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Hay provided in a rack as exploration and nest-building material for crated and non-crated sows. Adequate quantity and usage before and after parturition

Diploma Thesis

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Table of Content

1. Introduction

1.1 Background

Pigs are naturally motivated to explore their environment and if the housing conditions allow it, they spend up to 75 % of their daily activity on explorations (Zwicker et al. 2012). They explore their surroundings by digging, sniffing, biting and chewing digestible and indigestible materials. Through these behaviours pigs become familiar with their habitat (Studnitz et al. 2007). In conventional intensive housing, the animals have limited opportunities to satisfy their curiosity and exploratory need (Zwicker et al. 2012). Aggressiveness, which is directed against other pigs or pen equipment, and stereotypies, result from a poorly enriched environment, in which the animals cannot express natural behaviour. The mentioned behavioural disorders and problems can be improved by providing various exploration materials. The environment of pigs, kept in intensive husbandry, can be enriched by objects and substrates that are chewable, destructible, deformable, odorous and edible. Care must be taken, to ensure, that the supply of exploration material keeps the animals occupied and is available over a longer period of time (Jordan et al. 2008).

In contrast to China and the USA, provision of exploration material is a legal requirement in the European Union (EU) (Van de Weerd und Ison 2019). In the EU, the supply of exploration material is regulated by Directive 2008/120/EG. This directive stipulates, that pigs of all categories must have permanent access to sufficient materials they can manipulate. Materials such as hay, straw, peat, sawdust, etc. are indicated as suitable materials. It is also noted, that materials used for enrichment must not injure the animals (Der Rat der Europäischen Union 2008). These conditions must be fulfilled in the EU, but each member state can decide how the directives are fulfilled or extended (Van de Weerd und Ison 2019). In Austria, where the study was carried out, the provision of exploration material is regulated by the "1. Tierhaltungsverordnung" (Austrian Animal Welfare Act) of 25.02.2020. This regulation states, that pigs must have permanent access to sufficient quantities of materials which they can chew, examine and move, such as roughage, hemp rope, wood, sawdust, mushroom compost, peat or a mixture of these materials. It must be ensured, that one of these materials is provided at least once a day, if chewable plastic or rubber play materials are used.

These materials must not endanger the health of the animals, even if they are eaten (Bundesministerium für Soziales, Gesundheit 2020). The exploration material offered, should be of lasting interest, be positioned in such way, that it can be moved and manipulated with the snout, be provided in sufficient quantity and be clean and hygienic (Troxler und Menke 2006). The quality and characteristics of the material are precisely specified, but the quantity that must be provided, is not defined.

In addition to exploration material, the husbandry itself has a great influence on the behaviour of pigs. Especially sows, prior to farrowing and during lactation, are affected by the worldwide commonly used farrowing pens in commercial pig production. These farrowing systems were established to make efficient use of space, to facilitate sow management and to protect piglets from crushing. This restrictive form of husbandry prevents sows from perform movement and express natural behaviour, that is typical for this phase (Yi et al. 2019, Zhang et al. 2020). This includes nest-building, which begins 24 hours before birth and is characterized by an initial phase, consisting of digging, scratching and sniffing. The initial phase is followed by a period consisting mainly of searching and placing nest-building material (Jensen 1993). Within 24 hours before birth, both crated and non-crated sows are motivated to build a nest. Even if no nest-building material is available, the sows show the typical behaviour for nest-building (Jensen 1986). The possibility of building a nest has many advantages for sows. There are reports of a shortened birth period, less sham chewing and stereotypies, a lower heart rate and lower cortisol concentrations in the blood. The animals show less restlessness and change of position postpartum. In order to evoke these positive effects, nest-building material can be offered in the farrowing unit (Jordan et al. 2008, Chaloupková et al. 2011, Zwicker et al. 2012, Bulens et al. 2015). The sow's motivation to build a nest decreases after birth. However, during lactation, the animals benefit from further provision of exploration material. This is particularly important for crated sows. In this way, needs, such as digging, exploring and foraging, can be satisfied (Edwards et al. 2019).

The acceptance of exploration and nest-building materials is significantly influenced by factors such as cleanliness, contamination by feces, accessibility, deformability, destructibility, manipulability and taste. Only if these criteria are considered, the provision of exploration and nest-building material is useful (Roy et al. 2019).

There are some studies that highlight the positive aspects of provision of nesting material. However, these studies usually only refer to the nest-building phase, but not to the entire period, the sow spends in the farrowing unit. In studies, where sows had nest-building and exploration material available during the entire lactation period, the definition "enriched farrowing pen" applied, if the pen floor was bedded with straw or sawdust. The amount of used material is not precisely defined or specified (Jarvis et al. 2006, Yi et al. 2019). In another study, the sows were offered a daily amount of 1kg nest-building and exploration material during the lactation period. However, when the amount of material was used up, the troughs were not refilled on that day. Therefore, no statement can be made on how much hay per day and sow was used for nest-building and during the time in the farrowing unit. (Edwards et al. 2019)

In this experiment long-stem hay was selected as nest-building and exploration material. In contrast to straw, hay also has nutritious qualities and can therefore not only be used as nest-building and exploration material but is also a source of nutrition for sows. In order to make it available for the sows and avoid contamination, the hay was offered exclusively in a rack attached to the farrowing crate.

1.2 Questions and Hypotheses

The aim of this thesis is, to compare hay usage and behaviour of non-crated and crated sows on Nest-Building Day and over the entire period the sows spend in the farrowing unit. It shall be determined, whether there are significant differences in hay usage as nest-building or exploration material or in nest-building behaviour on Nest-Building Day and over the period the sows spend in the farrowing pen due to crating and different pen types. In this study, four different crating periods, in combination with three different pen types (Flügel-pen, SWAP-pen, Trapez-pen), were used. The animals were randomly assigned to the different pen types and crating periods.

A further purpose of this study is to determine the "sufficient quantity of materials", mentioned in the “1. Tierhaltungsverordnung”, to which sows in farrowing pens must have constant access. This quantity is not further defined, therefore in this experiment, the amount of hay, which is considered as an adequate daily ration of enrichment and nest-building material, shall be determined.

Therefore, the following hypotheses are tested:

- Non-crated sows consume more hay than crated sows in the nest-building phase. In addition to the crating, the type of pen has an impact in hay usage on the Nest-Building Day as well.

- Non-crated sows show nest-building behaviour more often and for longer periods of time on Nest-Building Day, than crated sows. In addition to the crating, the pen type also influences the behaviour of the animals with regard to nest-building.

- The activity of the animals, the use of the rack and the amount of material used, changes during the housing period in the farrowing pen. It is assumed, that sow activity and hay usage decrease in the days after farrowing and then increases again until weaning of the piglets. This would also correspond to the behavior of domesticated pigs in a natural habitat. The behaviour is additionally influenced by the crating period and the pen type.

This experiment was carried out as part of the Pro-Sau project from 01.12.2013 until 10.07.2017 (Birgit Heidinger et al. 2017)

2. Material and Methods

2.1. Husbandry – Medau

This study was performed in the pig farm Medau, which is a research and teaching farm, that belongs to the University of Veterinary Medicine Vienna. At the time of the experiment, it was a combined system for piglet production, raising and fattening with space for 140 productive sows, 720 rearing piglets and 600 fattening pigs. Medau had a three-week-rhythm and worked with "All-in-all-out"-system. The main building was also location for utility and storage room, feed chamber, treatment room with pharmacy and office. The so called "black area", consisted of a conference room and sanitary facilities with changing rooms and showers. The entire farm worked with slurry system.

Beside the regular pig production area, a separate testing unit for scientific examination was part of the farm.

This testing unit was characterized by flexible interior for research projects, two multifunctional rooms for housing animals, an office and a storage room. The experiment took place in the testing unit only and for this project, one of these two rooms were equipped with farrowing pens. In total, twelve pens were arranged in three rows (Fig 1.) The testing unit was force-ventilated, and the central air extraction was provided by an exhaust fan, placed centrally in the ceiling area. The supply air system was ensured by a porous ceiling. Four radiators in the wall area served to heat the compartment.

The testing unit got cleaned if necessary and routinely a few days ante partum.

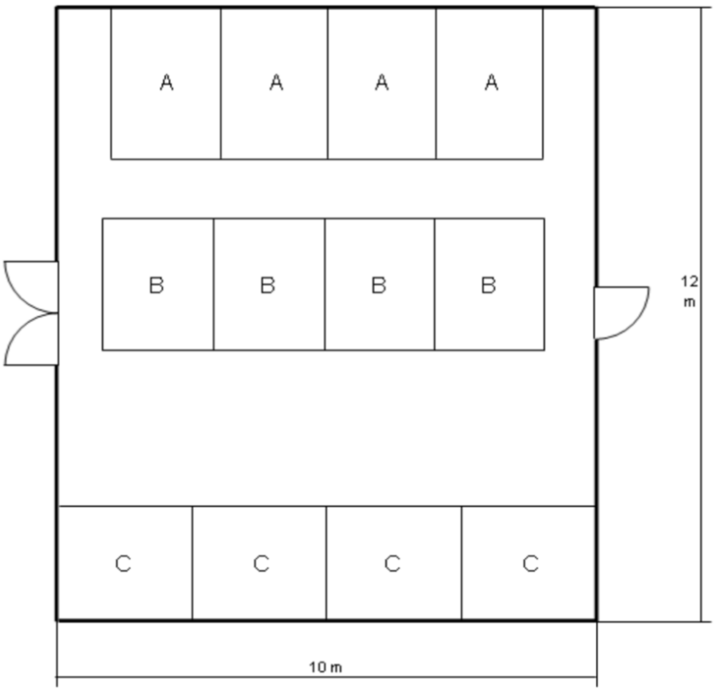

Fig. 1: Arrangement of the experimental pens ©Pro-SAU Abschlussbericht; SWAP-pen (A), Flügel-pen (B), Trapez-pen (C), unit of measurement: m

2.2. Housing

Five days before the calculated date of farrowing, sows were moved to the farrowing pens. All farrowing systems complied with the requirements of the “1. Tierhaltungsverordnung” (Austrian Animal Welfare Act) and showed all characteristics, farrowing pens have to fulfil from 01.01.2033. This means, farrowing pens must be designed to allow the animals to move when non-crated and the sows may only be crated during the critical phase of the piglets' lives. The pens must have a minimum size of 5.5m^2. At least half of the space is planned as lying area for sows and piglets. A minimum width of 1.6m is required and one third of the floor has to be concrete floor. It must be possible to adapt the farrowing units to the size of the animals, both, lengthwise and crosswise (Bundesministerium für Soziales, Gesundheit, Pflege und Konsumentenschutz 2020).

