

University of Hohenheim
Faculty of Agricultural Sciences
Institute of Farm Animal Ethology and Poultry Science

Prof. Dr. Werner Bessei

**ENVIRONMENTAL ENRICHMENT IN INTENSIVE PRODUCTION
SYSTEMS FOR FARM ANIMALS**

Doctoral Dissertation
Submitted in fulfilment of the requirements for the degree
“Doctor der Agrarwissenschaften”
(Dr.sc.agr. / Ph.D. in Agricultural Sciences)

to the
Faculty of Agricultural Sciences

presented by
Duška JORDAN
born in Ljubljana, Slovenia

Stuttgart-Hohenheim, 2010

This thesis was accepted as a doctoral dissertation in fulfilment of the requirements for the degree “Doktor der Agrarwissenschaft” by the Faculty of Agricultural Sciences at the University of Hohenheim, Stuttgart, Germany on 26 May 2010.

Date of oral examination: 2 June 2010

Examination committee:

Supervisor and reviewer:

Prof. Dr. Werner BESSEI

University of Hohenheim, Faculty of Agricultural
Sciences, Institute of Farm Animal Ethology and
Poultry Science

Co-supervisor and co-reviewer:

Prof. Dr. Ivan ŠTUHEC

University of Ljubljana, Biotechnical Faculty,
Department of Animal Science

Additional examiner:

Dr. Klaus REITER

Bayerische Landesanstalt für Landwirtschaft,
Institut für Tierhaltung und Tierschutz

Vice-Dean and Head of the Committee: Prof. Dr. rer. nat. Andreas FANGMEIER

I hereby declare, that I completed this doctoral thesis independently and only the indicated sources and resources were used and marked.

Duřanka JORDAN

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1 GENERAL INTRODUCTION

1.1 BACKGROUND AND MAIN RESEARCH OBJECTIVE

In intensive production systems fattening pigs are housed on concrete or slatted floors with no substrate to chew and root (van de Weerd and Day, 2009), while rabbits (EFSA-AHAW Panel, 2005; McNitt et al., 2000) and laying hens (EFSA-AHAW, 2005; Scientific Veterinary Committee, 1996) are conventionally kept in wire-mesh cages without bedding, equipped only with a feeder and nipple drinkers. Such systems represent a barren, unstructured and stimulus-poor environment where animals are additionally confronted with limited floor area (EFSA-AHAW Panel, 2005; Scientific Veterinary Committee, 1996; van de Weerd and Day, 2009; Verga, 2000). Animals' needs and welfare are neglected to a large extent (Baumans, 2005), the expression of numerous behavioural patterns animals are highly motivated to perform is thwarted (Gunn-Dore, 1997; Lehmann, 1987; Scientific Veterinary Committee, 1996; van de Weerd and Day, 2009). Consequently harmful and abnormal behaviour can appear. Pigs which have appropriate rooting substrates spend a considerable amount of time chewing them (Jensen et al., 1993). However, when lacking this possibility, they redirect their oral activities to the nearest substitutes, mostly pen fixtures and penmates (Beattie et al., 2001). This results in increased harmful social behaviour, aggressiveness (Day et al., 2002a; Kelly et al., 2000) and behaviour directed to pen hardware, such as bar biting (Whittaker et al., 1998), biting floors and walls (Lyons et al., 1995; Petersen et al., 1995). In rabbits thwarting of motivated behaviour contributes to increased inactivity (Huls et al., 1991; Morton et al., 1993) and it may also result in stress expressed as restlessness with more frequent changes of their behaviour (Lehmann, 1987). As a sign of suffering, frustration, fear or even boredom they may also develop various abnormal kinds of behaviour (Baumans, 2005; Wemelsfelder, 1994), such as bar biting, excessive grooming, nose sliding etc. (Gunn and Morton, 1995; Morton et al., 1993). In laying hens barren environment contributes to the development of feather pecking (Blokhuys, 1989), which is a serious problem in commercial egg production (McAdie et al., 2005). However, in fast growing broilers leg disorders, which have been recognised as a major cause of poor animal welfare (EU, 2000), could not be ascribed to housing conditions, but mostly to decades of intensive

selection for growth rate and feed conversion. Such intensive selection resulted in shorter fattening period but also in numerous skeletal and cardiovascular diseases (Emmerson, 1997). The above-mentioned problems can be alleviated with appropriate environmental enrichment in fattening pigs (e.g. Beattie et al., 1996; Blackshaw et al., 1997; Day et al., 2002a; Fraser et al., 1991; Guy et al., 2002; Kelly et al., 2000; Lyons et al., 1995; Schaefer et al., 1990), growing rabbits (e.g. Jordan et al., 2003; Princz et al., 2008; Verga et al., 2005), laying hens (e.g. Barnett and Newman, 1997; Duncan et al., 1992; McAdie et al., 2005) and even fast growing broilers (e.g. Bizeray et al., 2002c; Kells et al., 2001; Olanrewaju et al., 2006; Reiter and Bessei, 1996; Schwean-Lardner et al., 2006).

There are numerous ways of how to enrich animals' environment. Possible enrichment represents enlargement of available floor area (van de Weerd and Baumans, 1995), establishment of suitable structure of the enclosure (Young, 2003), provision of objects for manipulation and play (Appleby, 1995; Mench et al., 1998; Young, 2003) and even different kind of auditory, visual, olfactory and tactile stimuli (Baumans, 2005; van de Weerd and Baumans, 1995). Environmental enrichment that animals tend to be highly motivated to make use of is nutritional enrichment (Baumans, 2005). This is understandable if we consider the amount of time and effort animals in nature put into searching and handling their feed. In intensive production systems the situation is just the opposite. Feed is always dispensed in the same location and animals are usually fed with a single complete feed mixture offering no heterogeneity and possibility to choose (Newberry, 1995). For these reasons, a promising enrichment for pigs, which like objects and substrates that are chewable, deformable, destructible, odorous and ingestible (van de Weerd et al., 2003), would be substrates like straw. They meet the requirements of variability and responsiveness and they also serve as a stimulus and outlet for rooting and chewing (Fraser et al., 1991). Rabbits, on the other hand, have a great need for gnawing wood (Grün, 2002), which in semi-natural enclosure they satisfy with gnawing roots and branches (Stauffacher, 1992). Therefore, sticks of soft wood could be an effective way to enrich their environment (Baumans, 2005). Enhancing diet complexity with providing several diets instead of only one presents another possible way of nutritional enrichment. It has been shown in broilers that when these diets were given to animals in sequence over a certain period of time (this feeding method is called sequential feeding) their behaviour

modified (Bouvarel et al., 2008; Leterrier et al., 2008; Noirot, 1998), while in laying hens feed conversion improved (Umar Faruk et al., 2010b). Scattering feed in the bedding to stimulate foraging behaviour also presents a potential enrichment (Chamove, 1989). Stimulation of foraging behaviour by scattering whole grain in the litter is traditionally used in deep litter systems for laying hens. Perhaps the same could be achieved in broilers, which are very difficult to animate. However, the increment in physical activity in fast growing broilers is of great importance, because it can reduce or at least delay the onset of leg disorders (Haye and Simons, 1978; Reiter and Bessei, 1998; Reiter, 2004).

In the past, certain environmental enrichment was usually provided to animals based on what was intuitively perceived as important for them, was inexpensive and made of locally available materials (Olsson et al., 2003). However, nowadays it is becoming increasingly important to evaluate environmental enrichment according to animals' benefit, that is, in terms of improving their welfare (Chave, 2003). For this purpose, the effect of environmental enrichment on one or more of the welfare indicators (mortality, morbidity, species-specific behaviour, physiological parameters, performance) (Hoy, 2004) has to be examined.

The main objective of the thesis was to examine the influence of environmental enrichment on behaviour or/and performance of fattening pigs, growing rabbits, laying hens and fast growing broilers. Additionally, environmental enrichment in laying hens was also evaluated by regarding the feather condition, due to the seriousness of the feather pecking problem.

1.2 OBJECTIVES OF INDIVIDUAL STUDIES

The thesis includes four studies, each conducted on a different animal species or production type.

Straw presents effective environmental enrichment for fattening pigs. However, in some agricultural areas hay is more easily available than straw. In our first study (Subheading 2.1) we wished to establish if hay, as environmental enrichment, had the same beneficial influences on fattening pigs as straw. Nevertheless, in slatted floor systems usage of raw materials presents a high risk of blockage of the dunging canal under slatted

floors. In our study this was prevented by giving pigs only a small amount of substrate laid in a rack, which was designed in such a way that pigs were hindered to draw large wisps of straw or hay from it. Apart from the comparison of straw and hay as environmental enrichment, we also wished to establish if enrichment is of the same importance for females and castrates. For this purpose, the behaviour of fattening pigs housed separately by sex in groups of 16 animals was recorded by direct observation during light period for three days on the commercial pig farm in Slovenia. Beside the behaviour, growth rate and lean mean percentage were also recorded.

Rabbits have a great need for gnawing and for this reason a wooden stick seemed to be a simple and effective way of enriching growing rabbit barren environment. Therefore, in our second study (Subheading 2.2) we wished to establish if growing rabbits housed individually in wire-mesh cages show any interest in wooden sticks made of *Picea abies* and whether such enrichment influences the duration and frequency of certain behavioural pattern. The study was performed on 16 males of Slovenian sire line SIKA for meat production at the Rabbit production centre of Department of Animal Science, Biotechnical Faculty, University of Ljubljana, Slovenia. Rabbit behaviour was recorded by infrared video camera during four observation days equally distributed over fattening period for 24 hours a day. Video recordings were analysed with the Observer 4.1 software (Noldus Information Technology, Wageningen, Netherlands), where all behavioural patterns were defined as state and recorded continuously.

Sequential feeding method, which enables to feed animals with more than one diet, has been used in feeding chickens with whole cereals. Sequential feeding with whole wheat has been shown to modify broilers' behaviour. However, to our knowledge the possible influence of sequential feeding on laying hens behaviour has not yet been established. For this reason the third study (Subheading 2.3) was designed to test whether sequential feeding with whole wheat would induce changes in laying hen's behaviour. Additionally, we also recorded feed intake, feather condition and egg production. These parameters were measured on non beak-trimmed ISA Brown laying hens housed in conventional cages in groups of five at INRA, Nouzilly, France from 30 to 37 weeks of hens' age.

Fast growing broilers are subjected to severe leg problems which negatively influence their welfare. Nevertheless, these disorders can be mitigated with increased physical activity. The problem is that broilers are very difficult to animate. One of the possibilities to induce locomotor activity is stimulation of foraging behaviour. In laying hens housed in deep litter systems, scattering whole grain in the litter has been used to elicit scratching and locomotor activity. The aim of our fourth study (Subheading 2.4), which was carried out at the Experimental station for animal husbandry, animal breeding and small animal breeding of Hohenheim University, Unterer Lindenhof, Eningen u.A., Germany, was therefore to apply this procedure in broilers. We tried to achieve this in two ways: 1) by scattering whole wheat grains in the litter in addition to standard feed offered ad libitum in a trough and 2) by removal of feed trough and scattering standard feed pellets in the litter. Behaviour, live weight and feed consumption were monitored on 120 Ross 308 broiler chickens of mixed sex housed in small groups in wooden boxes between 1 and 39 days of age.

2 SCIENTIFIC PAPERS

2.1 STRAW OR HAY AS ENVIRONMENTAL IMPROVEMENT AND ITS EFFECT ON BEHAVIOUR AND PRODUCTION TRAITS OF FATTENING PIGS

Arch. Tierz., Dummerstorf **51** (2008) 6, 549-559

Department of Animal Science, Biotechnical Faculty, University of Ljubljana, Ljubljana, Slovenia

DUŠANKA JORDAN, SILVESTER ŽGUR, GREGOR GORJANC and IVAN ŠTUHEC

Straw or hay as environmental improvement and its effect on behaviour and production traits of fattening pigs

Abstract

Fattening pigs are commonly kept in intensive housing systems with slatted floor which represent a very barren environment, causing poor animal welfare. To improve such conditions a small amount of straw or hay (100 g per animal per day laid daily in a rack) was used in our study as an environmental enrichment (EE). Two replications, each including 96 fattening pigs of both sexes (3 pens of 16 females and 3 pens of 16 male castrates) from 60 kg to slaughter at average 96 kg live weight, were used to test the effect of EE and sex on behaviour, growth rate, and carcass composition. EE significantly increased the proportion of total activity during the illumination period (between 6 a.m. and 2 p.m.) on account of increased occupation with substrate ($P < 0.01$). EE also significantly reduced time spent biting pen bars and frequency of aggressive encounters ($P < 0.01$). The EE increased total activity in female animals during the observation period, but not in male castrates. None of the EE significantly influenced pigs' growth rate and lean meat percentage; however females in enriched environment grew slower and had greater lean meat percentage than the castrated males. Provision of a small amount of straw or hay to pigs in intensive housing systems can enrich barren environment in inexpensive and efficient way. Therefore such enrichment can be widely used also in large commercial pig production systems.

Keywords: pig, behaviour, housing, animal welfare, fattening and carcass traits

Zusammenfassung

Titel der Arbeit: Stroh oder Heu als Umweltverbesserung und ihr Einfluss auf das Verhalten und Produktionsmerkmale von Mastschweinen

Mastschweine werden üblicherweise intensiv auf Vollspaltenboden gehalten. Diese Form der Haltung ist reizarm und mindert das Wohlbefinden der Tiere. Um die Haltungsbedingungen zu verbessern, wurden zusätzlich zum Futter kleine Mengen Stroh bzw. Heu (100 g pro Tier und Tag) als Umweltsanierung (UA) in Rufen angeboten. Es wurden zwei Wiederholungen mit jeweils 96 Mastschweinen beider Geschlechter (3 Buchten mit je 16 weiblichen sowie 3 mit je 16 kastrierten männlichen Tieren) durchgeführt. Die Mastschweine standen von 60 kg (Anfangsgewicht) bis zum Schlachtgewicht von 96 kg im Versuch. Geprüft wurde der Einfluss der UA und des Geschlechtes auf das Verhalten sowie die Gewichtszunahme und die Zusammensetzung des Schlachtkörpers der Tiere. Die UA durch Stroh bzw. Heu führte zu einer intensiven Auseinandersetzung mit diesen Substraten; sie hat die Gesamtaktivität der Tiere während der Helligkeitsphase des Stalles (6 bis 14 Uhr) insgesamt deutlich erhöht ($P < 0,01$); gleichzeitig reduzierten sich die Dauer des Stangenbeißen und die Aggressionshäufigkeit wesentlich ($P < 0,01$). Die UA erhöhte während der Beobachtungen die Gesamtaktivität bei weiblichen, aber nicht bei männlichen Tieren. Sie hat die tägliche Zunahme und den Fleischanteil im Schlachtkörper nicht beeinflusst. Allerdings zeigten weibliche Tiere ein langsames Wachstum sowie einen höheren Fleischanteil als die Kastraten. Aus den Ergebnissen wird geschlossen, dass die Zufütterung von kleinen Mengen Stroh oder Heu in intensiven Haltungssystemen eine billige und wirksame Verbesserung der Haltungsbedingungen darstellt. Auch in größeren Schweinemastbetrieben könnte eine solche UA zweifellos kostengünstig eingesetzt werden.

