drawings and plates, and wrote and submitted the manuscript as corresponding author.

Systematics and integrative taxonomic revision of the tribe Scopulini Duponchel, 1845 in Iran (Lepidoptera: Geometridae: Sterrhinae)

Wanke, D., Hausmann, A., Min Lee, K., Murillo-Ramos, L., Sihvonen, P. & Rajaei, H.

Submitted to Zootaxa

I contributed to the study design, conducted morphological and molecular (mitochondrial and nuclear genes) investigations, prepared the scientific drawings and plates, and wrote and submitted the manuscript as corresponding author.

Taxonomy and systematics of the enigmatic emerald moth *Xenochlorodes graminaria* (Kollar, 1850) (Lepidoptera: Geometridae), and its assignment to a new genus

Wanke, D., Feizpour, S., Hausmann, A., Viidalepp, J. & Rajaei, H.

Integrative Systematics 5 (1), (2022): 61–71. https://doi.org/10.18476/2022.857803

I contributed to the study design, conducted morphological investigations, prepared the scientific drawings and plates, and wrote and submitted the manuscript as corresponding author.

Taxonomic revision of the genus *Nychiodes* Lederer, 1853 (Geometridae: Ennominae: Boarmiini) with description of three new species—an integrative approach

Wanke, D., Hausmann, A., Krogmann, L., Petrányi, G. & Rajaei, H.

Zootaxa 4812 (1), (2020): 1–61. https://doi.org/10.11646/zootaxa.4812.1.1

I contributed to the study design, conducted morphological and molecular (mitochondrial and nuclear genes) investigations, prepared the scientific drawings and plates, and wrote and submitted the manuscript as corresponding author.

First captive rearing of the Iranian endemic *Nychiodes subvirida* Brandt, 1938 (Geometridae: Ennominae, Boarmiini)

Wanke, D., Leipnitz, M. & Rajaei, H.

Entomologische Zeitschrift, Schwanfeld 131 (2), (2021): 123–125.

I contributed to the study design, conducted rearing experiments, the external and internal morphological investigations of the specimens, created the scientific plates and wrote the manuscript.

The African endemic species "*Nychiodes*" *tyttha* Prout, 1915 (Lepidoptera: Geometridae: Ennominae) belongs to the genus *Aphilopota* Warren, 1899

Wanke, D., Hausmann, A., Lees, D. C., Min Lee, K., Martin, G., Sihvonen, P., Staude, H. & Rajaei, H.

Nota Lepidopterologica 46, (2022): 1–17. https://doi.org/10.3897/nl.46.94940

I contributed to the study design, conducted morphological investigations, prepared the scientific drawings and plates, and wrote and submitted the manuscript as corresponding author.

Integrative taxonomic review of the genus *Synopsia* Hübner, 1825 in the Middle East (Lepidoptera: Geometridae: Ennominae)

Wanke, D., Hausmann, A., Sihvonen, P., Krogmann, L. & Rajaei, H.

Zootaxa 4885 (1), (2020): 27–50. https://doi.org/10.11646/zootaxa.4885.1.2

I contributed to the study design, conducted morphological and molecular investigations, prepared the scientific drawings and plates, and wrote and submitted the manuscript as corresponding author.

Taxonomic note on *Synopsia centralis* (Wiltshire, 1966) (Lepidoptera: Geometridae: Ennominae), and additional faunistic data on the genus *Synopsia* Hübner, 1825 in Iran

Wanke, D. & Rajaei, H.

Integrative Systematics 5 (1), (2022): 105–108. https://doi.org/10.18476/2022.556903

I contributed to the study design, conducted morphological investigations, prepared the scientific drawings and plates, and wrote and submitted the manuscript as corresponding author.

Tribal assignment of the genus *Eumera* Staudinger, 1892, using multi-gene analysis and description of a new species from the south Iranian province Kerman (Lepidoptera: Geometridae: Ennominae)

Wanke, D., Shirvani, A., Hausmann, A., Murillo-Ramos, L. & Pasi Sihvonen

Zootaxa 5270 (1), (2023): 92–104. https://doi.org/10.11646/zootaxa.5270.1.4

I contributed to the study design, conducted morphological and molecular (mitochondrial and nuclear genes) investigations, prepared the scientific drawings and plates, and wrote and submitted the manuscript as corresponding author.

Using a network based-method for the bioregionalization of geometrid moths in Iran

Wanke, D., Noori, S. & Rajaei, H.

Unpublished manuscript

I contributed to the study design, collected parts of the distribution data, georeferenced most of the data, was involved in running the analyses, prepared the scientific drawings and plates, and wrote parts of the manuscript.