Three different pen types (PT) were used for this experiment: “Trapez-pen”, “SWAP-pen” and “Flügel-pen”. All used farrowing systems provided the possibility of temporary sow crating, but also non-crated farrowing.

The three PT are described below:

2.2.1 Trapez-pen (T)

The Trapez-pen (T) was developed by the Austria company “Schauer”. The location of this pen type in the testing unit, is shown in Fig.1.

The pen (Fig. 2) was oriented parallel, and the crate was installed across the operation aisle and had a dimension of 2.50 x 2.20m. Concrete floor had a size of 1.14m^2 .The farrowing crate had a length of 1.90m and a width of 0.66m, length could be adjusted to the sow’s size through a “saloon-door”. By a swiveling side-part, the crate could be opened and closed. The opened state resembles a “trapezoid”. Opening the crate worked by means of a lever, without entering the pen. This meant good protection of the personnel. When the crate was open, the movement area for the sow had a dimension of 3.52m^2 and the movable side-parts, were supported by the pen wall. Furthermore, the opened side-part of the crate provided protection for the piglets, because it was fixed with enough distance from the pen-wall. Because of the diagonal arrangement of the crate, the sow had enough space for free, but also for assisted farrowing.

The piglet-nest (Fig. 2) was heated, L-shaped and had a size of 0.7m^2. Additionally, the nest could be equipped with a cover, to keep the microclimatic zone. Towards the feeding trough, one anti-crush bar with the length of 0.8m, was installed.

The hay rack (Fig. 3) was mounted on the side-parts of the crate, at the sow’s head-level. The rack was 50cm long and 35cm high, because of the incline back panel, the depth of the rack differed from 10cm at the bottom, to 24.5cm at the top. The rungs had a thickness of 1.2cm and a distance from 5-7.5cm to each other. The volume of the hay rack is approx. 21,5dm^3.

This pen came with one feeding trough at the front end of the crate.

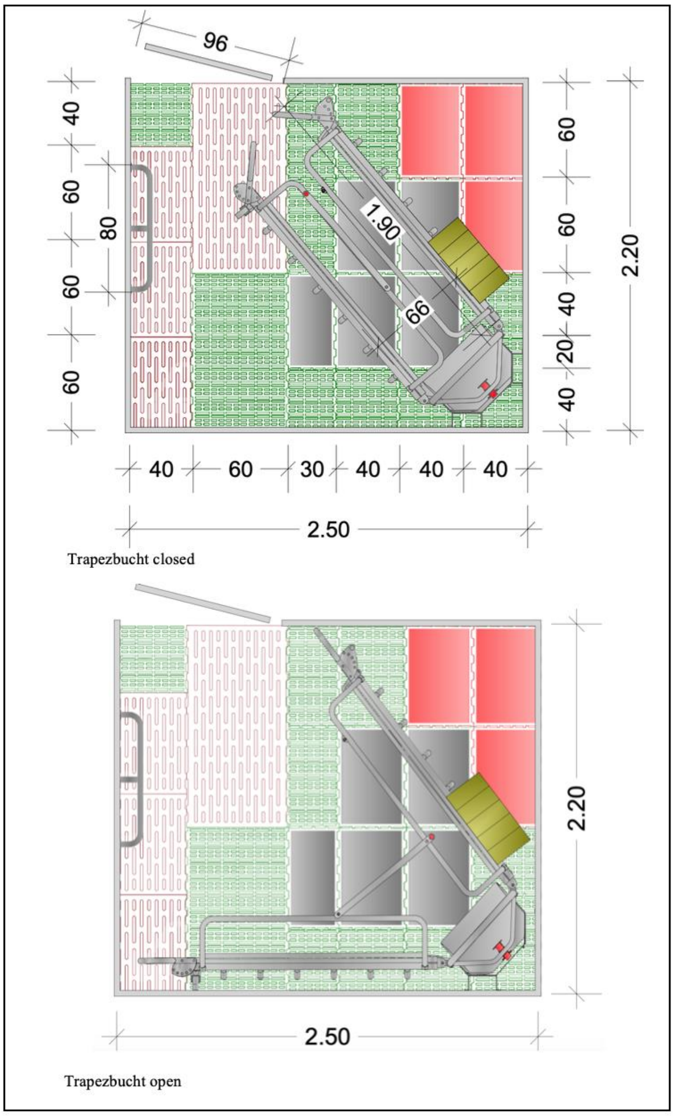

Fig. 2: Trapez-pen (T); crate closed and open ©Pro-SAU Abschlussbericht; yellow: hay rack; red: piglet-nest; grey: concrete floor; structured green and red: slatted floor; unit of measurement: m, cm

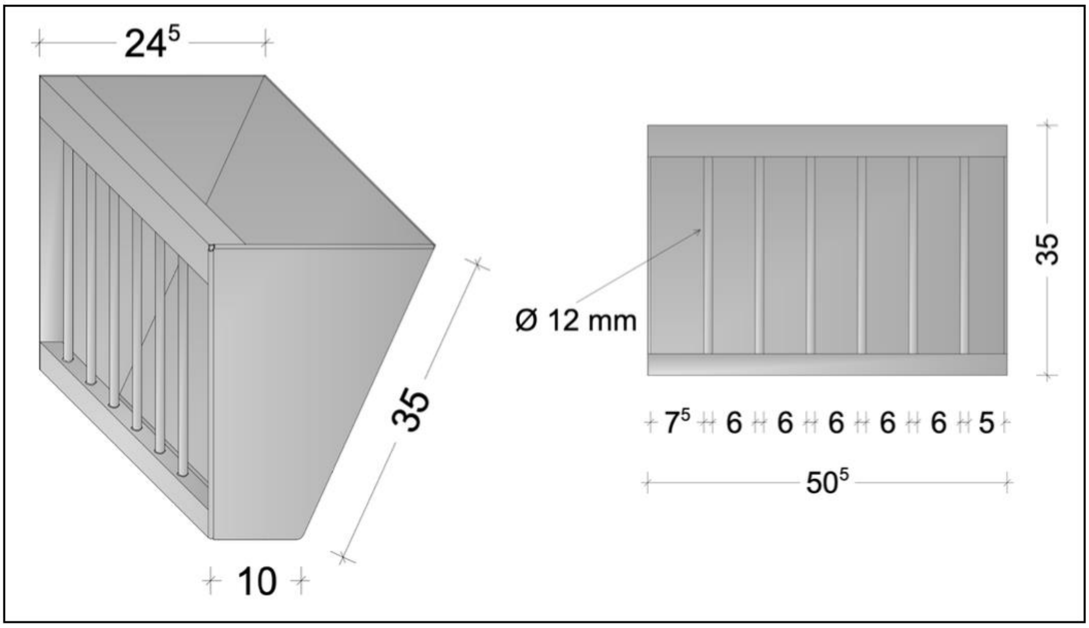

Fig. 3: Hay rack in Trapez-pen (T); unit of measurement: cm

2.2.2 SWAP-pen (S)

This pen was produced from the Danish company "Jyden". The location of this pen is shown in Fig 1. The SWAP-pen (S) had a dimension of 2.0 x 3.0m and a total size of 6.0m^2. The floor consisted of 3.5m^2 concrete floor and 2.5m^2 slatted floor, with a gradient from two percent between the concrete and slatted floor.

In this pen, the crate (Fig. 4) consisted of a sloped wall and a side-part, which was foldable and swiveling and had an adjustable bracket for closing the crate at the back end. The sloped wall had a length of 1.57m and the movable side-part had a full length of 2.08m or 1.25m when it was folded. When the sow was not crated, the movable side-part was folded and attached to the piglet-nest.

The piglet-nest had a triangular shape and a size of 1.01 x 1.25 x 1.1m. It came with an integrated heating, concrete floor and it was equipped with a cover, to keep the microclimatic zone inside the nest. The nest could get closed by means of a lever, to lock the piglets, if necessary.

Hay was provided in a hay rack (Fig. 5), installed on the side-parts of the crate, at the sow's head-level. The rack had a length of 51cm and a height of 48cm, the depth of the rack was

20cm. The rungs had a thickness of 0.8cm and a distance from 3-4.5cm to each other. The volume of the hay rack is approx. 37dm^3.

This pen came with two feeding troughs. One, at the front end of the crate, which could be filled when the sow was crated and a second one, in the back of the crate, which could be used when the sow was non crated.

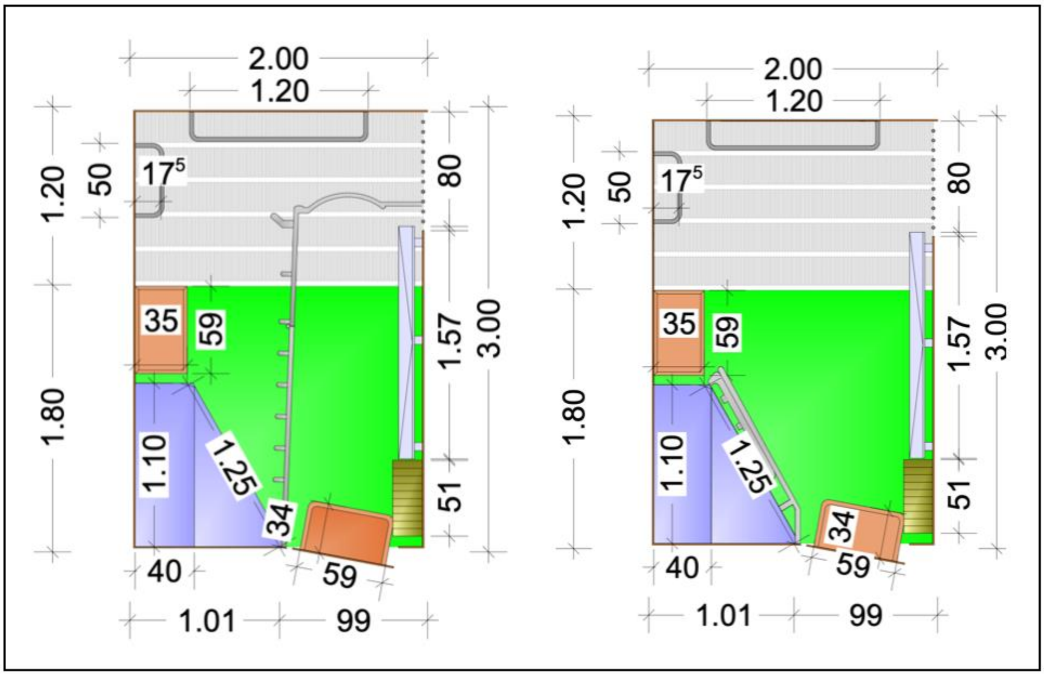

Fig. 4: SWAP-pen (S); crate closed and open ©Pro-SAU Abschlussbericht; yellow: hay rack; blue: piglet-nest; green: concrete floor; grey: slatted floor; unit of measurement: m, cm