Schlüsselwörter: Schwein, Verhalten, Haltung, Wohlbefinden, Mastleistung, Schlachtleistung

Introduction

Animal welfare research has been considerably intensified during the last years (SMIDT, 1992; SMIDT et al., 1995; TUCHSCHERER and MANTEUFFEL, 2000; WEBER and VALLE ZÁRATE, 2005). The present investigation will contribute to this topic. Pigs spend a considerable amount of time chewing the substrates in its environment (JENSEN et al., 1993). However, in a barren environment lacking the appropriate rooting substrates, pigs redirect their oral activities to the nearest substitutes, mostly pen fixtures and pen mates (BEATTIE et al., 2001). The result is increased harmful social behaviour, aggressiveness, and behaviours directed to pen equipment. The mentioned problems can be alleviated with appropriate environmental enrichment. Objects and substrates which are enriching the environment and liked by pigs should be chewable, deformable, destructible, odorous, and ingestible (VAN DE WEERD et al., 2003). It is also important that such enrichment should occupy animals for a longer period (SAMBRAUS, 1997; FRANKE, 2003). Substrates such as straw meet these requirements of variability and responsiveness. The “recreational” effect is a major potential benefit for the welfare of growing pigs, for it serves as a stimulus and outlet for rooting and chewing activities (FRASER et al., 1991).

The influence of environmental enrichment on pigs’ welfare in intensive housing systems is well known. In slatted floor systems enrichment with raw material has not been used due to a high risk of blockage of the dunging canal under the slatted floor. Small amount of raw material provided in a way that it would not cause the blockage of the dunging canal and which would occupy animals for a longer time would therefore be appreciated. It is also not known if the enrichment is of the same importance for female and castrated male fattening pigs. Additionally, we wanted to find out if hay as environmental enrichment has the same beneficial influences on pigs as straw, because in some agricultural areas hay is more available than straw. The aim of this study was to find out if the addition of small amount of straw or hay is an appropriate way to enrich slatted floor pens and if it has the same effect on the behaviour and production of female and castrated male fattening pigs.

Materials and methods

Animals

The research was performed in two replications on a commercial pig farm. Each of two replications lasting seven weeks included 96 fattening pigs from 60 kg live weight to slaughter at average 96 kg live weight. The animals were housed in six slatted floor pens (4.90 × 2.45 m) divided with full fences (Figure 1) containing 16 pigs each (three pens of females and three pens of male castrates). All animals were tail docked. They were fed on average with 2.4 kg of complete mixture of feedstuffs (12.9 MJ/kg ME, 14% CP) at 60 kg live weight with gradual increase up to 3.0 kg at the end of fattening period and 4 litres of fresh whey per animal and day. The complete mixture of feedstuffs and fresh whey were offered at 7.30 a.m. and 12.00 p.m. Mixture of feedstuffs was given first, but pigs did not start to eat until whey was poured in the troughs and moistened the mixture. Animals did not eat the whole meal at once but left a part of it for later, so feeding was practically *ad libitum*. Each day one third of the animals received 100 g of wheat straw per animal, the other third was given 100 g of hay per animal and one third of the animals were treated as a control group. Hay or straw was laid in the rack placed above the trough right after

morning feeding of mixture of feedstuffs. The rack had a triangular profile and measured 115×50 cm (Figure 2). The lower edge of the rack was 35 cm above the floor. The front side was made of 5×5 cm wire mesh, which enabled animals to draw blades of hay or straw from the rack. At the beginning of experiment, pigs drew large wisps of hay or straw from the top of the racks, which caused blockage of the dunging canal under the slatted floor. To prevent this, an elastic band was stretched over straw or hay from one short side of the rack to the other. The lights in the pig house were on during working hours, namely from 6.00 a.m. to 2.00 p.m., when the farm workers performed everyday tasks.

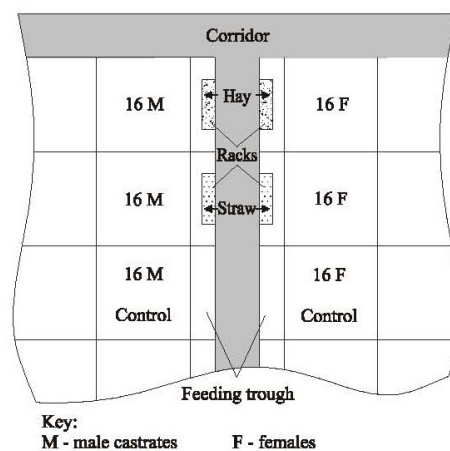


Fig. 1: Ground plan of experimental pens (Der Grundriss der Versuchsbuchten)

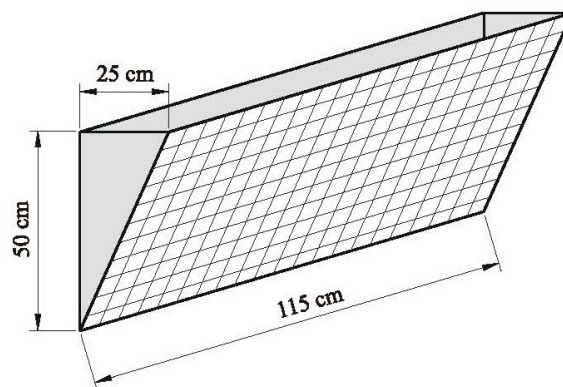


Fig. 2: The sketch of the rack used for straw or hay (Skizze der Raufe für das Stroh oder das Heu)

Behavioural observations

All the animals were marked with a four-digit number tattoo on their backs for the identification purpose. The first digit represented the treatment (0 – control group, 1 – straw group, 2 – hay group), the second one meant pig's sex (1 – male castrate, 2 – female), and the last two digits were the running number of the animal within treatment and sex (from 01 to 16).

Pigs were observed by direct observation for three days during light period lasting 8 hours in each replication. Observations were performed on day 10, 25, and 40 of each replication. Due to a large number of observed animals the observations were

performed by two observers. At the same time each observer recorded the behaviour of pigs in three pens which were switched between them over the observation days. Long-term behavioural elements: resting (lying or sitting), feeding, chewing straw or hay, and biting pen bars were recorded by instantaneous sampling (MARTIN and BATESON, 1993) in 56 intervals per observation period (between 6.00 a.m. and 2.00 p.m.). Long-term elements were mutually exclusive (feeding, chewing straw or hay, and biting pen bars were recorded only in standing position) and expressed as the percentage of observation period per animal. Total activity was defined as a sum of all long term behavioural elements except resting. Because total activity and resting always sum up to 100%, only the results for total activity are presented. Short-term activities: drinking and aggressive encounters (aggressive and other injurious behaviour) were recorded continuously (MARTIN and BATESON, 1993) as group events when they occurred and expressed as frequency per pen and observation period. Altogether, 576 records (two replications, three treatments each with 16 females and 16 male castrates per replication and three observation days per replication) were collected for long-term behavioural elements and 36 records (two replications, three treatments each with one pen of females and one pen of male castrates per replication and three observation days per replication) for short-term activities.

Growth rate and lean meat percentage

Individual live weight of animals was measured twice, at the beginning of experiment, before the housing in pens and just before slaughter. Lean meat percentage was estimated according to Slovenian regulation. Altogether, 192 records (two replications, three treatments each with 16 females and 16 male castrates per replication) were available for daily gain and lean meat percentage.

Statistics

Data analysis was conducted using statistical program package SAS (SAS, 2001). Feeding, chewing of straw or hay and total activity were assumed to be normally distributed and analysed with a general linear model (1) in GLM procedure. Model (1) included fixed effect of replication (R_i) with two levels, treatment (T_j) with three levels, sex (S_k) with two levels, and observation day within replication (D_{il}) with three levels. Biting pen bars and short-term activities (drinking and aggressive encounters) were not normally distributed. We assumed Poisson distribution for these traits and used generalized linear model (2) (McCULLAGH and NELDER, 1989) with default log link on expected value (λ_{ijkl}) using GENMOD procedure and GLIMMIX macro. Model (2) included the same set of effects as model (1). Growth rate of pigs and lean meat percentage were also assumed to be normally distributed and analysed with model (3). Significant interactions were also included in the models, if their inclusion improved the fit of the model for at least one analysed trait. Multiple comparison adjustment test by Scheffe (SAS, 2001) was used. Results for drinking and aggressive encounters were analysed with pen as a unit and presented on observed scale (event frequency), whereas other behavioural elements were analysed with animal as a unit and presented as percentage of observation period per animal. Only the results for the effect of treatment, sex, and interaction between

treatment and sex are presented because these effects were the main objective of our research.

$$y_{ijklm} \sim \text{Normal}(\mu_{ijkl}, \sigma_e^2)$$

$$\mu_{ijkl} = \alpha + R_i + T_j + S_k + D_{il} + RT_{ij} + RS_{ik} + TS_{jk} \quad (1)$$

$$y_{ijklm} \sim \text{Poisson}(\lambda_{ijkl})$$

$$\log(\lambda_{ijkl}) = \alpha + R_i + T_j + S_k + D_{il} + RT_{ij} + RS_{ik} + TS_{jk} \quad (2)$$

$$y_{ijk} \sim \text{Normal}(\mu_{ijk}, \sigma_e^2)$$

$$\mu_{ijk} = \alpha + R_i + T_j + S_k + RS_{ik} + TS_{jk} \quad (3)$$

Results

Behaviour

Pigs spent most of the observation period resting. On average they were active only from 23 to 27% of the observation period (Table 1).

Table 1

LSQ means $\pm$ standard error of long-term behavioural elements (percentage of observation period per animal) and short-term activities (frequency per pen in observation period) per treatment and sex (LSQ Mittelwerte $\pm$ Standardfehler bei Langzeitverhaltensmerkmalen [Anteil der Beobachtungsperiode pro Tier] und Kurzzeitaktivitäten [Häufigkeit pro Bucht in der Beobachtungsperiode] nach Behandlung und Geschlecht)

Behavioural elements	Control	Treatment Straw	Hay
<i>Long-term:</i>			
Feeding			
Average	20.97 $\pm$ 0.34 ^a	19.84 $\pm$ 0.34 ^{ab}	18.78 $\pm$ 0.34 ^b
Male castrates	19.90 $\pm$ 0.49 ^a	18.19 $\pm$ 0.49 ^{abx}	17.28 $\pm$ 0.49 ^{bx}
Females	22.04 $\pm$ 0.49	21.48 $\pm$ 0.49 ^y	20.28 $\pm$ 0.49 ^y
Chewing straw or hay			
Average	/	5.63 $\pm$ 0.28 ^a	7.13 $\pm$ 0.28 ^b
Male castrates	/	4.37 $\pm$ 0.38 ^x	5.80 $\pm$ 0.39 ^x
Females	/	6.89 $\pm$ 0.39 ^y	8.47 $\pm$ 0.41 ^y
Biting pen bars			
Average	2.56 $\pm$ 0.16 ^a	0.52 $\pm$ 0.07 ^b	0.35 $\pm$ 0.06 ^b
Male castrates	2.27 $\pm$ 0.21 ^a	0.48 $\pm$ 0.10 ^b	0.24 $\pm$ 0.07 ^b
Females	2.90 $\pm$ 0.24 ^a	0.56 $\pm$ 0.10 ^b	0.52 $\pm$ 0.10 ^b
Total activity ¹			
Average	23.56 $\pm$ 0.44 ^a	26.23 $\pm$ 0.44 ^b	27.12 $\pm$ 0.44 ^b
Male castrates	22.17 $\pm$ 0.62	23.05 $\pm$ 0.62 ^x	23.79 $\pm$ 0.62 ^x
Females	24.94 $\pm$ 0.62 ^a	29.41 $\pm$ 0.62 ^{by}	30.45 $\pm$ 0.62 ^{by}
<i>Short-term:</i>			
Drinking			
Average	12.14 $\pm$ 0.54	10.86 $\pm$ 0.52	12.77 $\pm$ 0.56
Male castrates	12.30 $\pm$ 0.77	9.84 $\pm$ 0.69	11.97 $\pm$ 0.76
Females	11.97 $\pm$ 0.76	11.97 $\pm$ 0.76	13.61 $\pm$ 0.81
Aggressive encounters			
Average	9.66 $\pm$ 0.86 ^a	3.67 $\pm$ 0.52 ^b	2.59 $\pm$ 0.44 ^b
Male castrates	7.91 $\pm$ 1.09 ^a	2.79 $\pm$ 0.63 ^b	2.02 $\pm$ 0.53 ^b
Females	11.79 $\pm$ 1.32 ^a	4.82 $\pm$ 0.84 ^b	3.32 $\pm$ 0.70 ^b

^{a, b} Values with different superscripts within a row are significantly different between treatments ($P < 0.05$).

^{x, y} Values with different superscripts within a column within each activity are significantly different between sexes ($P < 0.05$).

¹ Total activity is a sum of feeding, chewing straw or hay and biting pen bars.

The major part of active time was spent for feeding. The addition of straw or hay significantly influenced all observed behaviours, except drinking. Pigs in a control group spent significantly less time for total activity in comparison with animals in both experimental groups. Percentage of time spent eating the complete mixture of feedstuffs was also greater in the control group. The differences between the control and hay treatment were significant ($P < 0.01$), whereas between the control and straw group a trend of differences was noticed ($P = 0.067$). Pigs chewed hay for a greater percentage of observation periods than straw. Both substrates significantly reduced the percentage of time pigs spent biting pen bars and it also significantly reduced pigs' aggression. In the straw and hay group, the frequency of aggressive encounters among pigs was significantly lower than in the control group.

Between sexes in the control group there were no significant differences in the percentage of time spent feeding, biting pen bars, and for total activity, as well as in frequency of drinking and aggressive encounters. Nevertheless, in two activities a trend of differences between females and male castrates was noticed (feeding $P = 0.087$ and total activity $P = 0.079$). In straw and hay group females showed significantly more total activity than male castrates, which also spent significantly less time feeding. In time spent chewing straw or hay there were significant differences between sexes, too. Females spent more time chewing than castrated males. At the end of observation at 2.00 p.m., male castrates still had some chewing material in their racks, but the racks in females' pens were already empty.

Growth rate and lean meat percentage

The addition of straw or hay had no significant influence on pigs' growth rate during finishing period and lean meat percentage (Table 2), whereas sex of the animals significantly influenced both traits. Females in the hay group had significantly smaller growth rate than male castrates, but in the straw group a trend of differences was noticed ($P = 0.058$). In both experimental groups females also had greater percentage of lean meat.

Table 2

LSQ means $\pm$ standard error of growth rate and lean meat percentage of pigs per treatment and sex (LSQ Mittelwerte $\pm$ Standardfehler für tägliche Zunahme und Fleischanteil der Mastschweine nach Behandlung und Geschlecht)

	Control	Treatment Straw	Hay
Growth rate, g/day			
Average	765 $\pm$ 10	759 $\pm$ 10	773 $\pm$ 10
Male castrates	793 $\pm$ 14	793 $\pm$ 15	810 $\pm$ 14 ^x
Females	737 $\pm$ 4	725 $\pm$ 14	736 $\pm$ 15 ^y
Lean meat percentage, %			
Average	53.68 $\pm$ 0.38	53.46 $\pm$ 0.38	53.75 $\pm$ 0.38
Male castrates	52.86 $\pm$ 0.53	52.16 $\pm$ 0.53 ^x	52.44 $\pm$ 0.53 ^x
Females	54.50 $\pm$ 0.53	54.75 $\pm$ 0.53 ^y	55.07 $\pm$ 0.53 ^y

^{x,y} Least square means with different superscripts within a column within each trait are significantly different between sexes ($P < 0.05$).

Discussion

Behaviour

The daily addition of 100 g of straw or hay per animal laid in a rack resulted in significant behavioural differences compared to the non-enriched treatment, as found

by KELLEY et al. (2000) with 50 g of straw per animal daily. It seems that only a small amount of straw is required to provide welfare benefits, but it has to be daily renewed to preserve its effect of novelty and attract pigs' attention (FRASER et al., 1991; WHITTAKER et al., 1998; KELLEY et al., 2000; MOINARD et al., 2003). Straw or hay laid in the rack increased the proportion of time animals were active. Similar results were also reported by AREY and FRANKLIN (1995) and GUY et al. (2002), who reported that pigs in straw yards spent significantly less time lying inactive and more time lying active compared to those in fully slatted pens. However, in the present experiment, increased proportion of total activity was noticed only in females, and not in male castrates. Increased total activity of pigs observed in experimental groups occurred on account of their interest and occupation with straw or hay. Pigs, having the opportunity to manipulate loose stimuli in their environment, perform this behaviour during great part of their active time (VAN PUTTEN, 1980; PETERSEN et al., 1995; BEATTIE et al., 2000; ROHRMANN and HOY, 2004). Besides, straw and hay have all characteristics of substrates the pigs should have (VAN DE WEERD et al., 2003) to reinforce their exploratory and feeding motivation (DAY et al., 2002b). We observed that the racks with hay were empty earlier than the racks with straw in both sexes. However, pigs chewed hay for a greater percentage of observation periods (Table 1).