Danksagung

Abschließend möchte ich hier all jenen Personen meinen Dank aussprechen, die mich mit Rat und Tat unterstützt haben und die mir sowohl menschlich als auch fachlich in dieser Zeit zur Seite standen.

Zuallererst möchte ich Dr. Hossein Rajaei dafür danken, mir die wunderschöne Welt der Geometriden eröffnet zu haben. Für ein unfassbar spannendes Thema, sein Vertrauen, seine Unterstützung und seinen Eifer mir alle Techniken und Tricks für die Erforschung der Biodiversität mit auf den Weg zu geben. Deine Tür war immer offen für Fragen und spannende Diskussionen.

Mein aufrichtiger Dank gilt Prof. Dr. Lars Krogmann und Prof. Dr. Johannes Steidle welche sich zu Beginn meiner Promotion als Mentoren angeboten haben. Eure Vorlesungen und Praktika im Laufe meines Studiums begeisterten mich, waren eine Bereicherung während meiner ganzen Zeit an der Universität Hohenheim und haben entscheidenden Einfluss auf meinen weiteren Werdegang gehabt.

Mein besonderer Dank gilt Dr. Pasi Sihvonen, Dr. Axel Hausmann, Dr. Leidys Murillo-Ramos, Dr. Kyung Min Lee für ihre großartige Unterstützung und wissenschaftlichen Rat bei all meinen Vorhaben und Projekten.

Ich danke allen Ko-Autoren, für ihre hilfreichen Kommentare, Kritiken und Ideen, welche die Publikationen in dieser Arbeit zu etwas Besonderem gemacht haben, sowie den Künstlern welche eine schöne Erinnerung auf jedem Deckblatt in dieser Arbeit beigesteuert haben.

Besonders danken möchte ich Dr. Daniel Whitmore, dafür dass du für mich immer ein offenes Ohr hattest, für deine Kommentare und deine Unterstützung auf meinem Weg.

Außerdem möchte ich mich bei der gesamten entomologischen Abteilung des Staatlichen Museums für Naturkunde Stuttgart bedanken, die mich seit dem Beginn meiner Masterarbeit herzlich aufgenommen haben, für Fragen und Ideen immer offen waren und mich in meiner Forschung unterstützt haben.

Zudem danke Ich allen die mir durch den Zugang zu Ihren Sammlungen diese Forschungsarbeit ermöglichten: Axel Hausmann (Zoologische Staatssammlung München, Deutschland), Asghar Shirvani (Kerman, Iran), Bernd Müller (Berlin, Deutschland), Dirk Stadie (Eisleben, Deutschland), Geoff Martin, David Lees und Alberto Zilli (Natural History Museum, London, England), Gergely Petrányi (Budapest, Ungarn), Helen Alipanah ('Hayk Mirzayans Insect Museum', Iranian Research Institute of Plant Protection, Tehran, Iran), Hermann Staude (Südafrika), Jörg Gelbrecht (Königs Wusterhausen, Deutschland), Jörg-Uwe Meineke (Kippenheim, Deutschland), Marianne Espeland (Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Deutschland), Michael Leipnitz (Stuttgart, Deutschland), Pasi Sihvonen (Veikkola, Finnland), Peder Skou (Vester Skerninge, Dänemark), Ralf Fiebig (Rossleben, Deutschland), Robert Trusch und Michael Falkenberg (Staatliches Museum für Naturkunde Karlsruhe, Deutschland), Sabine Gaal-Haszler (Naturhistorisches Museum Wien, Österreich), Théo Léger und Wolfram Mey (Museum für Naturkunde der Humboldt-Universität, Berlin, Deutschland), Tobias Malm und Johannes Bergsten (Naturhistoriska Riksmuseet, Stockholm, Schweden), Toni Mayr (Feldkirch, Österreich), Werner Wolf (Bindlach, Deutschland).

Meinem Schwiegervater Manfred Hess danke ich für seine außerordentliche Unterstützung und Großzügigkeit während meines zweiten Bildungsweges. Weiterhin möchte ich meinen Schwiegereltern, meiner Schwester, meinen Nichten, Tanten und Onkel danken, die mich immer in meinem Tun bestärkt haben.

Abschließend möchte ich von Herzen meiner eigenen kleinen Familie danken. Meiner lieben Frau Kathrin, dass du mich in all den Jahren immer tatkräftig unterstützt, an mich geglaubt und an meiner Seite gestanden hast. Unseren beiden Kindern Lou und Ava, für die Freude die ihr in unser Leben bringt und eure Hilfe auch in stressigen Zeiten abschalten zu können. Danke.