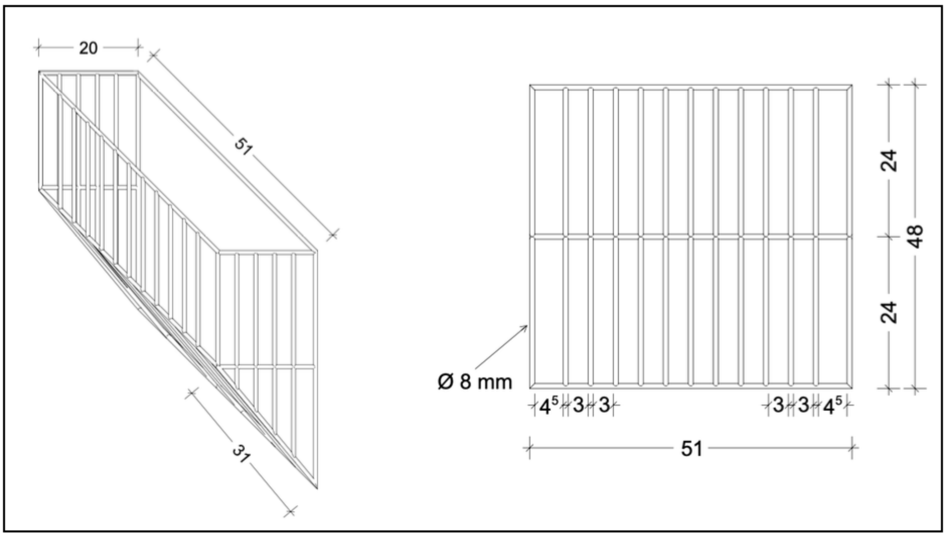

Fig. 5: Hay rack in SWAP-pen (S); ©Pro-SAU Abschlussbericht, unit of measurement: cm

2.2.3 Flügel-pen (F)

The Flügel-pen (F) was developed in Austria by the company "Stewa". The location of this pen type in the testing unit, is shown in Fig 1.

This pen (Fig. 6) was installed across the operation aisle and had a dimension of 2.10 x 2.62m and a total size of 5.5m^2. Concrete floor had a size of 0.96m^2. The farrowing crate was self-supporting and adjustable in width and length. Spring-loaded locks fixed the adjustable elements, thus, there were no lose parts inside the farrowing pen. When the farrowing crate was closed, the width was 0.65m and the length was 1.99m. The crate could be opened "wing-like", that allowed an easy and fast handling when opening or closing the crate. When the crate was open, the side-parts could be telescoped and a maximum range of motion for the sow was obtained. The movement area for the sow had a dimension of 3.12m^2.

In the back area of the pen, the sow had enough space for free, but also for assisted farrowing. The piglet-nest (Fig. 6) had a length of 1.20m, a width of 0.60m and a total size of 0.70m^2. Heating worked with a water-heater and the nest could be equipped with a cover, to keep the warmth inside.

When the crate was open, the opened side-parts completely separated the piglet-nest from the sow's movement area.

Additionally, F was equipped with three anti-crush bars, to protect the piglets from the sow.

Hay was provided in a hay rack (Fig. 7), installed on the side-parts of the crate, at the sow's head-level. The rack was 0.41m wide and long and had a depth of 21.5cm. The rungs had a thickness of 1cm and a distance from 6.5-5cm to each other. The volume of the hay rack is approx. 18dm^3.

This pen came with one feeding trough at the front end of the crate.

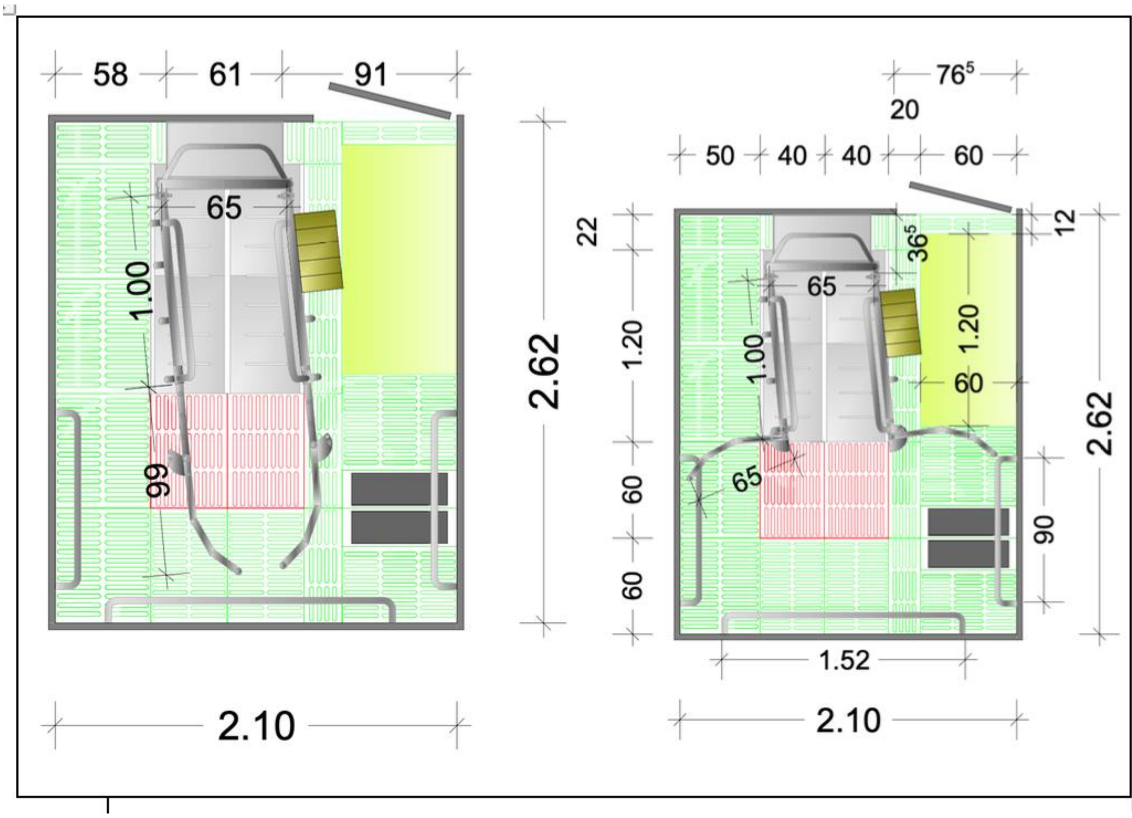

Fig. 6: Flügel-pen (F); crate closed and open ©Pro-SAU Abschlussbericht; yellow: hay rack; neon green: piglet-nest; grey: concrete floor; red and green: slatted floor; unit of measurement: m, cm

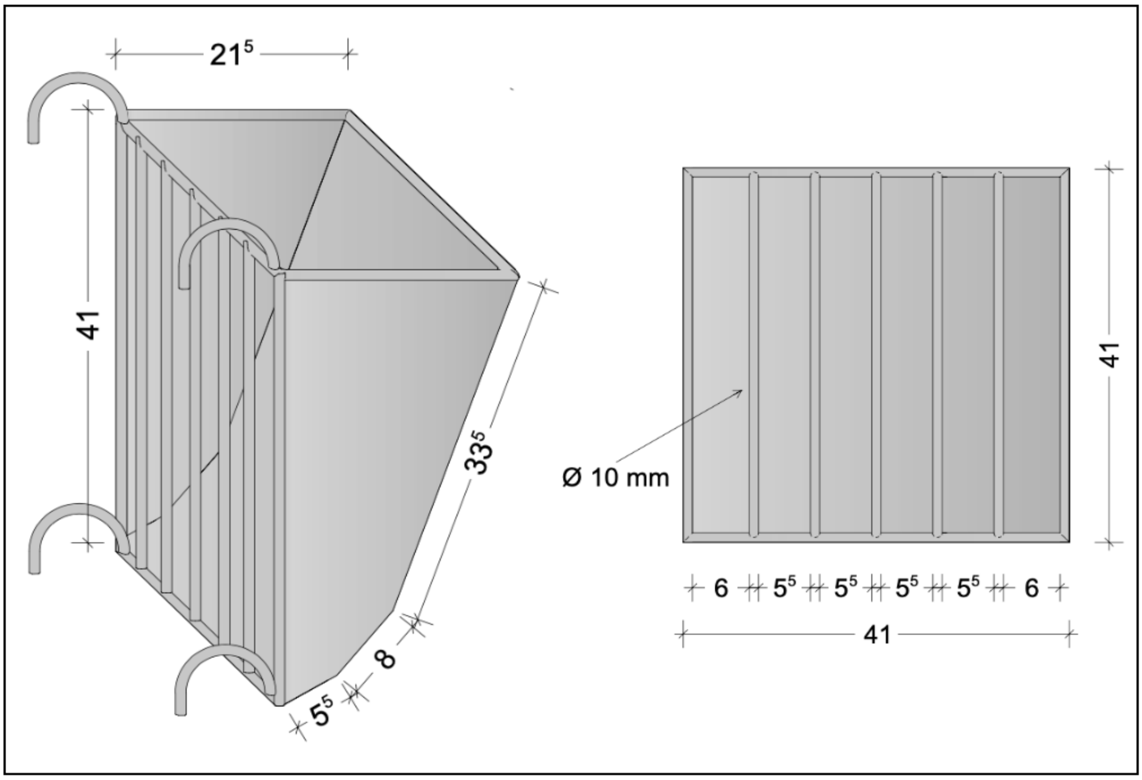

Fig. 7: Hay rack in Flügel-pen; ©Pro-SAU Abschlussbericht, unit of measurement: cm

2.3. Crating periods (CP)

In this experiment four crating periods (CP) were investigated. These periods were defined by a group of experts on the basis of scientific, economic and animal welfare aspects.