These two facts indicate that straw might be better enrichment in comparison to hay, because it lasts longer as chewing material. Female animals were occupied with hay and straw for a greater proportion of the observation period compared to male castrates. It seems they had a greater motivation for chewing. At the end of observation day male castrates still had some straw in the racks, which were empty the next morning. From this it can be concluded that male castrates continued chewing straw after the end of observation, also during the dark period of the day. Both substrates, hay and straw, given to the pigs, had a role of an environmental enrichment and improved animal welfare. Occupation with straw or hay resulted in lower percentage of time spent biting pen bars and lower frequency of aggressive encounters, which is in accordance with several studies (FRASER et al., 1991; LYONS et al., 1995; BEATTIE et al., 1996, 2001; O'CONNELL and BEATTIE, 1999; KELLY et al., 2000; DAY et al., 2002a).

On the basis of this result it can be also presumed, that it is not urgently required to enable the access to racks filled with straw or hay to all pigs at the same time as practiced in the case of feeding trough. The 115 cm long rack of straw or hay as environmental enrichment provided all 16 pigs the opportunity to draw blades of straw or hay from the rack without causing the increment of aggressive encounters among pen mates. Straw or hay also decreased the percentage of feeding time although several previous studies reported no significant influence of environmental enrichment on time spent or frequency of feeding (BEATTIE et al., 1996; GUY et al., 2002), and feeding pattern (FRASER et al., 1991). In the present study significantly decreased time of feeding during the observations was noticed only for male castrates in the hay group. Pigs in the hay and straw group had still some complete mixture of feedstuffs in their troughs at the end of daily observation at 2.00 p.m. It seems that in this case chewing of straw or hay had a feeding and recreational effect (FRASER et al., 1991), which lowered pigs' motivation for the consumption of complete mixture of feedstuffs. The frequency of drinking was not influenced by

treatment, which is in accordance with findings of BEATTIE et al. (1996) and WHITTAKER et al. (1998), who studied the effect of provision of straw on sows. Females seemed to be more active than male castrates, for they spent greater percentage of the observation period feeding and chewing straw or hay. These results are only partly in accordance with findings of GONYOU et al. (1992). They found that the only sex difference in barren environment was in time spent lying. Namely, barrows spent more time lying and less time standing than gilts. VARGAS VARGAS et al. (1987) observed higher social rank and more aggressive acts at gilts than at castrated males in mixed groups. Although male castrates in the present study chewed given substrate significantly less than females, they also reduced the frequency of biting pen bars and aggressive encounters in straw and hay group. This demonstrates improved animal welfare due to chewing substrate also in less active gender.

Growth rate and lean meat percentage

The addition of straw or hay did not influence pigs' growth rate, probably due to too small amount of offered substrate per animal. MORGAN et al. (1998) and BEATTIE et al. (2000) reported increased growth rate in pigs that had environmental enrichment in the form of straw bedding. Conflicting results appear also in other studies, where authors did not use straw as environmental enrichment but different kind of toys, such as car tires (SCHAEFER et al., 1990) chains (PEARCE et al., 1989; PEARCE and PATERSON, 1993; HILL et al., 1998), cloth strips, lifter bars, swivel wheels, dustbin lids (PEARCE and PATERSON, 1993) and a rubber hose (HILL et al., 1998). SCHAEFER et al. (1990) found that enriched environment improved pigs' growth rate, whereas PEARCE et al. (1989), PEARCE and PATERSON (1993), BLACKSHAW et al. (1997), and HILL et al. (1998) found no improvement in productivity when pigs were in enriched environment.

Straw or hay had no significant influence on lean meat percentage of pigs included in the experiment. In accordance with the present results are findings of HILL et al. (1998), who enriched pigs' environment with metal chains and rubber hose, and BEATTIE et al. (2001), who as an environmental enrichment used mushroom compost. They reported no significant effect of environmental enrichment on carcass fatness. On the contrary, some studies reported that pigs with straw and peat enriched environment had a greater growth rate (BEATTIE et al., 2000) or live weight (O'CONNELL et al., 2004), and heavier carcass weight with greater level of back fat thickness due to greater feed intake and better feed conversion (BEATTIE et al., 2000). Sex of the animals significantly influenced growth rate in the hay group, but in the straw group a trend of differences was noticed. Furthermore, in the straw and hay group significant differences were also observed in lean meat percentage. Females grew slower and had greater lean meat percentage. It is a well-known fact that castrated males grow faster than females due to their greater ability of feed consumption (PURCHAS, 1991; OLSSON et al., 2003) and produce fatter carcasses with lower lean meat percentage than females (PURCHAS, 1991; STEINBERG et al., 1992; BIEDERMANN et al., 2000; OLSSON et al., 2003; LATORE et al., 2004). However, in our study both sexes had the same feed consumption. The possible explanation for the observed sex differences in growth rate and lean meat percentage in enriched groups could be also the greater total activity of female animals (Table 1).

In conclusion small daily amount of straw or hay offered in racks served as an environmental enrichment and improved welfare of fattening pigs housed in a fully slatted floor pen. Both substrates reduced biting pen bars and aggressiveness among pigs, which are known as behavioural disorders in intensive housing systems, but did not influence growth rate and lean meat percentage of pigs. Significant sex differences were observed in pigs' behaviour as well as in their daily gains and lean meat percentage. Provision of straw or hay significantly increased total activity of female animals during the observation period, but this was not observed in male castrates. Females in enriched environment grew slower and had greater lean meat percentage than castrated males. Provision of a small amount of straw or hay to pigs in intensive housing systems can enrich barren environment in inexpensive and efficient way. Therefore such enrichment can be widely used also in large commercial pig production systems to improve animal welfare.

Acknowledgments

We are grateful to Mrs Karmela Malinger for proof reading the manuscript as well as to two referees that provided valuable comments on the earlier version of the manuscript, and Kristijan Hrastar and Matej Šušteršič for technical assistance and observation of the animals.

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Received: 2008-02-27

Accepted: 2008-08-26

Corresponding author:

Prof. Dr. IVAN ŠTUHEC
 Department of Animal Science
 Biotechnical Faculty
 University of Ljubljana
 Groblje 3
 SI-1230 Domžale
 Slovenia

email: ivan.stuhec@bfro.uni-lj.si

Published in Archiv für Tierzucht 51(2008)6, pp 549-559, ISSN 0003-9438 and reprinted with kind permission of Research Institute for the Biology of Farm Animals (FBN), Dummerstorf, Germany.

2.2 EFFECT OF GNAWING WOOD AS ENVIRONMENTAL ENRICHMENT ON BEHAVIOUR OF INDIVIDUALLY HOUSED GROWING RABBITS (ABSTRACT)

Duška JORDAN, Gregor GORJANC and Ivan ŠTUHEC

Department of Animal Science, Biotechnical Faculty, University of Ljubljana, Domžale, Slovenia

The aim of our study was to examine the influence of gnawing sticks as environmental enrichment on the duration and frequency of rabbit behavioural patterns. For this purpose 16 males of Slovenian sire line SIKa for meat production were recorded four days for 24 hours per day, namely between 45 and 48, 58 and 61, 72 and 75, and 86 and 89 days of rabbits' age. Animals were housed individually in wire cages equipped with a feeder and a nipple drinker. Half of the cages were enriched with wooden sticks of Norway spruce (*Picea abies*). Animals had free access to the feed and water, the daily duration of lighting was 12 hours. Rabbits spent the majority of time resting (57.3 to 58.4%). The most common active behavioural patterns were body care (a sum of grooming and scratching; 20.5 to 20.8%) and feeding (9.57 to 11.6%). They changed their behaviour from 47.2 to 47.5 times per hour. Environmental enrichment significantly influenced only the duration of feeding. Rabbits in enriched cages were feeding significantly longer, namely $2.08 \pm 0.87\%$ per hour.

Key words: growing rabbits, individual cages, environmental enrichment, animal behaviour, animal welfare

Published in Archiv für Geflügelkunde 72(2008)4, pp 181-188, ISSN 0003-9098. © Verlag Eugen Ulmer, Stuttgart

2.3 THE INFLUENCE OF SEQUENTIAL FEEDING ON BEHAVIOUR, FEED INTAKE AND FEATHER CONDITION IN LAYING HENS

Dušanka JORDAN^{a *}, Murtala UMAR FARUK^b, Philippe LESCOAT^b,
Mohamed Nabil ALI^{b, c}, Ivan ŠTUHEC^a, Werner BESSEI^d, Christine LETERRIER^e

^a University of Ljubljana, Biotechnical Faculty, Department of Animal Science, Groblje 3, SI-1230 Domžale, Slovenia

^b INRA, UR83 Recherches avicoles, F-37380 Nouzilly, France

^c Poultry Nutrition Department, Animal Production Research Institute, ARC., Dokki, Giza, Egypt

^d University of Hohenheim, Department of Farm Animal Ethology and Poultry Production, 470C, D-70599 Stuttgart, Germany

^e INRA, UMR 85 Physiologie de la Reproduction et des Comportements, F-37380 Nouzilly, France

* Corresponding author: Dušanka JORDAN

University of Ljubljana, Biotechnical Faculty, Department of
Animal Science, Groblje 3, SI-1230 Domžale, Slovenia

Tel.: + 386 1 7217 866; fax: + 386 1 7241 005

E-mail address: dusanka.jordan@bf.uni-lj.si

Abstract

Feeding of whole-wheat grains and a protein-mineral concentrate in sequence had been shown to modify behaviour in broilers and performance in laying hens. The objective of this study was to test whether sequential feeding with wheat would induce changes in laying hen's behaviour, feed intake, feather condition, and egg production. These parameters were measured on 320 non beak-trimmed ISA Brown laying hens from 30 to 37 week of age. The birds were placed in 64 standard cages (five birds/cage) and allotted to one of four treatments. The control (C) was fed a complete conventional diet. Three treatments were fed sequentially with whole wheat (SWW), ground wheat (SGW) or ground wheat with added vitamin premix+phosphorus+2% oil (SGWI). In sequential treatments, 50% of the ration was fed as wheat and the remaining 50% as a protein-mineral concentrate (balancer diet). All treatments received their daily ration in two distributions: 09:00 (4 h after light on) and 16:00 h (5 h before light off). During weeks 30, 32 and 34, hens' behaviour was recorded using scan sampling method (once per week during the light period), while focal sampling was used between the 32 and 34 weeks (two hours after each feeding, and two hours in between). Feather condition of individual hen was scored at 30 and 37 weeks, number of eggs and feed intake were recorded weekly.

Sequential feeding delayed the oviposition for almost one hour. When fed wheat-based diet (09:00 - 16:00 h) SWW birds spent less time feeding and stood still longer compared to birds in other treatments. Four hours after distribution of wheat diets, the occurrence of feather peaking was the highest in SWW and the lowest in the SGW treatment. The poorest feather condition was recorded in the SWW treatment. Total feed intake was the highest in the C treatment, while the intake of wheat diet and the ratio wheat diet intake/total feed intake was the highest in the SGWI treatment. We concluded that sequential feeding with whole wheat had detrimental effect on behaviour of laying hens probably due to long period of access to wheat used in this work. It is therefore suggested that wheat should be used either ground or presented on shorter time sequence. The time access should be reduced when whole wheat is used.

Key words: laying hens; sequential feeding; behaviour; feather condition; performance

1 Introduction

Increasing complexity of rearing conditions, also called “the enrichment”, has been often studied to find devices, which would increase the behavioural repertoire and thus improve the welfare of farm animals (Newberry, 1995). In poultry, devices such as perches, dust-bath, toys, strings etc. have been used to enhance general activity or reduce harmful behaviours such as feather pecking. However, very little attention has been paid to the complexity of the diet. In commercial poultry production, laying hens are fed with only one single complete diet, formulated to provide the nutrients requirements. This diet does not offer any heterogeneity, thus no possibility for the birds to choose. Possible enrichment may then consist in enhancing diet complexity by providing several diets instead of only one. Giving access to two diets at the same time often leads to unbalanced intake since birds prefer high to low energy diets (Picard et al., 1997). In an attempt to avoid this, birds have been given access to the diets at different times. This feeding method is called sequential feeding, since various diets are given in sequence over time (Gous and Du Preez, 1975). Sequential feeding has been mainly used in broiler chickens with diets varying in energy or crude protein (Bouvarel et al., 2004, 2008). However, in the past it has also been used in laying hens, with minerals being offered separately in the evening, so that calcium would be at birds disposal during the night, when the eggshell formation is in process. In broiler chickens it has been shown that commercial performance obtained with sequential feeding did not differ from standard feeding when a high-energy and a low-protein diet was fed to birds on one day and the following day was fed with a low-energy and a high-protein diet (Bouvarel et al., 2004, 2008). In addition, sequential feeding modified time spent in eating and exploring (Bouvarel et al., 2008), and enhanced broilers general activity. For these reasons it has been used to mitigate leg problems by reducing early growth without impairing body weight at slaughter, and thus improving the welfare of meat type chickens (Leterrier et al., 2008). Besides the welfare, sequential feeding is interesting from the nutritional point of view. Using two diets instead of only one allows different formulation of diets and use of various raw ingredients. For example, in sequential feeding it is possible to offer animals raw ingredients rich in protein in one diet and high-energy ingredient in the other diet. This of course is not possible in commonly used complete feed mixture since high levels of energy and protein are needed together in the same raw material. The use of raw ingredients has also economical benefits. Grinding, mixing and other handling

procedures associated with mash production are reduced to a great extent, which leads to substantial reduction of feed costs. Furthermore, the use of raw materials allows the use of locally grown cereals in the farm, which may additionally lower feed costs on account of transport reduction (Henuk and Dingle, 2002).

Due to the possibility of feeding birds with more than one diet, sequential feeding has been also used in feeding chickens with whole cereals. In this case a balanced nutrient intake was achieved with a protein concentrate (balancer diet), which provided additional necessary amounts of protein, vitamins and minerals (Bouvarel et al., 2004; Noirot et al., 1998; Rose, 1996). Sequential feeding with whole wheat has been shown to increase activity in broilers without impairing performance (Noirot, 1998), while in laying hens sequential feeding with wheat improved feed conversion (Umar Faruk et al., 2010). However, the possible influence of sequential feeding method on laying hens behaviour and consequently on their welfare is yet to be established. The present experiment was therefore designed to test whether sequential feeding with wheat would induce changes in laying hen's behaviour, feed intake, feather condition, and egg production.

2 Material and Methods

2.1 Animals and housing

The study included 320 non beak-trimmed ISA Brown laying hens obtained at the age of 15 weeks from a commercial supplier. They were distributed into 64 standard cages (five birds/cage). Live body weight was used as criterion such that there was no difference in weight among birds of the same cage and between the treatments. Cages were arranged into three-tier battery and were of following dimensions: length 60 cm, depth 56 cm (672 cm² area per hen), front height 41 cm and rear height 38 cm. Each cage was equipped with a feed trough (12 cm per hen) and two nipple drinkers. Temperature varied between 19 and 25 °C. Between 15 and 19 weeks of age photoperiod was gradually increased from 10 to 16 hours a day, with light on from 05:00 to 21:00 h. This lighting regime was maintained till the end of the experiment at 47 weeks of age.

During the experiment, eight hens died (1 C, 1 SGWI, 2 SGW, 4 SWW) and two from the SWW treatment had to be excluded because of their excessive feather pecking.