Each crating period was performed in all pen types.

In CP 3, the sows were crated when the last piglet was born, until morning of the fourth day of piglets' lives.

In CP 4, the sows were crated one day before calculated farrowing date, until morning of the fourth day of piglets' lives.

In CP 6, the sows were crated one day before the calculated farrowing date, until the morning of day six of piglets' lives.

In CP 0, the sows were not crated at all.

As farrowing date, day 115 of gestation was calculated. Based on this assumption, sows in CP 4 and CP 6 were crated at day 114 of gestation. If farrowing took place at a later date, the sow was crated longer, than one day before farrowing.

Because of practical reasons for certain work steps, sometimes crate-opening in the morning was not possible. If this was the case, the crate was opened the same day at a later time.

2.4. Nest-Building and Exploration Material

In this study, only high-quality, long-stem hay, provided in a hay rack, was used as nest-building and exploration material for sows and piglets. The hay rack, installed on the farrowing crate, was filled up twice a day. Exact procedure of refilling the hay racks is described in chapter 2.8.1.

2.5. Experimental Animals and Management

For this study, productive sows, of Large White and Large White x Landrace breed, were used. Both, gilts and multiparous sows were used. Clinically sick animals (high grade lameness, fever, treatment with antibiotics, actinomycosis, etc.) got excluded from the study. Before the sows moved from group housing pens in the gestation unit to the farrowing pens, they were washed and weighed. The experimental animals were randomly introduced to the three different pen types (F, S, T), where they were treated in pre-defined crating periods according to the experimental schedule.

Hormonal induction of labour was allowed, if there was a medical indication, or from day 116 of gestation.

After a four-week suckling period, the piglets were weaned on Thursday. The farrowing pens were cleaned and disinfected before the next group was placed. During the study, different detergents and disinfectants were used.

From arrival in the farrowing pens, until the first day after farrowing, the animals were fed with gestation feed (ZuchtsauenKorn T®, Garant GmbH, Austria) and from day two after farrowing, the animals received an increasing proportion of lactation feed (ZuchtsauenKorn S®, Garant GmbH, Austria). At the fifth day of lactation, only lactation feed was used, which was fed two times per day, until the end of second lactation week and three times per day from the third lactation week, until weaning.

From the twelfth day of life, piglets got pre starter feed. Additionally, piglets from sows with insufficient milk or big litters, received milk in an extra bowl. Each pen was equipped with a drinking trough for the sow and piglets.

Medau is member of "Tiergesundheitsdienst (TGD) Niederösterreich", which is an animal health service. For medical care, the University Clinic of Swine of the University of Veterinary Medicine Vienna, was responsible. During this study, the farm had an unsuspicious PRRS (Porcine Reproductive Respiratory Syndrome)-status.

The experimental animals got vaccinated against Porcine parvovirus and Erysipelas (Parvoruvac®, Merial GmbH, Germany)

Due to insufficient milk and vaginal discharge post-partum, the sows were treated with prostaglandin-F2α-analogue (0,7ml, i. m., Estrumate®, MSD Animal Health, Haar, Germany) after farrowing, if there was a medical indication.

Gilts, bought from other farms, were kept in quarantine for at least six weeks. During that period, they got all necessary vaccinations and were integrated to the group afterwards.

2.6 Experimental Design and Methods

The practical part of this study was divided into two parts. The amount of hay was measured by weighing the hay, while the behavioural observation was based on video recordings.

2.6.1 Offering and Weighing Hay

In this study, hay was the only exploration and nest-building material for sows, that are housed in farrowing pens. The hay rack was filled twice a day after the remaining amount of hay was removed. A commercial scale, with an accuracy of 10 g was used to weigh the quantity of hay. The data were recorded manually in the project book and the hay usage per day per sow was calculated.

The personnel, who was involved in this experiment, received a detailed training.

The exact procedure of filling the racks is described in the following chapters and the dates, where the racks were filled and hay was weighted, are shown in Fig.8.

2.6.1.1 Procedure 1 (P1)

P1 was only used on Introduction Day. The racks were routinely filled for the first time between eleven and twelve a.m., after moving the sows to the farrowing pens. Time and amount of hay, that was required to fill the rack, was determined and noted in the project book. In the next step, the rack was filled with the determined amount of hay.

For the second time, the racks were checked between two and three p.m. and the remaining quantity of hay was weighed and put back into the rack. Afterwards, the hay, which was necessary to completely fill the rack, was weighted and filled into the rack.

All information was noted and collected in the project book.

It was of great importance, that the sows always had hay from the first to the last haying of the day. If there was no hay in the rack between the two haying dates, an additional hay supply was allowed, if time and given quantity were noted under “additional hay offer”.

2.6.1.2 Procedure 2 (P2)

P2 was used from the Introduction Day until the sixth day after farrowing and on two consecutive days in Week 2, 3 and 4 of piglet life. The racks were routinely filled twice a day. Between eight and nine a.m. all pens were processed one after the other. The remaining hay in the rack was weighted and put back into the rack. Afterwards, hay, which was necessary to completely fill the rack, was weighted and filled into the rack. The exact time and quantity of hay were noted in the project book.

Between eleven a.m. and one p.m., there was an inspection tour through the stable. Hay racks, more than half empty, were filled. Only in this case the following steps were necessary:

Remaining hay in the rack was weighted and put back into the rack. Afterwards, the hay, which was necessary to completely fill the rack, was weighted and filled into the rack. Time and determined quantities were noted in the project book under “additional hay offer”.

In any case, the inspection tour was recorded in the project book.

Between two and three p.m., all pens were processed one after the other. Remaining hay in the rack was weighted and put back into the rack. Afterwards, hay, which was necessary to completely fill the rack, was weighted and filled into the rack. The exact time and determined quantity of hay were noted in the project book.

It was of great importance, that the sows always had hay from the first to the last haying of the day. If there was no hay in the rack between the two haying dates, an additional hay supply was allowed, if time and given quantity were noted under “additional hay offer”.

2.6.2. Continuous Video Observation

The animals were observed using digital video technology. Each experimental pen was equipped with an IP camera (GV-BX 1300-KV, Europe Vision Systems s.r.o., Czech Republic) in a waterproof housing (HEB32K1, Europe Vision Systems s.r.o., Czech Republic). In order to evaluate night shots, the cameras were adapted with an infrared spotlight (Microlight, IR-LED294S-90). The cameras were installed centrally above the pen, to be able to capture the whole area.

The recordings were transferred to a video server (NRV-SYS-i5, Videosecur Handels Ges.m.b.H., Austria) and stored by “Geovision Inc. Multicam Surveillance System” program on an external storage disk, each with 2 or 3 TB storage capacity. The videos were recorded at a frame rate of 30fps. After data recording, the recorded storage disks were transferred to the Institute of Animal Welfare Science of the University of Veterinary Medicine Vienna. Interact (version 14.0, Mangold, Germany) was used as labelling tool for recording sow behaviour.

Two trained observers labelled the behavioural data. In order to achieve reliable results, inter-observer reliability was tested. This is a measure that shows how consistent an observer is in evaluating a phenomenon or how high the degree of agreement is for different observers. Inter-observer reliability can be used to indicate to what extent the results are influenced by the observer. Thus, it is also a measure for the objectivity of a result. A kappa-value of 0.8 min for each observed behaviour was obtained.

2.6.2.1 Observation Dates

The recordings were made on the following pre-defined observation days: Introduction Day, Nest-Building Day, Day 5 after farrowing, on one day during Week 2, 3 and 4. There are two different schemes for the video observation.

For Introduction Day, Day 5 and the day in Week 2, 3 and 4, observation scheme 1 (S1) was used. With S1, observations started, when the sows were offered hay for the first time of a day and were performed on every second hour, four times a day. Every observation interval was one hour. For example, when feeding was at 08:15 a.m., then the observation periods were from 08:15 to 09:15 a.m., from 10:15 to 11:15a.m., from 12:15 to 13:15 p.m. and from 14:15 to 15:15 p.m.

For Nest-Building Day observation scheme 2 (S2) was used. On this day, 24 hours were recorded continuously until the first piglet was born. Sows crated in CP4 or CP 6 had to be crated 24 hours before the calculated farrowing date**.**

The observation dates are shown in Fig.8.

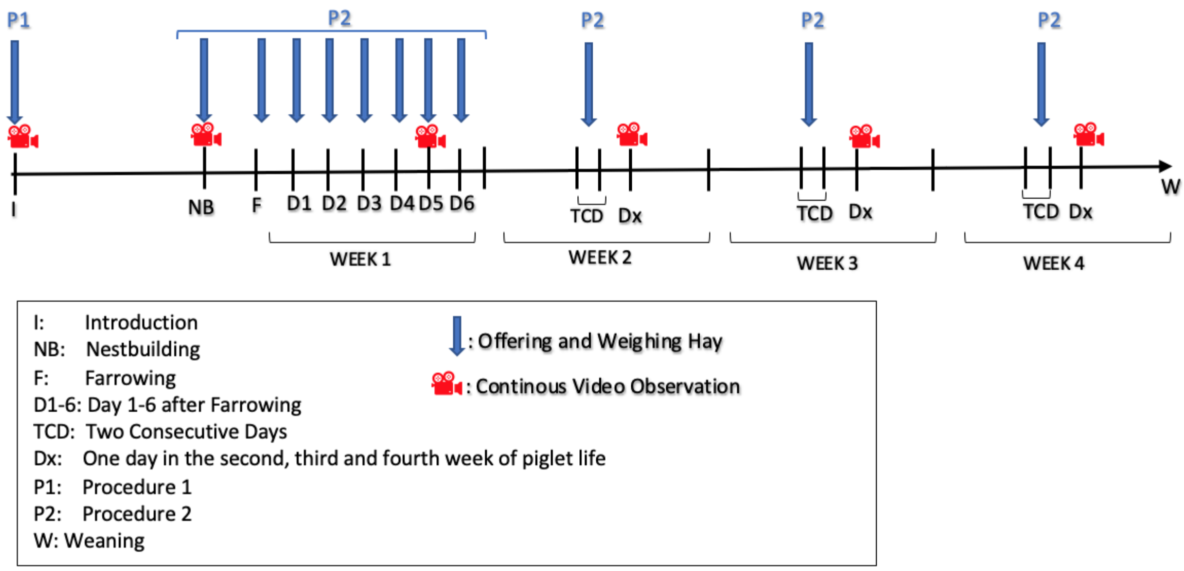

Fig. 8: Dates for Video Observation and Offering and Weighing Hay

2.6.2.2 Ethogram

Nest-building and exploratory behaviour of the experimental sows in the three pen types (PT) in combination with a crating period (CP) were analyzed. The following pre-defined behavioural patterns were used:

2.6.2.2.1 Manipulation of the Hay Rack: Duration and Frequency

The sow's snout is located in a 10cm radius of the hay rack. An exception is made if the sow obviously manipulates the crate while her snout is within 10cm radius of the rack. Up and down movements of the snout can be seen, or the sow plucks hay of the rack.