2.2 *Experimental treatments*

From 15 to 18 weeks of age all the hens were habituated to sequential feeding using whole wheat (3130 kcal/kg ME, 12.9% CP) in the morning followed by a balancer diet (2633 kcal/kg ME, 19% CP) after the wheat was removed from the feed trough. During this period, birds were phase fed to account for increase in feed intake with age. Thus, wheat offered was increased from 20% (week 15) to 50% (week 18). The duration of the period birds had access to wheat was increased from 3 hours (week 15) to 7 hours (week 18).

At 19 weeks of age, hens were allotted to one of four treatments (Fig. 1), which were randomised among cages. Each treatment contained 16 cages, with two neighbouring cages belonging to the same treatment. Each bird received a total of 121 g/hen/day of feed, corresponding to 105% of the estimated daily feed intake. All treatments, including the control one, were hand-fed in two distributions (09:00 and 16:00), with 50% of the daily ration in each distribution. The control treatment (C) received a complete conventional diet (2753 kcal/kg ME, 18% CP) throughout the two distributions. The remaining three treatments were fed sequentially. Two sequential treatments received either whole (SWW) or ground wheat (SGW) during the first distribution and balancer diet (B2) during the second distribution. Another sequential treatment (SGWI) received ground wheat with added vitamin premix+phosphorus+2% oil during the first distribution and the balancer diet (B1) during the second distribution. The composition of the experimental diets is presented in Table 1.

The balancer diets B1 and B2 were formulated such that ingesting equal proportion of wheat-based diet and balancer diet will provide on average the same nutrient intake as the control treatment. In sequential treatments, the previous diet was always removed from the feed trough by a vacuum cleaner before the next distribution, while in the control treatment it was removed only before the first distribution. Particle size distribution of the diets is shown on Fig. 2.

2.3 *Measurements*

2.3.1 *Behaviour*

Behaviour was monitored from 30 to 37 weeks of age, that is in the middle of experimental period, after the birds reached the peak of egg production. It was recorded directly by scan and focal sampling, with the observer standing in front of the cage at a

distance of approximately 2 m. On account of the feeding regime birds were used to frequent noise and people presence, therefore in order to avoid disturbing the hens, the observer had to wait only for a few moments before recording the behaviour. Scan sampling was conducted once a week by two observers at 30, 32 and 34 weeks of age. Hens' behaviour was recorded at one hour interval during the light period between 05:00 and 21:00 h. In the hours of feed distribution, the recording of behaviour started at the moment all the animals received feed. Each observer alternated sides and rows of the battery every hour. The number of hens standing up (number of all the animals that were not lying irrespective of what behavioural pattern they were performing) as well as performing the following behavioural patterns was recorded: feeding (pecking at the feed in the trough), drinking and standing still (standing without performing any other behavioural pattern). The number of eggs laid was also recorded.

Focal sampling was performed by one observer between 32 and 34 weeks of age using Observer 3.0 software (Noldus Information Technology, Wageningen, The Netherlands). Behaviour of hens was recorded over four days, six hours per day, that is two hours after feed delivers, starting at the moment when all the animals were fed (morning period: 09:00 to 11:00 and evening period: 16:00 to 18:00) and two hours in between (afternoon period: 12:30 to 14:30). In each cage, the behaviour of all birds was recorded simultaneously for 2 minutes within each of the three periods respectively. Each day we recorded the behaviour in 16 cages (4 cages per treatment) equally dispersed over the battery, making it possible to collect information on all the 64 cages in four days. We recorded number of animals feeding (defined as state) and occurrence of feather pecking (included gentle as well as strong pecks, where the feathers were plucked out), beak pecking (pecking at the beak of other hens; a behaviour usually observed during feeding), object pecking (pecking at the parts of the cage e.g. walls, trough) or aggressive pecking (vigorous, rapid pecks at another animal). These behavioural patterns were defined as events.

2.3.2 Feather condition

Feather condition of individual laying hen was scored twice at 30 and 37 weeks of age, using the scoring system of Tauson et al. (2005). Six body parts (back, wings, tail,

vent/cloaca, neck and breast) were scored separately with scores from one to four with higher scores representing better plumage condition.

2.3.3 Performance

The number of all the eggs produced was recorded daily per cage and the percentage was calculated from the weekly data. Feed intake was measured weekly as the difference between total weekly feed offered and total weekly feed leftover. In sequential treatments, wheat and balancer diet intakes were measured separately and summed to obtain the total feed intake.

2.4 Statistical analysis

Data analyses were conducted using Statview 5.0 (SAS Institute Inc., USA). Average data from cages were analysed with the exception of data on feather condition, where individual hen represented the experimental unit. Data from scan sampling, except the number of eggs laid, were divided into four periods according to the daily rhythm of feeding (Fig. 3). Period 1 included scans before the first feed distribution (from 05:00 to 08:00 h), period 2 the scan just after feed distribution (09:00 h), period 3 scans between the first and the second feed distribution (from 10:00 to 15:00 h) and period 4 scans after the second feed distribution (from 16:00 to 20:00 h). Although hens had at their disposal greater amount of feed than the estimated daily feed intake, feed delivery represented an important stimulus with a great impact on hens' behaviour, which resulted in subordinating most of the observed behavioural patterns to these events. Therefore the analysis and consequently the data presentation were done separately for each of the period.

To investigate if hens in one treatment laid eggs earlier or later compared to hens in the other cages, the number of laid eggs obtained during scan sampling was transformed into index of laying according to the Eq. (1). The higher the value of index the earlier hens laid the eggs. However, the result of the index was transformed to hours to make understanding easier. This was done by defining an index of 16 to be 5:00 h, and adding one hour more to this for each subsequent, but smaller, index (i.e. an index of 15 would be 6:00 h etc.).

$$\text{Index of laying} = \sum_{i=16}^1 (i \cdot N) / N_{SUM} \quad (1)$$

where: i = value assigned to individual scan hour (value 16 is equivalent to the scan at 05:00 h and value one to the scan at 20:00 h); N = number of eggs laid in particular hour; N_{SUM} = sum of eggs laid during observation period (from 05:00 to 21:00 h).

Feeding (from scan and focal sampling), standing still and standing up were analysed with repeated measures ANOVA. The model included the effects of treatment (C, SGWI, SGW, SWW), period (scan sampling: period 1 – 4; focal sampling: morning, afternoon, evening period) and their interactions. The effect of treatment within individual period was tested with ANOVA, while differences between periods within individual treatment were assessed using repeated measures ANOVA. The effect of treatment on the index of laying, number of eggs produced corrected by hen number, total feed intake, intake of the individual diets and ratio between wheat-based diets and total feed intake was analysed using ANOVA. In the case the main effect (treatment or period) was significant, differences between means were tested by the Bonferroni test.

Drinking and feather condition were not normally distributed therefore the treatment effect within individual period or scoring was tested with nonparametric Kruskal-Wallis test followed by the Mann Whitney U test with Bonferroni correction for pairwise multiple comparison of means. Differences in drinking behaviour between periods were determined using Friedman test and differences between scores of the first and the second feather scoring with the Wilcoxon signed rank test. Differences in occurrence of feather, object or beak pecking and aggression between treatments were tested with χ^2 test. In the results occurrence of feather and object pecking is presented as the percentage of cages where these behavioural patterns were observed.

3 Results

3.1 Behaviour

Treatment influenced time of oviposition (ANOVA: $F_{3,60} = 7.878$, $P = 0.0002$, Fig. 4). In the C treatment hens reached the peak in laying approximately one hour and 40 minutes after light-on, while in sequential treatments, the majority of eggs were laid almost one hour later compared to the C treatment.

Repeated measures ANOVA revealed that interaction between treatment and period was significant only in feeding ($F_{9,180} = 11.099$, $P < 0.0001$) and standing still ($F_{9,180} = 4.178$, $P < 0.0001$). In both behavioural patterns the effect of treatment (feeding:

$F_{3,60} = 16.545$, $P < 0.0001$; standing still: $F_{3,60} = 4.665$, $P = 0.0054$) and period was significant (feeding: $F_{3,60} = 469.135$, $P < 0.0001$; standing still: $F_{3,60} = 375.560$, $P < 0.0001$). Sequential feeding induced two peaks in feeding behaviour, each observed at the time of distribution of diets (Fig. 3). Similar daily rhythm was observed in all three observation days and in all treatments, even in the control one. The ANOVA analysis showed that treatment significantly influenced time spent on feeding in all four periods (Table 2), but in standing still, which appeared to be inversely related to feeding, only in periods 2 and 3. In all treatments, the highest percentage of feeding was observed in periods 2 and 4, while hens stood still mostly during period 1. The Bonferroni pairwise comparisons revealed that in the first period of the observation day, hens in the C treatment fed longer than hens in the SGW and SWW treatment, while in period 4 they spent significantly less time feeding than birds in the other treatments. In the second and the third period the lowest percentage of feeding was observed in the SWW birds.

Time spent standing up was influenced only by period (repeated measures ANOVA: $F_{3,60} = 49.306$, $P < 0.0001$), but not by treatment (repeated measures ANOVA: $F_{3,60} = 1.670$, $P = 0.1829$). Interaction between treatment and period was not significant as well (repeated measures ANOVA: $F_{9,180} = 1.413$, $P = 0.1855$). The highest percentage of standing up (96.4%) was noticed in period 4, while the lowest (80.0 to 82.1%) was observed in period 1. Time spent drinking was similarly as time spent standing up influenced only by period (Friedman test: $df = 3$, $\chi^2 = 169.172$, $P < 0.0001$) and not by treatment (Kruskal-Wallis test: $df = 3$, $H = 4.797$, $P = 0.1873$). The highest percentage of drinking (10.7 to 11.2%) was noticed in the period 4, while the lowest (0.0%) was observed in period 2 (data not shown).

Duration of feeding (focal sampling) analysed with repeated measures ANOVA was significantly influenced by treatment ($F_{3,60} = 2.853$, $P = 0.0446$) and period ($F_{2,60} = 74.841$, $P < 0.0001$) as well as the interaction between treatment and period ($F_{6,120} = 5.963$, $P < 0.0001$). The Bonferroni pairwise treatment comparisons within each period (Fig. 5) confirmed the results obtained with scan sampling presented in Table 2. In the morning (Fig. 5), after the first feeding, hens in the SWW treatment spent less time feeding than hens in the other two sequential treatments and in the afternoon less than hens in the C treatment. In the evening, after the second feeding, the situation was just the opposite with the SWW hens feeding significantly longer than the C hens. Treatment significantly

influenced the occurrence of feather pecking in the afternoon (χ^2 test: $df = 3$, $\chi^2 = 11.004$, $P = 0.0117$), which was more often observed in the SWW treatment than in the SGW (Fig. 6 a). Treatment significantly influenced also the occurrence of object pecking in the evening (χ^2 test: $df = 3$, $\chi^2 = 8.260$, $P = 0.0409$). The percentage of cages where object pecking was observed was higher in the SGWI treatment compared to the SGW and SWW treatment (Fig. 6 b). Treatment had no influence on the occurrence of beak (χ^2 test: $df = 3$, $\chi^2 = 0.722$, $P = 0.8680$) and aggressive (χ^2 test: $df = 3$, $\chi^2 = 1.422$, $P = 0.7003$) pecking (data not shown). The latter was observed very seldom, altogether in only 10 cages.

3.2 Feather condition

Sum of feather condition scores for all six evaluated body parts showed that with time, feather condition had been significantly impaired in the SWW treatment (Table 3). In the first scoring, when hens were 30 weeks old, there was no difference in feather condition between treatments, however in the second scoring, SWW hens had significantly lower sum of scores in comparison to hens in the C and SGW treatment.

Condition of feathers on the hen's back and vent/cloaca gave, according to our observation in the present experiment, the real insight into severity of feather pecking. Sum of these two scores showed significant impairment of feather condition with time regardless of treatment (Table 3), while at each scoring there was a significant difference between treatments. At 30 weeks of age, when the first scoring was performed, hens in the SGW treatment had higher sum of scores in comparison with SGWI and SWW hens. In the second scoring, in spite of impairment, feather condition on the back and vent/cloaca remained significantly better in the SGW compared to the SWW treatment.

3.3 Performance

ANOVA analysis showed that treatment had a significant influence on total feed intake ($F_{3,60} = 25.748$, $P < 0.0001$; Table 4), the intake of individual diets (wheat or GWI: $F_{2,45} = 9.761$, $P = 0.0003$; balancer diet: $F_{2,45} = 17.538$, $P < 0.0001$; Table 4) as well as on the ratio between wheat-based diets and total feed intake ($F_{2,45} = 13.665$, $P < 0.0001$; Table 4). The Bonferroni pairwise comparisons between treatments revealed that hens in the C treatment had higher total feed intake than hens in the three sequential treatments. Comparing the intake of individual diets, hens in SGWI treatment ate higher quantity of wheat and lower quantity of balancer diet in comparison to the SGW and SWW treatments.

In these two treatments, wheat to total intake ratio was significantly lower than in the SGWI treatment.

The number of eggs per hen (Table 4) in the period studied (30 to 37 weeks) was significantly influenced by treatment ($F_{3,60} = 3.646$, $P = 0.0175$). Hens in the SGW treatment laid less eggs compared to the C hens. However, the production of eggs for the entire experimental period (week 19 to 44) was 91.1% and did not significantly differ between treatments (data not shown).

4 Discussion

Sequential feeding significantly delayed the mean time of oviposition for almost one hour compared to the control treatment. Some studies on broiler breeders reported delay in mean oviposition time when there was a delay in feeding time (Backhouse and Gous, 2005; Wilson and Keeling, 1991). On the contrary, in the cafeteria access to energy, protein and calcium diets, which gave hens the opportunity to consume nutrients parallel to their needs for egg formation, eggs were laid about two hours earlier compared to the complete feeding (Chah and Moran, 1985). According to the above mentioned findings, the explanation for delayed laying in treatments fed sequentially would therefore be a lack of essential nutrients necessary for the egg formation at the time needed. The other possible explanation for delayed oviposition in sequential treatments was the uneven supply of proteins. According to the findings of Keshavarz (1998a), for optimum performance hens need quality proteins available throughout the day. These findings may explain why in sequential treatments hens laid eggs later compared to the control, but they do not correspond to our results regarding the egg production. Within the studied period of 30 to 37 weeks of hens' age egg production was lower only in one treatment fed sequentially (SGW) and not in all three of them, therefore difficult to explain. Besides, this difference did not persist over longer period. The treatments did not result in differences in the number of eggs laid between 19 and 44 weeks.

Treatment significantly influenced feeding behaviour as well as feed intake. Observed daily rhythm of time spent feeding with two peaks, one in the morning and the other one in the afternoon, corresponds to the results of Bessei (1977) and Walser and Pfirter (2001). It is also comparable with the results of several authors studying the daily rhythm of feed intake (Choi et al., 2004; Savory, 1980). However, it seems that in our study the time spent

in feeding was not regulated only by photoperiod (Lewis et al., 1995), oviposition and egg formation process (Morris and Taylor, 1967; Savory, 1977; Wood-Gush and Horne, 1970), but also by feed distribution itself. Well-marked peaks at feed distribution hours in the daily feeding activity are pointing out that stimulus of novel feed increased feeding motivation of all hens, even those in the C treatment, which had at their disposal only one diet. Results obtained with scan and focal sampling supplement each other and correspond to previous findings on the daily rhythm of feed intake. Feed consumption was reported to be low prior to oviposition and increase immediately afterwards (Ballard and Biellier, 1969; Savory, 1977; Wood-Gush and Horne, 1970). In the middle of the light period hens usually eat less (Savory, 1980), while in the late afternoon, when the egg enters the uterus, another increment occurs, which is more pronounced and lasts longer (Ballard and Biellier, 1969; Savory, 1977).

According to the previous findings, laying hens consumed the greatest amount of feed in the afternoon (Hetland et al., 2003; Holcombe et al., 1976; Keshavarz, 1998a, 1998b), even regardless of dietary regimen (Holcombe et al., 1976; Keshavarz, 1998b). Since balancer diets were offered hens in the afternoon, this could be one of explanations why in our study the intake of balancer diets was greater compared to the wheat-based diets. Different intake of individual diets between treatments is difficult to explain, because the only remarkable difference in diet composition between SGWI and SGW and SWW treatments was in phosphorus content. Hens in the C treatment had significantly greater total feed intake compared to hens in sequential treatments, which supports earlier findings of Leeson and Summers (1978) and Reichmann and Connor (1979). Smaller feed intake in sequential treatments is indicating, that sequential treatments seem to offer hens sufficient opportunity to consume nutrients according to their daily cyclic requirements. When having this opportunity, hens used the nutrients more efficiently compared to the control treatment, where they had to consume also other nutrients and not only the one they needed at certain part of the day (Henrik and Dingle, 2002; Robinson, 1985), which consequently leads to a greater feed intake.

When given access to the wheat-based diets, hens in the SWW treatment spent less time feeding compared to the other treatments. This is related to the particle size, since hens fed fine structured diets need more time to consume the required amount of feed (Aerni et al., 2000; Savory and Mann, 1997; Vilarino et al., 1996; Walser and Pfirter, 2001).

However, feeding large particle diets (El-Lethey et al., 2000; Lindberg and Nicol, 1994) and with this related shorter time spent feeding (Aerni et al., 2000; van Krimpen et al., 2005; Walser and Pfirter, 2001) was often reported to be related to a higher risk of feather pecking. The same connection appeared also in our study. In the afternoon, when hens in general spent the least time feeding, feather pecking was the most pronounced in the SWW treatment. Moreover, comparing the time hens spent feeding and standing still revealed a negative connection between these two behavioural patterns. The lower the percentage of time spent feeding the longer the time standing still. Increased time of standing still in the SWW treatment during the periods hens had at their disposal the wheat diets showed that the particle size influenced also this behavioural pattern and not just the feeding and feather pecking. This result confirmed earlier findings of Savory and Mann (1997). Contrary to standing still, object pecking seemed to be unrelated to feeding or feather pecking whatever the period. In object pecking the difference between treatments occurred in the evening period after changing the diets. It is hard to explain why hens in the SGWI treatment pecked more parts of the cage than hens in the other two sequential treatments. Perhaps the reason for this was the change from preferred to a less-preferred diet as observed by Dixon (2006) with chicks from a laying strain, although it is hard to say why would hens preferred the B2 diet over the B1. The reason the occurrence of object pecking was unrelated to time spent feeding or occurrence of feather pecking was probably linked to the absence of objects of interest in the cage, since a previous study demonstrated that giving hens access to strands of string induced pecking at these strings and reduced feather pecking (McAdie et al., 2005).

In line with behavioural results, hens in the SWW treatment had the worst feather condition compared to the C or the SGW treatment. Feather scores appeared especially related to the variations in feather pecking observed in the afternoon. Although small, the differences in the sum of scores are very important, because of seriousness of the feather pecking problem present in laying hens. They are warning us about the possible negative consequences of feeding hens sequentially with the whole wheat. With time the feather condition got worse regardless the treatment. This has been clearly shown when only the sums of scores for the back and vent/cloaca, which in our opinion give real insight into severity of feather pecking, were compared. The negative impact of time on the feather

condition supports previous findings of several authors (Blokhuys et al., 2001; Huber-Eicher and Sebö, 2001; Savory and Mann, 1997).

In the present study, the effect of sequential feeding with wheat on the behaviour, feed intake, feather condition, and egg production was tested on laying hens housed in standard cages, which will be banned in the EU in the near future. However, taking into account the experiments dealing with the sequential feeding in broilers housed in pens (e.g. Bouvarel et al., 2004, 2008; Leterrier et al., 2008), we can be quite certain this feeding method is applicable also in alternative housing systems to cages, e.g. floor pens. Of course, we cannot state with certainty what would be the effect of sequential feeding with wheat on laying hens housed in e.g. enriched cages or floor pens. Nevertheless, we can expect that sequential feeding with ground wheat with or without additional ingredients would have no detrimental effect on the occurrence of feather pecking and consequently on laying hens' welfare. However, the negative effect of feeding hens with whole wheat might either come to a greater expression or diminish on account of hens' spending more time exploring their environment when this is enriched.

5 Conclusions

Sequential treatments with wheat delayed the oviposition but otherwise had no detrimental effect on the behaviour of laying hens except when whole wheat was used. Large particle diet reduced the time spent feeding and increased the occurrence of feather pecking, which resulted in impaired feather condition. Therefore, when sequential feeding is to be employed in laying hen, wheat should be offered as ground or if whole wheat is to be fed, then perhaps it should be presented for shorter time periods. This may help to reduce its negative impact on the occurrence of feather pecking and consequent deterioration of feather condition.

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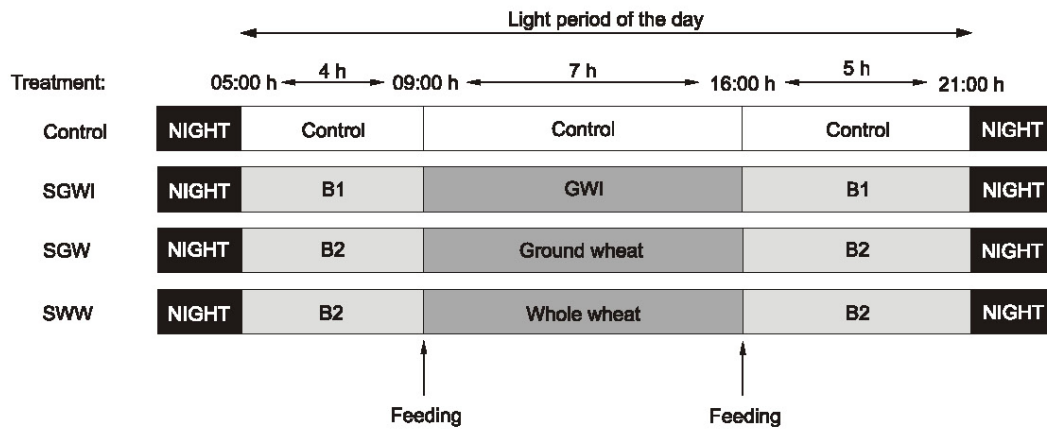


Fig. 1: Time schedule of diets distribution (treatment: SGWI: sequential with ground wheat having additional ingredients; SGW: sequential with ground wheat; SWW: sequential with whole wheat; diet: B1, B2: balancer diet; GWI: ground wheat having additional ingredients)

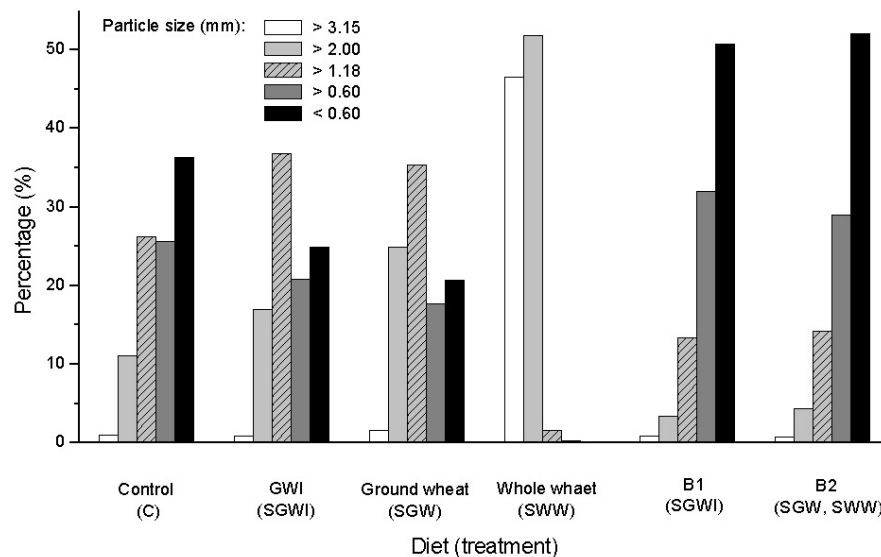


Fig. 2: Particle size distribution of the diets with the treatment (in parenthesis) the individual diet belongs to (treatment: C: control; SGWI: sequential with ground wheat having additional ingredients; SGW: sequential with ground wheat; SWW: sequential with whole wheat; diets: GWI: ground wheat having additional ingredients; B1, B2: balancer diet)



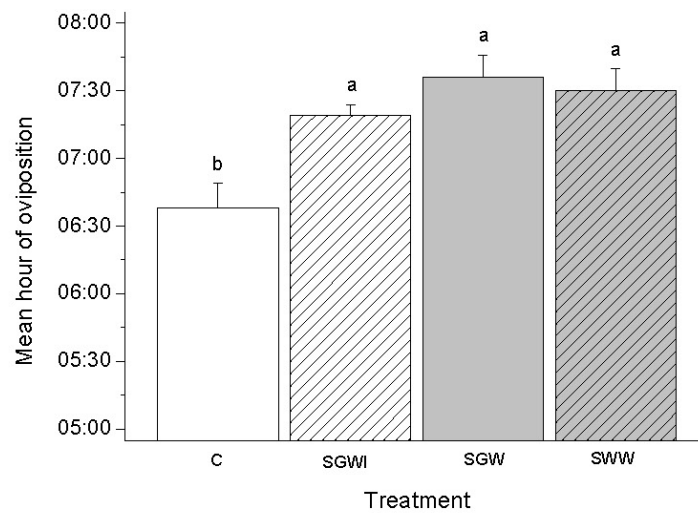


Fig. 4: Mean hour of oviposition (mean $\pm$ S.E.M.; C: control; SGWI: sequential with ground wheat having additional ingredients; SGW: sequential with ground wheat; SWW: sequential with whole wheat). Significant differences (Bonferroni test $P < 0.008$) are indicated by different letters (a, b).

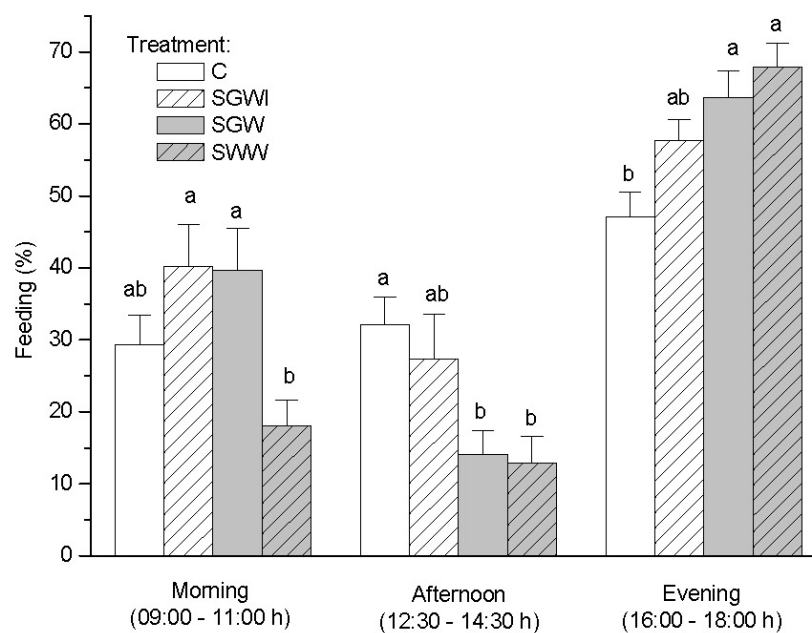


Fig. 5: Duration of time spent for feeding (mean $\pm$ S.E.M.) by period of the day recorded with focal sampling (C: control; SGWI: sequential with ground wheat having additional ingredients; SGW: sequential with ground wheat; SWW: sequential with whole wheat). Significant differences (Bonferroni test $P < 0.008$) are indicated by different letters (a, b).

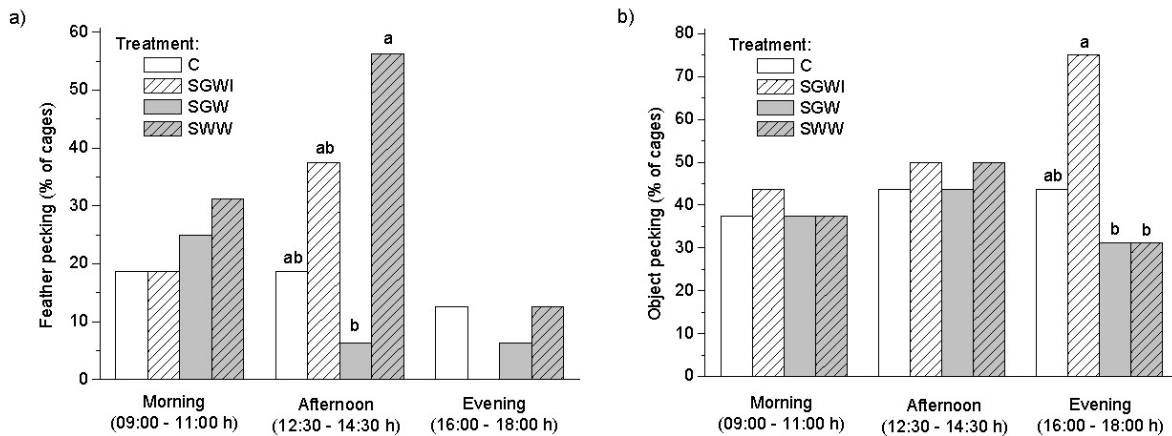


Fig. 6: Percentage of cages where feather pecking (a) and object pecking (b) were recorded with focal sampling in certain period of the day (C: control; SGWI: sequential with ground wheat having additional ingredients; SGW: sequential with ground wheat; SWW: sequential with whole wheat). Significant differences (χ^2 test $P < 0.05$) are indicated by different letters (a, b).

Table 1: Composition of experimental diets

Treatment ¹	Control	Sequential			
	C	SGWI		SGW, SWW	
Diet ²		GWI	B1	Wheat	B2
Ingredient (%)					
Wheat	50.00	92.35		100.00	
Soya bean meal T48	17.00	0.34	41.36		41.06
Sunflower meal			3.00		
Maize	16.13		34.05		34.27
Calcium carbonate	7.96		14.93		15.23
Maize gluten 60	3.29	1.17			2.44
Wheat offal	2.54		3.55		
Bicalcium Phosphate	1.16	2.72			2.68
Soya bean oil	0.80	2.04	1.60		1.60
Sup 64 J02 ³	0.50	0.50	0.50		1.00
Sodium Bicarbonate	0.20	0.19	0.18		0.40
Refined salt	0.20	0.20	0.22		0.43
DL-Methionine	0.11		0.34		0.27
L-Lysine 78 Pou	0.11		0.05		0.07
Ucx Super Jaunis ⁴		0.48	0.22		0.55
Calculated composition					
ME (kcal/kg)	2753	3130	2400	3130	2400
CP (%)	18.0	12.9	23.0	12.9	23.0
Ca (%)	3.64	0.97	6.20	0.03	7.20
P (%)	0.53	0.76	0.39	0.29	0.81

¹ C: control; SGWI: sequential with ground wheat having additional ingredients; SGW: sequential with ground wheat; SWW: sequential with whole wheat

² GWI: ground wheat having additional ingredients; B1, B2: balancer diet (protein concentrate)

³ Vitamin and mineral premix supplied the following amounts per kilogramme of diet: Vitamin A 1600000 IU, Vitamin D3 480000 IU, Vitamin E 2000 mg, Vitamin K3 400mg, Vitamin B1 109 mg, Zn 11000 mg, Mn 12000 mg, Cu (sulphate) 1200 mg, Fe 4000 mg, I 200 mg, Se 60 mg, DL-Methionine 120 g, Canthaxanthine 200 mg.