The behaviour starts, when the sow's snout moves towards the hay rack and touches the imaginary 10cm radius of the rack. The sow begins to move the snout up and down or starts to pluck the hay.

The behaviour ends, when the sow moves her snout away from the rack and passes the imaginary radius again.

The accuracy of the recording is half a second and breaks longer than 2 seconds are recorded.

2.6.2.2.2 Manipulation of Pen Elements: Duration and Frequency

The sow touches the pen equipment with a part of the head, showing upward, downward and lateral movements of the head, or biting towards the pen equipment. When the sow performs this movement at the crate, a movement of the crate can often, but not necessarily, be detected. Includes manipulation of the crate, crush bars, walls and trough. Can also be observed in situations where the head is above the trough, but the snout is not directed towards the bottom of the trough or the head is not lowered. In this case this behaviour is not recorded as "head above the trough".

This behaviour starts when the sow touches the pen equipment with part of its head and starts to make movements with the head towards the pen equipment.

The behaviour ends when the sow moves the head away from the equipment.

Accuracy of the recording is half a second and breaks longer than 2 seconds are recorded.

2.6.2.2.3 Exploration of the Floor: Duration and Frequency

Includes all types of movements of the sow's head, while the snout is directed towards the ground.

Behaviour begins, when the sow lowers her head, so that the snout touches or almost touches the ground. Recording starts from a distance of about 2-3cm above the ground.

The behaviour ends, when the head is raised again.

The accuracy is 2 seconds, breaks longer than 2 seconds are recorded.

A distinction is made between exploration behaviour on the closed floor and on slatted floors.

2.6.2.2.4 All Behaviours: Duration and Frequency

This behaviour summarizes all behaviours observed in this experiment. It consists of the sum of all durations or frequencies of the observed behaviours and is a measure for the overall activity on the respective observation day.

2.6.2.2.4 Undefined Behaviour

The sow shows a behaviour that cannot be clearly classified as belonging to the above-mentioned behaviours. Includes also cases in which a behaviour cannot be judged, for example due to technical circumstances (dirty lens, parts of the pen not visible on the video image, head of the sow covered by hay rack, etc.)

2.7 Statistical Analyses

2.7.1 Video observation

The collected data from 44 sows was transferred from the labelling program (Interact, Mangold V14.0) to Excel, version 16.41 (Microsoft Office Professional Plus, headquarters in Redmond, Washington, USA). The statistical analysis was performed with version 3.5.2 of R (R Core Team (2019). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria) and with the R Studio version 1.0.136 (RStudio Team (2019). RStudio Integrated Development for R. RStudio, Inc, Boston, MA).

All observation days were analysed separately from each other. Unless otherwise specified, a p-value $\leq$ 0.05 was considered statistically significant. On Nest-Building Day (whole observation day and 3 phases separately) and Day 5 after farrowing, a two-way ANOVA with pen type and crating as independent factors was applied for variables with (before or after transformation) normally distributed data. For non-normally distributed data, the effects of the two factors were determined separately. A Kruskal-Wallis test was applied to identify the overall pen type effect and the interaction between pen type and crating. Pairwise comparisons were performed testing using Dunn test with Bonferroni correction if p was <0.1. A two-sided Wilcoxon rank-sum test was used to compare crated with non-crated sows, followed by a one-sided test if p was <0.1.

For statistical analysis the days in Week 2 and Week 3 were evaluated together. In the following, the two observation dates are presented as Week 2&3.

2.7.2 Hay Usage

The data from 57 sows was collected in the test-unit on paper charts and then transferred to Excel, version Microsoft Office Professional Plus (headquarters in Redmond, Washington, USA). For the statistical analysis of hay usage, version 3.5.2 of R (R Core Team (2019). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria) and R Studio version 1.0.136 (RStudio Team (2019). RStudio Integrated Development for R. RStudio, Inc, Boston, MA), were used.

Hay usage was analyzed with a general linear model using function *lm* from package *lme4.* As not all sows were observed on all observation days, only data from Introduction Day, Nest-Building Day and days 1-6 postpartum were included. Mean hay usage per day was defined as response variable. Three outliers with high leverage were identified and excluded from the dataset, resulting in an overall sample size of 54 sows. In order to reach normal distribution of the residuals, data were log10 transformed. Pen type, confinement period and treatment (0/1) were defined as categorical fixed effects in the model, while parity was included as linear fixed effect. A significance cut off of 5% was employed and p-values for pairwise comparisons were adjusted using Tukey's method.

Furthermore, mean hay usage on Nest-Building Day was analysed separately from all other days and according to the scheme described in section 2.7.1, Video observation.

3. Results

3.1 Observed Behaviour

In this chapter, the results of the behavioural observations, on the observation days, are presented. On each observation day, it was examined, whether the sows in different pen types, crated or non-crated, showed significant differences in duration and frequency of the observed behaviour.

Tables, Boxplots and bar charts are used for graphical presentation.

The tables show how long (Duration) or how often (Frequency) a sow in a pen type (PT), crated (CP1) or non-crated (CP0), showed a certain behaviour, on a certain observation day. The sample size (n), mean value (mean), standard deviation (sd), minimum (min), median and maximum (max) can be read from the table. The applied statistical tests, with the corresponding p-values from each observation day, are also presented in tables. Not all tables are included in the following text, but the missing tables can be looked up in the appendix.

Boxplots (Box-and-Whiskers) are used to summarize important ratios in a graph and show the distribution of numerical and ordinal data. The "box" corresponds to a rectangle divided in two by the median. The two horizontal lines correspond to the first and third quartiles (Q1 and Q3), which enclose the central 50% of the data. The vertically extending lines indicate variability outside Q1 and Q3 (Bärlocher 1999).

Furthermore, stacked bar charts are used for graphical representation. The x-axis of the diagrams shows the type of pen, crated or non-crated, and the y-axis shows either the frequency or the duration. Additionally, the behaviour "Undefinable Behaviour" is shown.

3.1.1 Nest-Building Day

On Nest-Building Day, the three pen types F, S and T were compared. Sows manipulated the hay rack for an average of 5.84 minutes to 7.19 minutes. The sows in F used the hay rack longest (7.19 ± 6.08) and also with the highest frequency (39.33 ± 36.09), sows in T shortest (5.84 ± 5.79) and also with the lowest frequency (33.08 ± 35.37).

For the duration of "Exploration Floor", T (15.69 ± 17.47) was in first place, followed by F (13.8 ± 3 19.13) and S (9.41 ± 14.96). Also, in terms of frequency, T was ahead of F, followed by S.

On Nest-Building Day, "Manipulation Pen Elements" was shown longest and most frequently (23.42 ± 31.74 minutes, 106.13 ± 136.26 times) by the sows in the S, followed by the animals in F (17.89 ± 19.13 minutes, 92.89 102.03 times) and the animals in T (16.13 ± 15.9 minutes, 82.64 ± 78.31 times).

The sows in S, when all defined behaviours were considered together as “All Behaviours”, were most active on the Nest-Building Day, followed by the F and S. The results from “All Behaviours”, are shown in Fig.9 and Fig.10.

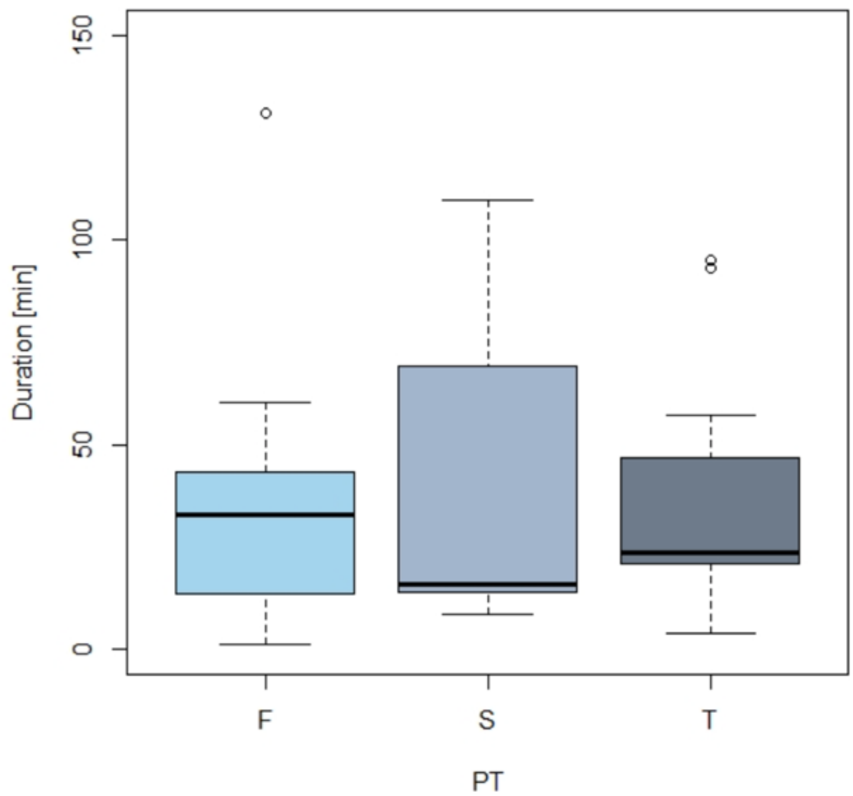

Fig. 9: Duration (min) of "All Behaviours" on Nest-Building Day; F = Flügel-pen, S = SWAP-pen, T = Trapez-pen