⁴ Yolk pigment contains per kilogramme of diet: Cantaxanthine E 161g 300 mg, Luteine E 161b 1633 mg, Zeaxanthine E 161h 91 mg, Cryptoxanthine E 161c 36 mg.

Table 2: Duration of feeding and standing still ($\pm$ S.E) by treatment and period of the day (scan sampling)

	Treatment ¹				<i>F</i> -value ³ df (3, 60)	<i>P</i> -value ³
	C	SGWI	SGW	SWW		
<i>Feeding (%)</i> ²						
Period 1	15.0 ± 1.9 ^{a, Z}	10.2 ± 2.0 ^{ab, Z}	7.8 ± 1.5 ^{b, Z}	8.5 ± 0.9 ^{b, Y}	4.031	0.0112
Period 2	62.2 ± 3.8 ^{bc, W}	77.4 ± 3.2 ^{a, W}	76.7 ± 3.7 ^{ab, W}	48.4 ± 4.9 ^{c, W}	12.321	0.0001
Period 3	33.2 ± 2.0 ^{a, Y}	32.2 ± 1.8 ^{a, Y}	27.8 ± 1.6 ^{a, Y}	14.9 ± 1.5 ^{b, X}	23.942	0.0001
Period 4	45.3 ± 1.4 ^{b, X}	53.4 ± 1.1 ^{a, X}	52.5 ± 1.3 ^{a, X}	53.1 ± 1.1 ^{a, W}	9.931	0.0001
<i>F</i> -value; df (3,15) ⁴	85.668	185.213	185.655	73.162		
Period effect (<i>P</i> -value) ⁴	0.0001	0.0001	0.0001	0.0001		
<i>Standing still (%)</i> ²						
Period 1	43.3 ± 1.9 ^W	45.8 ± 2.6 ^W	51.7 ± 2.3 ^W	49.5 ± 2.7 ^W	2.371	0.0794
Period 2	9.9 ± 2.3 ^{ab, Z}	7.7 ± 2.1 ^{ab, Z}	4.3 ± 1.6 ^{b, Z}	14.4 ± 3.0 ^{a, Y}	3.365	0.0243
Period 3	21.5 ± 1.8 ^{b, X}	27.4 ± 2.2 ^{b, X}	26.4 ± 1.5 ^{b, X}	36.2 ± 2.3 ^{a, X}	9.685	0.0001
Period 4	13.3 ± 1.5 ^{YZ}	9.8 ± 1.0 ^{YZ}	11.1 ± 1.3 ^{YZ}	11.8 ± 0.6 ^{YZ}	1.686	0.1797
<i>F</i> -value; df (3,15) ⁴	114.650	93.353	149.964	62.741		
Period effect (<i>P</i> -value) ⁴	0.0001	0.0001	0.0001	0.0001		

¹ C: control; SGWI: sequential with ground wheat having additional ingredients; SGW: sequential with ground wheat; SWW: sequential with whole wheat

² Period 1: 05:00-09:00 h; period 2: 09:00-10:00 h; period 3: 10:00-16:00 h; period 4: 16:00-21:00 h

³ Analysis data were obtained by ANOVA.

⁴ Analysis data were obtained by repeated measures ANOVA.

^{a, b, c} Means in the same row with a different superscript differ significantly (Bonferroni test $P < 0.008$).

^{w, x, y, z} Means in the same column with a different superscript differ significantly (Bonferroni test $P < 0.008$).

Table 3: Feather condition by treatment and time of scoring

	Treatment ¹				<i>H</i> -value (df=3) ³	<i>P</i> -value ³
	C	SGWI	SGW	SWW		
<i>Sum of scores for all six body parts</i> ²						
Scoring 1	20.8 ± 0.2	20.5 ± 0.2	21.1 ± 0.1	20.4 ± 0.2	3.834	0.2800
Scoring 2	20.8 ± 0.2 ^a	20.1 ± 0.3 ^{ab}	21.0 ± 0.2 ^a	19.7 ± 0.3 ^b	13.169	0.0043
<i>Z</i> -value ⁴	-0.133	-1.773	-0.518	-3.774		
Time effect (<i>P</i> -value) ⁴	0.8946	0.0762	0.6043	0.0002		
<i>Sum of scores for back and vent/cloaca</i> ²						
Scoring 1	7.8 ± 0.1 ^{ab}	7.6 ± 0.1 ^b	7.9 ± 0.0 ^a	7.5 ± 0.1 ^b	10.100	0.0177
Scoring 2	7.5 ± 0.1 ^{ab}	7.3 ± 0.1 ^{ab}	7.6 ± 0.1 ^a	7.2 ± 0.1 ^b	8.739	0.0330
<i>Z</i> -value ⁴	-3.541	-2.822	-4.147	-4.056		
Time effect (<i>P</i> -value) ⁴	0.0004	0.0048	0.0001	0.0001		

¹ C: control; SGWI: sequential with ground wheat having additional ingredients; SGW: sequential with ground wheat; SWW: sequential with whole wheat

² Scoring 1 was performed at 30 and scoring 2 at 37 weeks of age. The higher the sum of scores the better the feather condition.

³ The treatment effect within each scoring was evaluated with the Kruskal-Wallis test.

⁴ Differences between scoring 1 and scoring 2 were evaluated with the Wilcoxon signed rank test.

^{a, b} Means in the same row with a different superscript differ significantly (Mann Whitney U test with Bonferroni correction $P < 0.008$).

Table 4: Feed intake and egg production from 30 to 37 week of age

	Treatment ¹				<i>F</i> -value	<i>P</i> -value
	C	SGWI	SGW	SWW		
<i>Total feed intake</i>						
Intake (g)	112.6 ± 0.9 ^a	106.4 ± 0.6 ^b	103.5 ± 0.7 ^b	105.4 ± 0.9 ^b	25.748	<0.0001
<i>Intake of the individual diets</i>						
Wheat or GWI ² (g)	-	49.6 ± 1.0 ^a	44.4 ± 0.7 ^b	46.2 ± 0.9 ^b	9.761	0.0003
Balancer diet (B1, B2) (g)	-	56.8 ± 0.5 ^b	59.1 ± 0.2 ^a	59.2 ± 0.3 ^a	17.538	<0.0001
Ratio (%):	-	46.6 ± 0.7 ^a	42.8 ± 0.4 ^b	43.7 ± 0.5 ^b	13.665	<0.0001
Wheat (or GWI ²)/total intake						
<i>Number of egg corrected by hen number (%)</i>						
	97.8 ± 0.4 ^a	97.0 ± 0.4 ^{ab}	95.3 ± 0.7 ^b	96.4 ± 0.5 ^{ab}	3.646	0.0175

¹ C: control; SGWI: sequential with ground wheat with additional ingredients; SGW: sequential with ground wheat; SWW: sequential with whole wheat

² GWI: ground wheat having additional ingredients (see Table 1)

^{a, b} Means in the same row with a different superscript differ significantly (Bonferroni test $P < 0.008$).

Submitted to Applied Animal Behaviour Science and is under second revision for publication.

2.4 EFFECT OF WHOLE WHEAT AND FEED PELLETS DISTRIBUTION IN THE LITTER ON BROILERS' ACTIVITY (ABSTRACT)

Duška JORDAN¹, Ivan ŠTUHEC¹ and Werner BESSEI²

¹ Department of Animal Science, Biotechnical Faculty, University of Ljubljana, Groblje 3, SI-1230 Domžale, Slovenia

² Department of Farm Animal Ethology and Poultry Production 470C, University of Hohenheim, D-70599 Stuttgart, Germany

The objective of this study was to enhance the locomotor activity of fast growing broilers by stimulation of foraging behaviour. The study included 120 Ross 308 broiler chickens of mixed sex fattened from 1-39 days of age in small groups (10 birds/group from 1 to 27 and 6-7 birds from 27 to 39 days of age). Chickens were randomly allotted to one of three treatments (four groups/treatment). The control birds (C) were fed with pellets in a trough, W birds additionally to pellets in a trough received a small quantity of whole wheat scattered twice a day in the litter, and in the P treatment the trough was removed at 14 days of age and pelleted grower was scattered in the litter five times a day. Feed intake and feed conversion were similar in the C and W treatment. In the P treatment it was not possible to measure how much of the pellets offered in the litter the birds actually ate and how much remained in the litter. From 15 to 39 days of age the P birds grew significantly slower compared to the C and W birds, which resulted in 13% lower slaughter weight (C: 2185.7 ± 39.1 g, W: 2219.8 ± 54.7 g, and P: 1913.0 ± 64.4 g). P birds spent significantly ($P < 0.05$) less time lying in the 3 (P: $33.7 \pm 5.0\%$, C: $66.1 \pm 2.6\%$, W: $61.0 \pm 1.5\%$) and 4th week ($23.0 \pm 6.8\%$, C: $62.3 \pm 4.0\%$, W: $56.9 \pm 6.1\%$) of age compared to the C and W birds, whereas this difference disappeared in the 5th week. Birds from the P treatment walked for a longer time than C and W birds from 3rd week onwards. They showed also more scratching and pecking. Scattering feed pellets in the litter significantly increased broilers activity, which was not achieved with the whole wheat scattered in the litter. Scattering pellets in the litter seems to be a promising method to

enhance broilers' activity and thus contributes to their welfare. However, improvements should be brought to avoid reduction in body weight at slaughter age.

Key words: broilers, environmental enrichment, behaviour, performance, animal welfare

Accepted for publication in Archiv für Geflügelkunde, ISSN 0003-9098, © Verlag Eugen Ulmer, Stuttgart. It will be published in volume 75, issue 2 (April 2011) or 3 (July 2010).

3 GENERAL DISCUSSION AND CONCLUSIONS

3.1 GENERAL DISCUSSION

Enrichment of barren, unstructured housing conditions is gaining its importance due to increasing demand for improvement of animal welfare in intensive production systems. Enrichment such as increment of environmental complexity, offer of different kinds of substrates and objects to manipulate, etc. may enable animals to express behaviour they are highly motivated to perform, stimulate performance of species-specific behaviour, reduce the frequency of abnormal or harmful behaviour, increase animals' general activity and thus contribute to improvement of animal welfare. Beside animal behaviour, the evaluation of environmental enrichment often includes animal performance. Although performance itself is not a reliable welfare indicator, it is of extreme importance that environmental enrichment has no negative impact on animal performance regarding its application into practice.

3.1.1 Behaviour

Environmental enrichment influenced the behaviour of animals in all four studies - fattening pigs, growing rabbits, laying hens and fast growing broilers. In fattening pigs (Subheading 2.1) the daily provision of 100 g of straw or hay per animal in a rack significantly influenced all observed behavioural patterns, except drinking. Large behavioural differences in pigs were also reported by Kelly et al. (2000) using only 50 g of straw per animal daily. It seems that even a small amount of roughage is sufficient for substantial behavioural differences and consequently for the welfare improvement. However, to keep pigs' attention, the roughage has to be renewed daily (Fraser et al., 1991; Kelly et al., 2000; Moinard et al., 2003; Whittaker et al., 1998). In our study, fattening pigs showed large interest in offered environmental enrichment, with females being occupied with hay and straw for a significantly greater percentage of observation period compared to castrates. The same trend regarding sex difference has been shown in total activity. On account of occupation with straw and hay pigs were more active in general. However, the difference was significant only in females. They were generally more active and occupied with chewing the substrates for a greater percentage of time than castrates. Similar results

were also reported by Elkmann and Hoy (2008). Occupation with straw as well as hay resulted in lower percentage of time spent biting pen bars and lower frequency of aggressive encounters in both sexes. Positive influence of roughage on biting pen bars and aggression has been reported in several studies (Beattie et al., 1996, 2001; Day et al., 2002a; Fraser et al., 1991; Kelly et al., 2000; Lyons et al., 1995; O'Connell and Beattie, 1999). In our study both substrates, hay and straw, had characteristics adequate to reinforce pigs' exploratory and feeding motivation (Day et al., 2002b; van de Weerd et al., 2003). Although straw and hay had a similar impact on the behaviour, straw might be more suitable than hay, because it lasts longer as chewing material. During the observation period pigs chewed hay for a greater percentage of time than straw which resulted in racks with hay being empty earlier than racks with straw.

In contrast to fattening pigs, the environmental enrichment in growing rabbits housed individually in wire-mesh cages influenced only the duration of feeding time, with rabbits in cages enriched with Norway spruce (*Picea abies*) gnawing sticks feeding significantly longer ($2.08 \pm 0.87\%$) compared to the rabbits in unenriched cages (Subheading 2.2). This is not in agreement with an earlier experiment of Jordan et al. (2004), who found no significant difference between cages with and without gnawing sticks in duration of feeding time. Similarly, the influence of gnawing sticks on other behavioural patterns (e.g. resting, grooming, caecotrophy, sniffing cagemates, rearing up, exploratory behaviour, jumping) revealed no consistent results among different studies (e.g. Brooks et al., 1993; Huls et al., 1991; Jordan et al., 2003, 2004; Lidfors, 1997; Luzi et al., 2003; Verga et al., 2005). Even in biting wire and cage equipment, which is one of the most common behavioural abnormality in cage systems (Gunn and Morton, 1995; Morton et al., 1993), results of various studies differ. Some authors found no influence of gnawing sticks on biting wire and cage equipment (Jordan et al., 2004; Lidfors, 1997), while others reported significant decrement of this behavioural abnormality when gnawing sticks were added either to individually (Jordan et al., 2003) or group housed growing rabbits (Luzi et al., 2003; Verga et al., 2005). Gnawing sticks did not change the frequency of transitions from one behaviour to another and from one posture or position during resting to another, which confirmed earlier findings of Lidfors (1997). Frequent behavioural changes and changes in posture and position during resting indicate that rabbits are restless and they are

showing displacement activities. Lehmann (1987) suggested that frequent changes of behaviour indicate poor welfare and that rabbits were under stress. Despite the fact that in previous studies (Brooks et al., 1993; Huls et al., 1991; Jordan et al., 2004) rabbits showed the greatest interest in the wood of *Pinaceae*, in our study they had almost no interest in Norway spruce gnawing sticks. They gnawed only 0.06 times per hour, which equals to 0.09% of the observed time. This is unusual regarding the assumed great need of rabbits for gnawing (Grün, 2002) and findings that when kept in quasi-natural conditions they gnaw branches and roots (Stauffacher, 1992). However, Berthelsen and Hansen (1999) and Jordan et al. (2004) also reported low interest of individually housed rabbits in gnawing wood. In our study, rabbits' lack of interest could not have been caused by the type of wood. The possible reason for rabbits' low interest in gnawing sticks and consequently the limited influence on their behaviour might lie in the fact that sticks were constantly present. Under these conditions, they lost their effect of novelty, which is an important aspect of environmental enrichment (Johnson et al., 2003).

The importance of the novelty stimulus effect on animals' behaviour has been demonstrated in laying hens, where environmental enrichment presented sequential feeding method (Subheading 2.3). The daily rhythm of time spent feeding had two peaks, one in the morning and the other one in the afternoon, which corresponds to the results of Bessei (1977) and Walser and Pfirter (2001). However, it seems that in our study the time spent feeding was not only regulated by photoperiod (Lewis et al., 1995), oviposition and egg formation process (Morris and Taylor, 1967; Savory, 1977; Wood-Gush and Horne, 1970), but also by feed distribution itself. Well-marked peaks of feeding activity in the hours of feed distribution show that stimulus of novel feed increased feeding motivation of all hens, even those in the control treatment (C), which had only one diet at their disposal. However, this effect was more pronounced in sequential treatments, where hens were offered different diets in sequence. An exception were hens in the SWW treatment, which spent less time feeding compared to hens in other treatments during the period when animals had wheat-based diets at their disposal (09:00 to 16:00 o'clock). The reason for this was the difference in the particle size. Hens fed mash diets need more time to consume the required amount of feed compared to hens fed crumbled or pelleted diets (Aerni et al., 2000; Savory and Mann, 1997; Vilarino et al., 1996; Walser and Pfirter, 2001). Feeding crumbled and

pelleted diets was often reported to increase feather pecking (Aerni et al., 2000; El-Lethey et al., 2000; Lindberg and Nicol, 1994; van Krimpen et al., 2005; Walser and Pfirter, 2001). The same effect appeared in our study as a result of feeding hens with whole wheat. In the afternoon, when hens in general spent the least time feeding, feather pecking was the most pronounced in the SWW treatment. Moreover, particle size did not only influence the feeding and feather pecking, but also standing still. Comparison of the time hens spent feeding and standing still revealed a negative relationship between these two behavioural patterns. The lower the percentage of time spent feeding, the longer the time standing still. Hens in the SWW treatment had the worst feather condition compared to the hens in the C treatment or hens fed sequentially with ground wheat (SGW). Feather scores appeared especially related to the feather pecking observed in the afternoon. Although small, the differences in feather scores are important due to importance of feather pecking problem in laying hens. With the increment of hens' age feather condition deteriorated regardless of the treatment. These results support previous findings of several authors (Blokhuys, 1989; Huber-Eicher and Sebö, 2001; Savory and Mann, 1997), who reported negative impact of age on laying hens feather condition. Sequential feeding significantly delayed the mean time of oviposition for almost one hour compared to the control treatment. Possible explanation for this might be lack of essential nutrients necessary for the egg formation at the time needed (Backhouse and Gous, 2005; Keshavarz, 1998b; Wilson and Keeling, 1991).

Fast growing broilers spend a large proportion (60 – 90%) of their time inactive (Arnould and Faure, 2003; Bokkers and Koene, 2003; Murphy and Preston, 1988; Reiter, 2004; Weeks et al., 2000). The percentage of inactive behavioural patterns increases from the first week of age onwards (Bessei, 1992; Scherer, 1989). In the present study (Subheading 2.4), scattering small amount of whole wheat twice a day in the litter did not stimulate foraging behavioural patterns, such as walking, scratching and pecking, when a standard diet was offered in a trough (W). This confirmed the results of Bizeray et al. (2002b). In fact, there was no difference in any of the observed behavioural patterns between the control (C) and W birds. Only the removal of troughs and scattering the entire daily quantity of complete feed mixture pellets five times a day in the litter (P) beneficially influenced time spent walking, scratching and pecking. Relatively high levels of these

active behavioural patterns show that even fast growing broilers are capable of performing active behavioural patterns at a higher level, although only in the case when this is necessary to meet their nutrient requirements or when they are forced into it (Reiter and Bessei, 1998; Rutten, 2000).

3.1.2 Performance

The offer of straw or hay did not influence growth rate of fattening pigs (Subheading 2.1). This was probably due to insufficient amount of provided substrate. Previous studies, where the environment of pigs was enriched with straw in the form of bedding, reported increase in growth rate (Beattie et al., 2000; Morgan et al., 1998). In the present study, the addition of straw or hay did not influence the lean meat percentage. These results are in contrast to the results of Beattie et al. (2000) reporting that in pigs, environmental enrichment with straw and peat resulted in heavier carcass weight, greater level of back fat thickness, greater feed intake and better feed conversion. However, we recorded sex $\times$ enrichment interaction for both traits, growth rate and lean meat percentage. Females provided with hay and straw grew slower and had greater lean meat percentage compared to castrates. Since in our study both sexes had the same feed consumption, the only possible explanation for the observed sex $\times$ enrichment interaction could be greater activity of female animals. This is supported by the results of Elkmann and Hoy (2008) who found lower growth rate in females compared to castrates on account of their greater activity.

Feeding laying hens with diets of different nutrient contents either simultaneously or sequentially has been shown to positively influence feed intake (e.g. Leeson and Summers, 1978; Umar Faruk et al., 2010b) and egg shell quality (e.g. Chah and Moran, 1985; Leeson and Summers, 1978; Umar Faruk et al., 2010b) with no detrimental effect on egg production (e.g. Chah and Moran, 1985; Keshavarz, 1998a; Umar Faruk et al., 2010b). This beneficial influence is a consequence of hens being able to meet their daily cycle requirement for nutrients more effectively (Henuk and Dingle, 2002; Robinson, 1985). Provision of several diets instead of only one enhance diet complexity and may be considered as enrichment with positive influence on laying hens' behaviour and welfare. However, this aspect has not been elucidated so far. In contrast to the above-mentioned studies, in the present study the SGW hens had slightly lower egg production during the

time of observation (30 – 37 weeks) compared to the other three treatments (Subheading 2.3). This negative influence, however, disappeared when the entire laying period (19 – 44 weeks) was taken into account (results published by Umar Faruk et al., 2010a). Sequential feeding significantly reduced the total feed intake, which supports earlier findings of Leeson and Summers (1978), who fed layers simultaneously with diet rich in energy and protein and diet rich in calcium without any negative effect on egg production. This beneficial effect on the total feed intake has been explained by hens having the opportunity to adjust nutrient supply to their specific requirements for energy, protein and calcium at various times of the day. Mongin and Sauveur (1974) and Nys et al. (1976) demonstrated that when given calcium separately from the basal diet layers ingested more calcium in the afternoon and evening. The increased requirement for calcium at this time of day may lead to excess feed intake when calcium is provided in a compound diet (Henrik and Dingle, 2002; Robinson, 1985). Increased requirement for calcium in the afternoon and evening was also confirmed in our study by greater intake of calcium-rich balancer diet. In general, it seems that sequential feeding enables hens to meet their daily cycle requirement for nutrients, especially calcium, more effectively and thus enhance the welfare of laying hens from the nutritional point of view. Since egg production was not significantly reduced when the entire laying period was considered, and feed intake was substantially decreased, the beneficial effect on hens' welfare in the SGW treatment is expected to corroborate the economic aspects of egg producers.

In fast growing broilers (Subheading 2.4), body weight, feed intake and feed conversion developed in line with the standards of Ross 308 provided by the breeding company (Ross, 2007), when birds received either a complete feed mixture in a trough (C) or whole wheat scattered in the litter additionally to complete feed mixture (W). Although feeding whole wheat as a complement to a standard diet usually leads to reduction in growth rate due to reduced protein intake (Damme et al., 2007), this was not the case in our study. In contrast to laying hens, where the distribution of whole grain in the litter elicits intensive pecking and scratching activities (Appleby et al., 2004), broilers in the present study showed almost no interest in the whole wheat scattered in the litter. We were not able to measure the wheat intake. However, it can be concluded that, if any of the scattered wheat was consumed, the amount must have been too small to influence the nutrient balance of the

daily ration, which in the W birds consisted of compound pellets and whole wheat. This finding is in agreement with the results of Bizeray et al. (2002a). In the P birds the actual feed intake could not be measured either, since it was not possible to record the amount of pellets remained in the litter. This raised the question whether delay in growth of P birds was due to higher energy requirement for walking, scratching and pecking or due to lower feed intake. Estimate of the extra energy requirement for physical exercise revealed that the P birds had about 2% higher energy requirement (van Kampen, 1976) compared to the C and W birds. This is not enough to explain the reduction in body weight of about 13%. Therefore, it has to be assumed that part of the pellets in the litter was either not found or has been destroyed by the birds when stepping over them or by taking humidity from the litter. When pellets were reduced to fine particles, birds were not able to recover them from the litter.

3.2 CONCLUSIONS

Keeping farm animals in barren environment will not be tolerated in the future for the welfare reasons. Therefore, methods are sought to increase the level of environmental stimuli under commercial conditions. In the frame of the thesis, we examined the efficiency and suitability of environmental enrichment in different farm animal species or production type – fattening pigs, growing rabbits, laying hens and fast growing broilers. Based on the obtained results, we conclude the following:

1. Small daily amount of straw or hay offered in racks as environmental enrichment reduced biting pen bars and aggressiveness among fattening pigs housed in fully slatted floor pens under commercial conditions without influencing growth rate and lean meat percentage. Hay and straw also increased the total activity of female animals on account of their longer occupation with substrates compared to castrated males. This might indicate that enrichment is of greater importance for females than castrates. However, greater activity might be the cause for females' lower weight gain and greater lean meat percentage. Nevertheless, straw as well as hay proved to be efficient environmental enrichment for female and castrated fattening pigs, which under certain conditions can also be used in fully slatted floor pens (Subheading 2.1).

2. Growing rabbits housed individually in wire-mesh cages showed little interest in gnawing wooden sticks made of Norway spruce (*Picea abies*). Consequently, the influence of gnawing of sticks on rabbits' behaviour was limited – they influenced only the duration of feeding, while there was no positive influence on recorded abnormal behavioural patterns (i.e. biting wire and cage equipment, frequency of behavioural changes and changes in posture and position during resting). For this reason, wooden sticks do not represent efficient environmental enrichment for growing rabbits housed individually in wire-mesh cages. However, the results among different studies are not consistent in the effect of gnawing sticks on growing rabbits' welfare. Further research is needed before the final conclusion on gnawing sticks as environmental enrichment for growing rabbits can be made (Subheading 2.2).
3. Daily rhythm of feeding activity in laying hens fed sequentially with wheat showed that this particular feeding method has enrichment effect on intensively kept laying hens. Additionally, sequential feeding offered hens the opportunity to adjust nutrient supply, especially calcium, to their daily cyclic requirements, and thus reduce the feed intake without affecting egg production. When whole wheat was used, an increased risk of feather pecking was observed. In order to avoid this damaging behaviour the time of presenting whole wheat should be reduced or wheat should be offered as grounded. Sequential feeding method changed characteristic of laying hens' circadian rhythm, including the time of oviposition (Subheading 2.3).
4. Whole wheat scattered in the litter, as the addition to standard diet offered in a trough, had no influence on the behaviour and performance of fast growing broilers and thus no enrichment effect. On the contrary, removal of troughs and scattering the entire daily quantity of feed pellets five times a day in the litter proved to be an efficient method of increasing time broilers spent walking, scratching and pecking and thus possibly contribute to their welfare. However, this feeding method slowed down birds' growth, most likely because they were unable to consume the total amount of pellets scattered in the litter. During scratching a part of the pellets have been destroyed and lost in the litter. Therefore, further research is needed to solve the above-mentioned problems (Subheading 2.4).

4 SUMMARY (ZUSAMMENFASSUNG)

4.1 SUMMARY

Barren and space restricted environment of intensive production systems thwarts the expression of numerous behavioural patterns due to inadequate stimulation. This is also considered the major cause of abnormal and damaging behavioural patterns which impair animal welfare. In addition, inadequate stimulation may decrease the general level of animals' activity, and thus contribute to the expression of leg disorders, especially in fast growing animals. Environmental enrichment may beneficially influence animal behaviour and for this reason decrease or even prevent leg disorders in fast growing broilers. There are numerous ways of how to enrich animals' rearing conditions (e.g. enlargement of available floor area, establishment of suitable structure of the enclosure with setting e.g. visual barriers, platforms, hide boxes, provision of objects for manipulation and play, more heterogeneous feed etc.), however, not all of them will necessarily improve animal welfare. The objective of the thesis was therefore to elucidate the suitability of selected environmental enrichment in fattening pigs, growing rabbits, laying hens and fast growing broilers. For this purpose, four studies were conducted. In the first study (Subheading 2.1) we wished to examine the effect of small amounts of straw or hay (100 g per animal per day) on the behaviour, growth rate and carcass composition of fattening pigs housed in slatted floor pens (4.90 x 2.45 m). The experiment was performed on a commercial pig farm in two replications, each including 96 fattening pigs of both sexes (three pens of 16 females and three pens of 16 male castrates equally divided into three treatments) from 60 kg to slaughter at average 96 kg live weight. Animals were fed with a complete feed mixture and fresh whey twice a day, at 7:30 and 12:00 o'clock. Animals did not eat the whole meal at once but left a part of it for later, so feeding was practically ad libitum. Hay or straw was laid in the rack placed above the trough straight after the morning feeding. The behaviour of pigs was recorded directly by two observers for three days during the entire light period (6:00 to 14:00 o'clock) in each replication using instantaneous sampling. Individual live weight of animals was measured at the beginning of the experiment and before slaughter. The lean meat percentage was estimated according to Slovenian regulation. In the second study (Subheading 2.2) the influence of gnawing sticks as

environmental enrichment on behaviour of individually housed growing rabbits was studied. At the age of 44 days 16 males of Slovenian sire line SIKA for meat production were housed in the upper tier of two-tier wire-mesh cages (dimension 40 x 37.5 x 30 cm) equipped with a feeder and a nipple drinker. Half of the cages were enriched with wooden sticks of Norway spruce (*Picea abies*), fixed horizontally under the ceiling. Water and complete feed mixture were available ad libitum, the daily duration of lighting was 12 hours (6:00 to 18:00 o'clock). Rabbit behaviour was recorded with infrared video camera (Panasonic WV-BP330) 24 hours per day between 45 and 48, 58 and 61, 72 and 75, and 86 and 89 days of age. Video recordings were analysed with »Observer 4.1« software. The beginning and the end of individual behavioural patterns were continuously registered for each rabbit. The third study (Subheading 2.3) included laying hens with enhanced diet complexity as environmental enrichment. Instead of one, hens were fed two diets in sequence. Sequential feeding with whole wheat has been shown to modify behaviour in broilers and performance in laying hens. As the influence of this feeding method on the behaviour of laying hens has not been established yet, this was the matter of our study. In addition, we monitored feed intake, feather condition and egg production. These parameters were measured on 320 non beak-trimmed ISA Brown laying hens from 30 to 37 week of age. The birds were placed in 64 standard cages (five birds/cage, 672 cm² area per hen) and allotted to one of four treatments. The control (C) was fed a conventional complete diet. Three treatments were fed sequentially with whole wheat (SWW), ground wheat (SGW) or ground wheat with a vitamin premix, phosphorus and oil (SGWI). In sequential treatments, 50% of the ration was fed as wheat from 9:00 to 16:00 o'clock and the remaining 50% as a protein-mineral concentrate (balancer diet) from 16:00 to 9:00 o'clock. All birds received their daily ration in two distributions: 9:00 (4 hours after light on) and 16:00 o'clock (5 hours before light off). During weeks 30, 32 and 34, hens' behaviour was recorded directly by two observers using scan sampling method (once per week during the light period with one hour interval). Focal sampling was performed by one observer between the 32nd and 34th week (2 minutes per cage within each of the following three periods: 9:00-11:00, 12:30-14:30 and 16:00-18:00 o'clock). Feather condition of individual hens was scored at 30 and 37 weeks. Number of eggs and feed intake were recorded weekly. In the fourth study (Subheading 2.4) we examined the effect of environmental enrichment on foraging behaviour and locomotor activity in fast growing

broilers. The study included 120 Ross 308 broiler chickens of mixed sex kept from 1 to 39 days of age in wooden boxes (dimension 77 x 77 cm) in small groups (10 birds/group from 1 to 27 and 6-7 birds from 27 to 39 days of age). The broilers were randomly allotted to three treatments (four groups/treatment). The control birds (C) were fed with pellets in a trough, the W birds received, in addition to pellets in a trough, a small quantity of whole wheat scattered twice a day (6:00 and 18:00 o'clock) in the litter. In the P treatment the trough was removed at 14 days of age and feed pellets were scattered in the litter five times a day (6:00, 10:00, 14:00, 18:00 and 22:00 o'clock). The behaviour of broilers was recorded between 5:00 to 7:30 hours once per week from the second to the fifth week of age. Video records were analysed using scan sampling every 30 minutes for 10 minutes with one scan every minute. Live weight per group was recorded weekly, while feed consumption per group was recorded for the period between 1 and 27 and 28 to 39 days.