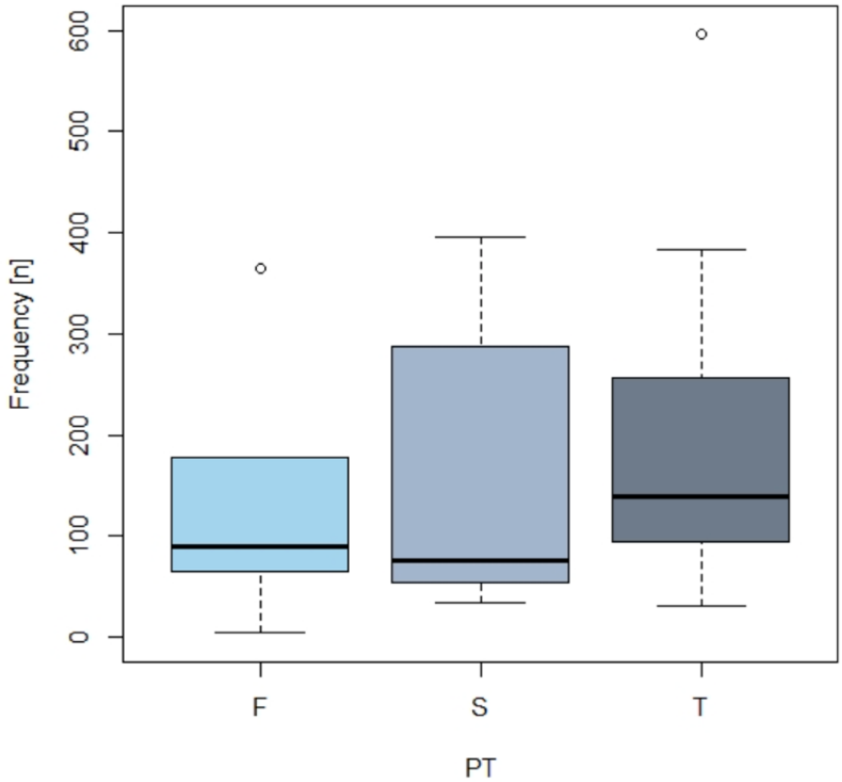

Fig. 10: Frequency (n) of "All Behaviours" on Nest-Building Day; F = Flügel-pen, S = SWAP-pen, T = Trapez-pen

On Nest-Building Day, the PT (F, S, T) in combination with crated (CP1) and non-crated sows (CP0) were compared. Tab.1 shows the descriptive values of the duration of all observed behaviours and Tab.2 shows the frequency of all observed behaviours on Nest-Building Day.

Tab. 1: Duration of all observed behaviours on Nest-Building Day for each pen type (PT) x crating period (CP) combination; F = Flügel-pen, S = SAWP-Pen, T = Trapez-pen; 0 = non-crated, 1 = crated

Nest-Building - PTxCP/Duration						
PTxCP	**n**	**mean**	**sd**	**min**	**median**	**max**
All Behaviours						
F0	3	45.45	13.7	33.04	43.17	60.15
F1	6	35.65	48.78	1.1	13.67	130.95
S0	3	51.57	51.01	14.17	30.85	109.67
S1	5	32.39	42.1	8.52	15.48	107.5
T0	7	20.78	12.62	3.73	22.47	36.13
T1	5	54.94	39.89	9.7	57.21	95.13
Manipulation Rack						
F0	3	6.96	6.14	2.2	4.78	13.9
F1	6	7.31	6.63	0.39	6.14	19.19
S0	3	10.96	7.24	4.83	9.1	18.95
S1	5	4.23	3.95	0.26	5.04	9.56
T0	7	4.92	4.28	0.67	4.5	13.11
T1	5	7.13	7.83	0.71	3.5	20.37
Exploration Floor						
F0	3	12.08	10.52	3.4	9.05	23.77
F1	6	14.7	23.21	0	0.71	53.96
S0	3	17.69	24.54	1.28	5.9	45.9
S1	5	4.44	2.85	0.34	5.21	7.79
T0	6	5.55	2.24	1.18	6.24	7.51
T1	5	27.87	20.41	4.5	29.7	57.5
Manipulation Pen Elements						
F0	3	26.41	10.09	17.19	24.86	37.19
F1	6	13.63	21.9	0	6.4	57.8
S0	3	22.92	27.53	6	8.07	54.68
S1	5	23.72	37.2	4.78	8.35	90.15
T0	6	12.95	8.06	1.87	12.36	25.82
T1	5	19.94	22.74	1.93	7.14	55.54

Tab. 2: Frequency of all observed behaviours on Nest-Building Day for each pen type (PT) x crating period (CP) combination; F = Flügel-pen, S = SAWP-Pen, T = Trapez-pen; 0 = non-crated, 1 = crated

Nest-Building - PTxCP/Frequency						
PTxCP	**n**	**mean**	**sd**	**min**	**median**	**max**
All Behaviour						
F0	3	231.67	116.2	152	178	365
F1	6	160.5	252.35	4	72	672
S0	3	317	370.98	34	180	737
S1	5	131	148.32	47	65	395
T0	7	108.57	60.9	14	132	175
T1	5	286	231.66	52	338	597
Manipulation Rack						
F0	3	40.33	44.75	14	15	92
F1	6	38.83	35.81	2	33	107
S0	3	52.33	42.34	6	62	89
S1	5	26.4	31.86	3	18	81
T0	7	21.57	15.18	4	17	44
T1	5	49.2	50.38	8	20	126
Exploration Floor						
F0	3	63	38.12	19	84	86
F1	5	55.8	108.02	0	2	248
S0	3	114.67	156.35	7	43	294
S1	5	24.8	19.94	3	22	56
T0	6	43.17	17.83	10	48	58
T1	5	125	100.33	18	144	251
Manipulation Pen Elements						
F0	3	128.33	54.24	80	118	187
F1	6	75.17	119.78	0	34.5	317
S0	3	150	200.51	21	48	381
S1	6	79.8	100.4	22	39	258
T0	6	58.33	27.39	14	63	85
T1	5	111.8	111.56	14	68	271

On Nest-Building Day, the hay rack was manipulated on average with a duration of 4.23 to 10.96 minutes and between 21.57 and 52.33 times. Sows in S0 used the hay rack longer and more often than the animals in the S1. In F and T, the crated animals (F1, T1) manipulated the racks longer and more often, than the non-crated (F0, T0) sows. The descriptive results of the use of the hay rack, are shown in Tab.1 and Tab.2. It can be seen, that the animals in S0 used the hay rack the most, also in comparison with the other PT x CP combinations. The results are graphically shown in Fig.11 and Fig.12.

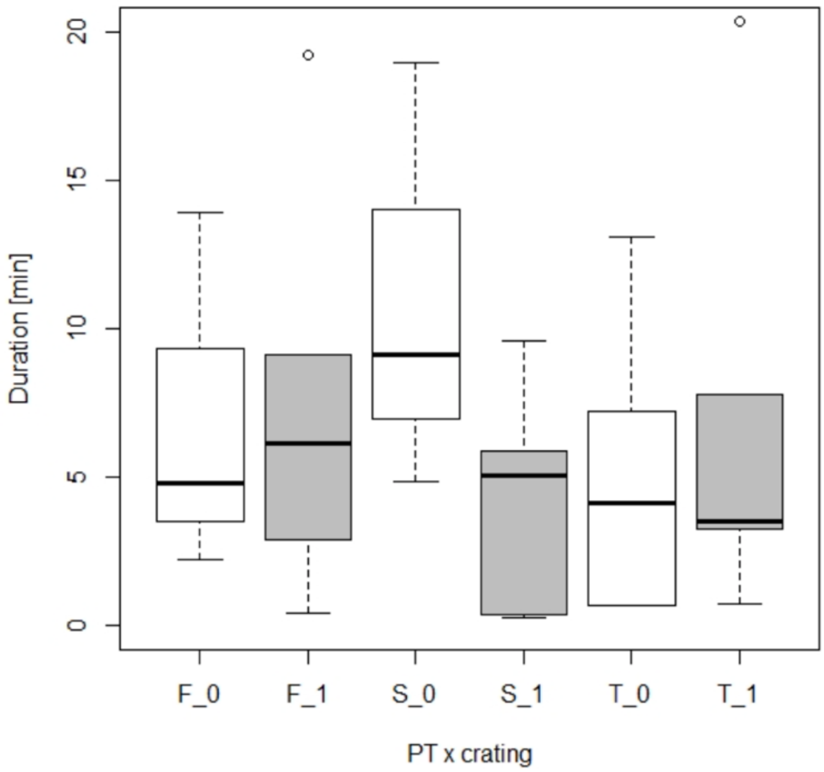

Fig. 11: Duration (min) of "Manipulation Rack" on Nest-Building Day for each pen type (PT) in combination with non-crated (0) and crated (1) sows; F = Flügel-pen, S = SWAP-pen, T = Trapez-pen

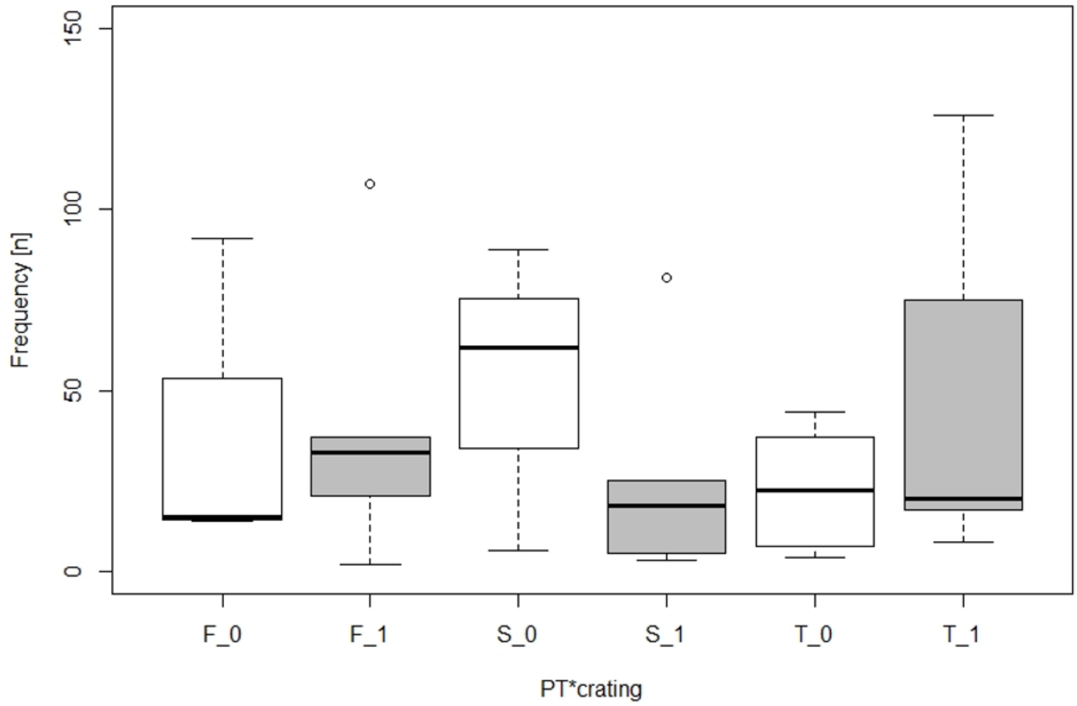

Fig. 12: Frequency (n) of "Manipulation Rack" on Nest-Building Day for each pen type (PT) in combination with non-crated (0) and crated (1) sows; F = Flügel-pen, S = SWAP-pen, T = Trapez-pen

Looking at the results of "All Behaviours" (Tab.1, Tab.2), which summarizes all observed behaviours, it is evident that the sows were active on the Nest-Building Day on average between 20.78 to 54.94 minutes and 108.57 to 286 times. Of these, the sows in T1 were active the longest and most often and the animals in T0, the shortest and least from all PT x CP combinations on Nest-Building Day. This result is illustrated by the figures Fig.13 and Fig.14. When summarizing all behaviours, it can be seen that the sows were altogether more active in S0 than in S1. In F, the sows in F0 were also more active than the sows in F1. The sows in T1 were more active than in T0 on Nest-Building Day.

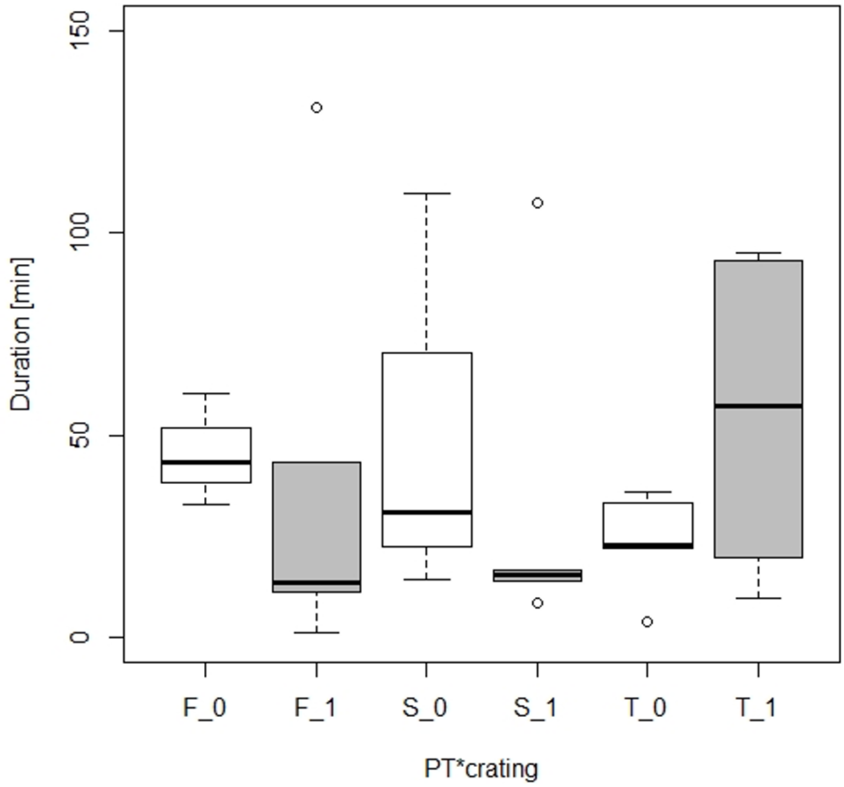

Fig. 13: Duration (min) of "All Behaviours" on Nest-Building Day; F = Flügel-pen, S = SWAP-pen, T = Trapez-pen; 0 = non-crated, 1 = crated

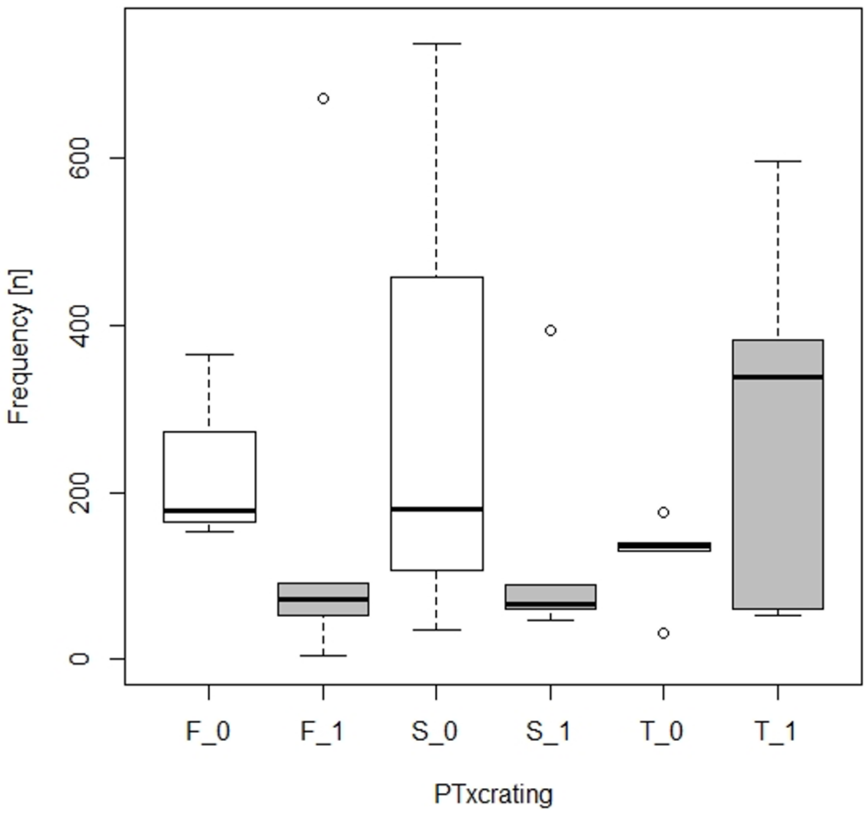

Fig. 14: Frequency (n) of "All Behaviours" on Nest-Building Day for each pen type (PT) in combination with non-crated (0) and crated (1) sows; F = Flügel-pen, S = SWAP-pen, T = Trapez-pen;

The duration and frequency of "Exploration Floor" and "Manipulation Pen Elements" can be found in Tab.1 and Tab.2.

To test the hypothesis, that the PT affects the nest-building behaviour, the pen types F, S and T were compared and for testing the difference between the PT x CP combinations on Nest-Building Day, the pen types (F, S, T) were compared in combination with two different crating periods CP0 and CP1, 0 stands for non-crated and 1 for crated at that time of observation. The comparisons of the PT and also all PT x CP combinations did not yield significant results (Tab. 3) on Nest-Building Day.

Tab. 3: p-Values and used tests from all observed behaviours (Duration and Frequency) on Nest-Building Day; PT (pen type), CP (crating period), PT x CP (pen type x crating period)

Nest-Building		**Duration**		**Frequency**
	Test	**p-Value**	**Test**	**p-Value**
All Behaviours				
PT	ANOVA	0.97	Kruskal-Wallis	0.92
CP	ANOVA	0.68	Wilcoxon	0.32
PTxCP	Kruskal Wallis	0.56	Kruskal-Wallis	0.57
Manipulation Rack				
PT	ANOVA	0.83	ANOVA	0.91
CP	ANOVA	0.59	ANOVA	0.98
PTxCP	ANOVA	0.3	ANOVA	0.46
Exploration Floor				
PT	Kruskal-Wallis	0.33	Kruskal-Wallis	0.34
CP	Kruskal-Wallis	0.73	Wilcoxon	0.29
PTxCP	Kruskal-Wallis	0.28	Kruskal-Wallis	0.3
Manipulation Pen Elements				
PT	ANOVA	0.88	Kruskal-Wallis	0.95
CP	ANOVA	0.31	Wilcoxon	0.25
PTxCP	ANOVA	0.37	Kruskal-Wallis	0.62

3.1.2 Introduction Day, Week 2 & 3 and Week 4

In order to test the hypothesis that the activity of the animals and the use of exploration material in the rack, is subject to fluctuations and that PT and CP have an influence on this, the observed behaviours on Introduction Day, Week 2 & 3 and Week 4 were compared. The exact values for all these days can be looked up in the appendix.

Fig.15 and Fig.16 show the comparison of the different behaviours in all PT, on all observation days, excluding Nest-Building Day. For Day 5, only non-crated sows were included in these two graphs, since no sows were crated on Introduction Day, in Week 2&3 and Week 4. This ensures comparability of the graphs. Therefore, Day 5 is discussed separately in the next chapter.

On Introduction Day, the sows in S were the most active. They showed the longest duration and highest frequency of “All Behaviours” (23.49 ± 18.16 min., 74.33 ± 76.98 times), and “Manipulation Rack" (17.95 ± 10.13 min., 47.5 ± 28.17 times). After Introduction Day, both, duration and frequency of all observed behaviours, decreased in all pen types. This is shown in Fig. 15 and 16.

Fig. 15 shows the duration of all observed behaviours, in all PT. It can be seen, that in Week 2&3, the duration of the total activity in the different PT, with an average of 10.65 to 16.23 minutes, increased only slightly, compared to the duration of the total activity on Day 5, with an average of 7.35 to 8.51 minutes. However, the duration of "Manipulation Rack" increased again in Week 2 & 3, in all PT, with an average duration between 5.35 and 10.8 minutes. In Week 4, the manipulation of the rack continued to increase in F and T. Also, the duration of the total activity increased in these two PT in Week 4. In S the total activity in Week 4 decreased and the rack was manipulated for a shorter time than in Week 2 & 3.

Fig. 16. shows the frequency of all observed behaviours, in all PT. It can be seen, that in F and T, the frequency of the total activity dropped on Day 5 and then increased again in Week 2&3 and 4, the frequency of “Manipulation Rack” did the same in these two PT. For sows in S, the frequency of total activity increased on Day 5 and then decreased continuously in Week 2&3 and 4. The frequency of “Manipulation Rack” decreased continuously until Week 4.

This means, the use of the hay rack decreased after Introduction Day and increased again after Day 5 in the following weeks in all PT. In F and T, the hay rack was used both, longer and more frequently. The sows in S, used the hay rack longer again, but less often than on Day 5.