Environmental enrichment of fattening pigs with small amount of hay or straw increased the proportion of time animals were active on account of increased occupation with substrate ($P < 0.05$). However, increased proportion of total activity was noticed only in females, which also spent more time chewing substrate than castrated males. Both substrates significantly reduced time spent biting pen bars and the frequency of aggressive encounters. Neither hay nor straw negatively influenced pigs' growth rate and lean meat percentage, whereas sex of the animals significantly influenced both traits. Females grew slower and had greater lean meat percentage than castrated males. In contrast to fattening pigs, environmental enrichment had almost no influence on the behaviour of growing rabbits. Gnawing sticks made of Norway spruce did not attract much of rabbits' interest – they gnawed only 0.06 times/hour, which equals to 0.09% of observed time, and significantly influenced only the duration of feeding by $2.08 \pm 0.87\%$. There was no positive influence on recorded abnormal behavioural patterns (biting wire and cage equipment, frequency of behavioural changes). In laying hens, SWW birds spent less time feeding and stood still longer compared to birds in other treatments when fed wheat-based diet (9:00 to 16:00 o'clock). This influenced the occurrence of feather pecking, because four hours after distribution of wheat-based diets, the feather pecking was the highest in the SWW and the lowest in the SGW treatment. Consequently, the poorest feather condition was recorded in the SWW treatment. Total feed intake was the highest in the C

treatment, while birds ate greater amount of balancer diet compared to wheat-based diets. The egg production in the period from 30 to 37 weeks was lower in the SGW compared to the C treatment. Nevertheless, the number of eggs per hen for the entire laying period (19 - 44 weeks) did not significantly differ between treatments. In fast growing broilers, environmental enrichment with scattered whole wheat (W) did not influence any of the observed behaviour. However, scattering feed pellets in the litter (P) significantly decreased time spent lying in the third and fourth week of age. From the third week onwards, P birds spent also more time walking, scratching and pecking compared to the C and W birds. In feed intake, feed conversion and growth rate there was no difference between the C and W treatment, whereas birds in the P treatment grew significantly slower, which resulted in 13% lower slaughter weight.

In conclusion, small amount of hay and straw proved to be appropriate and inexpensive environmental enrichment for fattening pigs in intensive housing systems, which improved their welfare. The addition of wooden sticks for gnawing demonstrated to be unsuitable environmental enrichment for growing rabbits. Sequential feeding with wheat had a detrimental effect on laying hens' behaviour and feather condition when used with whole wheat. Therefore, wheat should be used either grounded or perhaps presented in shorter time periods. In fast growing broilers, scattering feed pellets in the litter proved to be a promising method for enhancing broilers' activity and thus improving their welfare. However, further research is needed to be able to avoid reduction in body weight at slaughter age.

4.2 ZUSAMMENFASSUNG

Intensive Tierhaltungssysteme sind durch hohe Besatzdichte und reizarme Umgebung gekennzeichnet. Die mangelnde Stimulation in dieser Umgebung führt zu Problemen bei der Ausführung verschiedener Verhaltensweisen. Die Folgen dieser Haltungsbedingungen sind oft eine verringerte allgemeine Aktivität sowie anomale und teilweise auch schädigende Verhaltensweisen. Insbesondere die reduzierte Aktivität wird bei schnell wachsenden Masttieren als Ursache für Beinschäden angesehen. Es wird angenommen, dass die genannten Probleme durch Anreicherung der Umweltbedingungen behoben werden können. Ziel der vorliegenden Arbeit war es deshalb, die Eignung verschiedener Methoden zur Anreicherung der Umwelt bei Mastschweinen, Mastkaninchen, Legehennen und Broilern zu untersuchen. Es wurden vier Versuche durchgeführt. Im ersten Versuch (Untertitel 2.1) wurde das Angebot von Stroh und Heu (100 g pro Tier und Tag) in einer Raufe auf Verhalten, Wachstum und Körperzusammensetzung von weiblichen und kastrierten männlichen Mastschweinen auf Spaltenboden untersucht. Im zweiten Versuch (Untertitel 2.2) wurde der Einfluss von Nagehölzern aus Fichte (*Picea abies*) auf das Verhalten einzeln gehaltener männlicher Kaninchen der slowenischen Zuchtlinie für die Fleischproduktion SIKA untersucht. In der dritten Studie (Untertitel 2.3) wurden zur Anreicherung der Umwelt bei Legehennen Rationen unterschiedlicher Art abwechselnd angeboten (sequential feeding). Die Rationen bestanden aus Weizen in unterschiedlicher Form (ganze Weizenkörner, geschrotete Weizenkörner und geschroteten Weizen mit einer Ergänzung von Vitaminen, Phosphor und Fett) sowie einem Ergänzerfutter in Mehlform. Jeweils eine Ration wurde vormittags und eine nachmittags verabreicht. Der Effekt dieser sequenziellen Verabreichung von verschiedenen Rationen gegenüber einer Standardfütterung mit einem Alleinfutter in Mehlform wurde an braunen Legehennen (ISA Brown) in Hinsicht auf Verhalten, Futteraufnahme, Befiederung und Legeleistung untersucht. In der vierten Untersuchung (Untertitel 2.4) wurde eine Anreicherung der Umwelt über die Verabreichung eines Teils der Futterration von Broilern über die Einstreu durchgeführt. Dabei wurden entweder ganze Weizenkörner, oder ein Alleinfutter in pelletierter Form in die Einstreu gestreut.

Die Anreicherung der Umwelt von Mastschweine in mit Heu und Stroh erhöhte den Anteil der Zeit, in der sich die Tiere mit dem Substrat beschäftigten. Die Erhöhung der Gesamtaktivität konnte jedoch nur bei weiblichen Tieren festgestellt werden. Diese wiesen auch mehr Zeit zum Kauen des Substrats auf als die Kastraten. Die beiden eingesetzten Substrate reduzierten signifikant die Zeit, die die Tiere mit Stangenbeißen zubrachten. Auch die Anzahl der aggressiven Auseinandersetzungen war reduziert. Wachstum und Anteil an Magerfleisch wurden zwar durch das Geschlecht (weibliche Tiere wuchsen schneller und hatten einen höheren Anteil an Magerfleisch als Kastrate), nicht aber durch die Anreicherung beeinflusst.

Im Gegensatz zu den Mastschweinen hatte die Anreicherung der Umwelt keinen Einfluss auf das Verhalten der Mastkaninchen. Die Knabberhölzer aus Fichtenholz wurden von den Tieren wenig beachtet. Lediglich die Dauer des Fressens wurde um $2,08 \pm 0,87\%$ verlängert.

Bei Legehennen war die Zeit des Fressens bei der Gruppe, die sequenziell mit ganzen Weizenkörnern und einer Ergänzungsfütterung gefüttert wurde, gegenüber der Kontrollgruppe reduziert und die Dauer des Stehens verlängert. Diese Behandlung förderte das Federpicken. Es wurde beobachtet, daß vier Stunden nach der Verteilung der ganzen Weizenkörner die Häufigkeit des Federpickens am höchsten war. Entsprechend der Verhaltensbeobachtungen konnte auch in dieser Gruppe, die ganze Weizenkörner erhielt, die schlechteste Befiederung festgestellt werden. In der Gruppe, die sequenziell mit geschrotetem Weizen und einer Ergänzungsfütterung gefüttert wurde, war dagegen in dem vergleichbaren Zeitabschnitt die Häufigkeit des Federpickens am geringsten. Die gesamte Futteraufnahme war in der Kontrollgruppe höher als in den Gruppen, die sequenziell gefüttert wurden.

Die Verteilung von Weizen in der Einstreu hatte keinen Einfluss auf das Verhalten schnell wachsender Broiler. Wenn die gesamte Futtermischung in die Einstreu gestreut wurde, stieg die Zeit, in welcher die Tiere aktiv waren und in der Einstreu pickten und scharren, gegenüber den beiden anderen Versuchsgruppen an. Allerdings hatte diese Behandlung einen negativen Einfluss auf das Wachstum der Tiere. Zwischen der Gruppe, die ganze

Weizenkörner in der Einstreu erhielt und der Kontrollgruppe wurde dagegen kein signifikanter Unterschied in Futteraufnahme, Wachstum und Futterverwertung festgestellt.

Zusammenfassend kann festgestellt werden, dass die Verabreichung kleiner Mengen an Heu oder Stroh offensichtlich eine geeignete und ökonomisch wenig belastende Methode ist, um die Umwelt von Mastschweine in intensiven Haltungssystemen anzureichern. Die steigende Beschäftigung mit dem Material und die reduzierte Aggression tragen zur Verbesserung des Wohlbefindens der Tiere bei. Das Angebot von Nagehölzer bei Kaninchen stellt dagegen keine geeignete Maßnahme zur Anreicherung der Umwelt bei Mastkaninchen dar. Die sequenzielle Fütterung von ganzen Weizenkörnern und einem Ergänzerfutter führte zu erhöhtem Federpicken und zu einer schlechteren Befiederung. Wenn Weizen in einem sequenziellen Fütterungsprogramm eingesetzt werden soll, sollte er in geschroteter Form verabreicht werden. Bei schnell wachsenden Masthühnern hat die Verabreichung von ganzen Weizenkörnern in die Einstreu zusätzlich zu einer pelletierten Ration keinen Effekt auf die Aktivität der Tiere. Dagegen kann die Aktivität deutlich gesteigert werden, wenn die gesamte pelletierte Ration in die Einstreu gestreut wird. Weitere Studien sind jedoch notwendig, um den negativen Einfluss der letzteren Behandlung auf das Gewicht zu beheben.

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ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to Prof. Dr. Werner Bessei who accepted the role of my supervisor and made my Ph.D. at the University of Hohenheim possible. I appreciate his help, kindness, readiness for discussion, suggestions in preparing and conducting the research.

I would also like to thank Prof. Dr. Ivan Štuhec, who took over the mentorship of Slovenian part of dissertation, for his help and support.

I am much obliged to Dr. Christine Leterrier who accepted me at the INRA, Nouzilly, France and to Dr. Philippe Lescoat and Ph.D. student Murtala Umar Faruk who were willing to include me in their experiment on sequential feeding in laying hens. They showed me what working together as a team can be like and what can be done if all of us have the same goal. Christine's mentorship, her support and willingness to help and discuss questions such as what and how made working with her a great pleasure. Christine, I would also like to thank you for letting me become a member of your family, for all your spare time dedicated to me, for all the beauties you showed me around Tours and the river Loire, which gained a special place in my heart. I will always look forward to coming back.

Further on, I would like to express my gratitude to the staff at the Experimental station for animal husbandry, animal breeding and small animal breeding of Hohenheim University, Unterer Lindenhof, Eningen u.A., Germany for their acceptance and kindness. I would especially like to thank the director of Unterer Lindenhof Leopold Peitz, who always found a nice word for me, and Jürgen Butscher for his technical assistance in the experiment and for being my interpreter and a driver whenever necessary. I would like to express my sincere gratitude to the workers responsible for the poultry, especially Heiko Stegmann and Jan Abegg, who always helped me whenever I asked for help (no matter how busy they were) and guided me with their advice in taking care of my chickens. I learned a lot from them. A special mention goes to Herr Rentschler.

I owe a great thank you to the lecturer M.Sc. Ajda Kermauner for her help regarding the experiment with growing rabbits. She was always ready for discussion and answering my questions about rabbits, and always willing to offer a friendly chat.

I would like to thank Gregor Gorjanc for his help and advice in statistical analysis of the data obtained in experiments on fattening pigs and growing rabbits. Our debates were of extreme value to me.

For their help in the rabbitry I would like to thank Igor Urankar and Peter Lipovšek, and for their help with the laying hens I would like to thank Dominique Boulay and Michel Couty. A special thank you goes to Kristijan Hrastar and Matej Šušteršič for their technical assistance and observation of fattening pigs.

Ada, thank you for your help in spending hours and hours watching rabbits and for all the time we spent together behind the Observer analysing video records. Although it was sometimes difficult, we had a great time together.

A special thank you goes to Helga Letzguß and Karin Heisler, two very special friends. Thank you for always being there for me, ready to help, getting me out of trouble, and thank you for all your little attentions that brightened my days and brought smile on my face.

Jan and Ute, thank you for all the walks, talks, dancing lessons and trips around the Unterer Lindenhof. I do not know how I would manage my stay in Germany without your company. A special thank you goes to the ladies in the kitchen and the apprentices living at the Unterer Lindenhof during my stay there. I never realised how close I had got with some of you until the moment I had to leave. In this place, I would also like to thank Jose Maria for his company during lunchtime and his efforts to talk German with me. I gained a new friend with you.

I would like to thank Paul Constantin for sharing the laboratory with me, for his help and our small talks. I would also like to thank Vanessa, Cecil, Murtala, Aurelie, Mohamed and Chantal for letting me into their lives and becoming my friends. Together with Christine

and Pol, you showed me that there are still good people in this world, willing to do so much for an almost complete stranger.

Nataša in Meta, thank you for all your advice and encouragement and, most of all, for being there for me all this time.

Ardita, although we only spent a short time together I have a feeling that we have known each other our entire lifetime. Even though we sailed on our own respective boats, we were together in this battle of gaining the Ph.D., we helped each other succeed. I am glad I had the opportunity of getting to know you and becoming a part of your life.

Dejan, where would I be without you? Thank you for your support, help, encouragement, patience, but most of all, thank you for your comforting embraces in the most difficult moments. I am also grateful to all other members of my family for their support and for their reassurance that they are always there with me, even if I am far, far away.

I would like to thank the colleagues at my former Chair, especially Darja, who sometimes had to take over a big part of my obligations, and all of you who thought of me and helped me in different ways to finish what I had started.

CURRICULUM VITAE

Personal data

Family name: Jordan
First name: Dušanka
Date of birth: 2 January 1976
Place of birth: Ljubljana, Slovenia
Sex: Female
Nationality: Slovene
Permanent address: Šalka vas 95, 1330 Kočevje, Slovenia
Contact: dusanka.jordan@bf.uni-lj.si

Education

1994 - 2000 B.Sc. in Animal Science
University of Ljubljana, Biotechnical Faculty, Slovenia
Thesis: “The effect of dog presence on working activity of mentally retarded children”

2000 - 2007 M.Sc. in Animal Science
University of Ljubljana, Biotechnical Faculty, Slovenia
Thesis: “Effect of gnawing wood as environmental enrichment on ethological, production and carcass traits of individually housed rabbits”

2007 - 2010 Ph.D. in Agricultural Sciences
University of Hohenheim, Germany
Thesis: “Environmental enrichment in intensive production systems for farm animals”

Employment:

2001 – to date Assistant for animal science and ethology at the Department of Animal Science, Biotechnical Faculty, University of Ljubljana, Slovenia

Additional education:

24.-25.05.2001 Training course “Animal welfare”, Ljubljana, Slovenia

27.10.2001 Seminar “Laboratory animals in biomedical research”, Ljubljana, Slovenia

14.-24.07.2002 Short-term scientific mission in the frame of COST Action 848 (WG 2) with the purpose to get familiar with the infrared videotechnique and the video tape analysis system Observer at Prof. Dr. Hoy Steffen, Institute for Animal Breeding and Genetics, Justus Liebig University Giessen, Germany

21.-22.10.2003 Seminar »Building on livestock farms«, Velenje, Slovenia

21.-24.06.2004 Additional education for workers in education and schooling “12th summer school: Problem based learning”, Radovljica, Slovenia

04.09.2004 Workshop “Writing and presenting scientific papers”, Bled, Slovenia

12.09.2006 Workshop “International research project management and realisation”, Domžale, Slovenia

03.-08.09.2007 Seminar “Methods of Farm Animal Ethology”, Research station for animal housing and animal breeding “Unterer Lindenhof” of the University of Hohenheim, Eningen u.A., Germany

09.-11.02.2010 Additional education for implementers of the most demanding tasks in livestock breeding, Rodica, Slovenia

Projects and membership:

EU project COST 848 Action 2000 – 2005, participation in WG 2 “Animal Welfare and Health”

Membership WPSA

Date: 16 March 2010

Signature: Dušanka Jordan