“Exploration Floor", was carried out less often and for a longer time by the sows in S after Day 5 until weaning. Sows in F showed this behaviour longer and with about the same frequency after Day 5 until weaning. In Week 2&3 and 4 sows in T showed the behaviour about as often and as long as on Day 5.

The exact values for Introduction Day, Week 2&3 and Week 4 can be looked up in the appendix.

In Week 4 there was a significant difference ($p = 0.02$) in the duration of "Exploration Floor" between T and S. All other results in Week 2 & 3 and Week 4 were non-significant and can be looked up in the appendix.

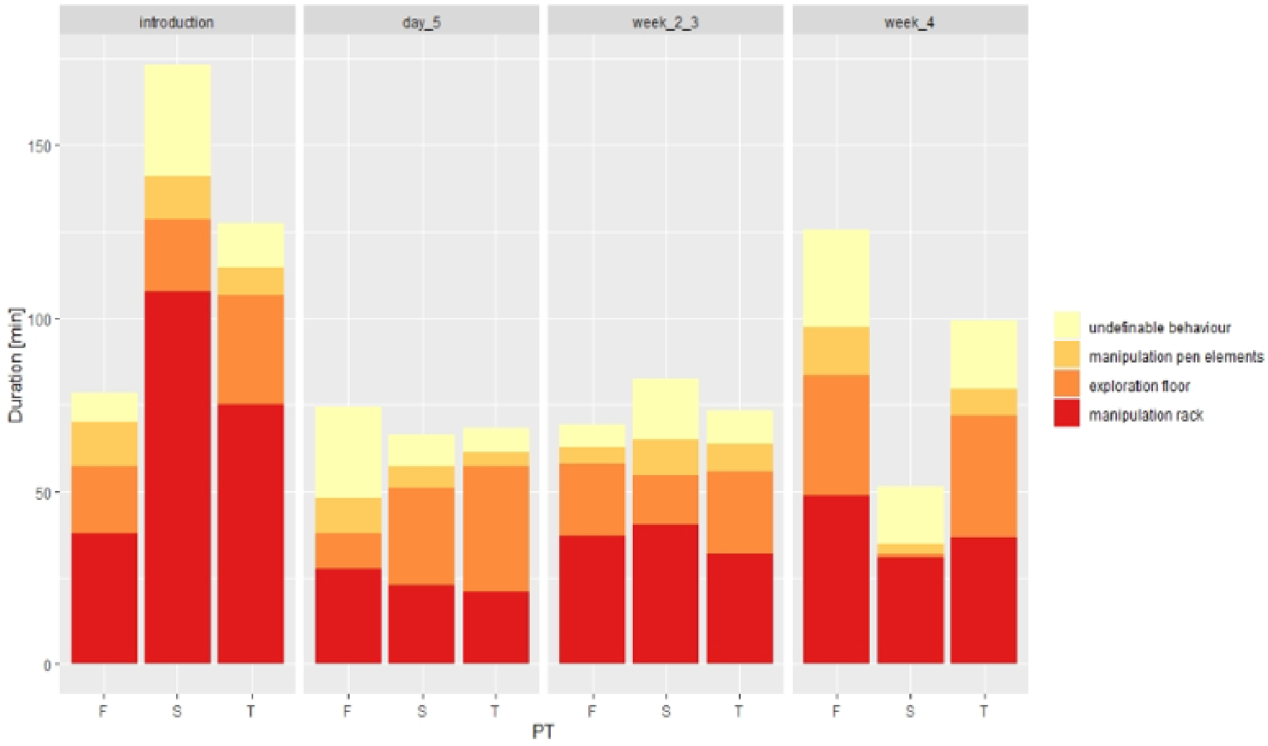

Fig. 15: Duration (min) of all observed behaviours in each pen type: Flügel-pen (F), SWAP-pen (S), Trapez-pen (T), comparison of all observation days, except Nest-Building- Day

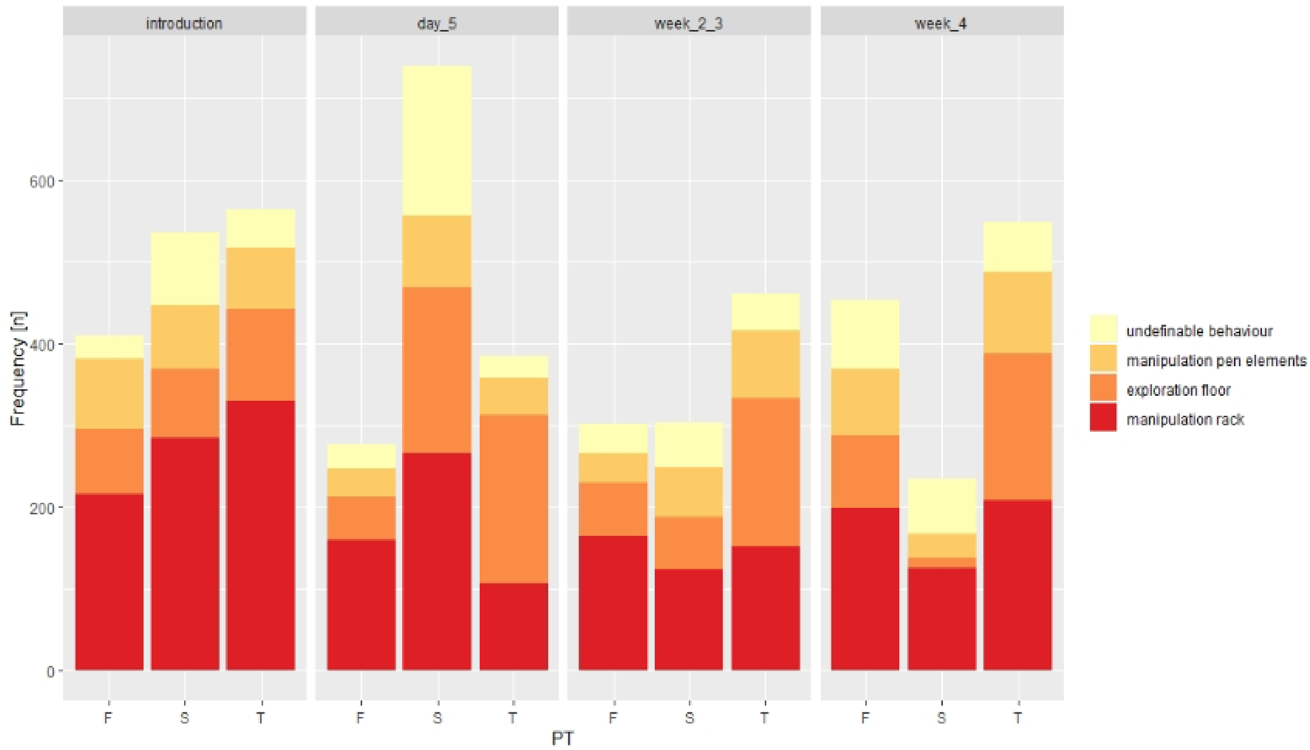

Fig. 16: Frequency (n) of all observed behaviours in each pen type: Flügel-pen (F), SWAP-pen (S), Trapez-pen (T); comparison of all observation days, except Nest-Building Day

3.1.3 Day 5

To investigate the behavioural differences between the PT on Day 5, F, S and T were compared on this observation day. The exact values can be found in Tab. 4 and Tab. 5.

On Day 5, the behavior "Manipulation Rack" was shown on average between 2.61 to 4.98 minutes and 14.8 to 30.78 times. The sows in the F used the rack the longest and with the highest frequency. The animals in the T, had the lowest duration and frequency.

The observed behaviours "Exploration Floor" and "Manipulation Pen Elements" were shown the longest and most often from sows in S and that is why, the animals in S are the most active on Day 5. This can be seen, in Tab. 4 and 5, looking at the results of "All Behaviours", which summarizes all observed behaviours. It is evident, that the sows were active on Day 5 on average between 7.35 to 8.51 minutes and 41.78 to 70.8 times. Of these, sows in S were active the longest and most often and the animals in F, the shortest and least from all PT on Day 5.

Tab. 4: Duration (min) of all observed behaviours in each pen type on Day 5

Day 5/Duration						
	n	**mean**	**sd**	**min**	**median**	**max**
All Behaviours						
Flügel-pen	9	7.35	7.04	1.16	5.85	24.11
SWAP-pen	10	8.51	16.53	0.14	1.64	53.99
Trapez-pen	10	8.11	12.3	0.53	3.34	40.58
Manipulation Rack						
Flügel-pen	9	4.98	3.63	0.38	4.01	11.2
SWAP-pen	10	2.87	6.99	0	0.39	22.58
Trapez-pen	10	2.61	1.97	0.14	2.17	5.57
Exploration Floor						
Flügel-pen	9	1.14	2.01	0	0.22	6.2
SWAP-pen	10	4.32	8.25	0	0.79	26.07
Trapez-pen	10	4.71	10.47	0	0.6	33.27
Manipulation Pen Elements						
Flügel-pen	9	1.23	2.12	0	0.55	6.71
SWAP-pen	10	1.33	1.8	0	0.63	5.34
Trapez-pen	10	0.8	1.23	0	0.13	3.61

Tab. 5: Frequency of all observed behaviours in each pen type on Day 5

Day 5/Frequency						
	n	**mean**	**sd**	**min**	**median**	**max**
All Behaviours						
Flügel-pen	9	41.78	32.2	6	36	105
SWAP-pen	10	70.8	159.98	2	16	523
Trapez-pen	10	44.9	70.45	3	20.5	238
Manipulation Rack						
Flügel-pen	9	30.78	28.19	2	27	93
SWAP-pen	10	16.67	35.71	0	4	111
Trapez-pen	10	14.8	9.85	1	17	28
Exploration Floor						
Flügel-pen	9	6.11	9.65	0	3	30
SWAP-pen	10	16.9	33.35	0	4	109
Trapez-pen	10	24.3	55.2	0	3	179
Manipulation Pen Elements						
Flügel-pen	9	4.89	4.7	0	4	15
SWAP-pen	10	12.3	12.86	0	9.5	37
Trapez-pen	10	5.8	9.75	0	1	31

Since there are crated sows in all pen types, as on Nest-Building Day, the three pen types F, S and T, in combination with crated (CP1) and non-crated (CP0), were compared on Day 5. The values from all behaviours in every PT x CP combination on Day 5, are shown in Tab. 6 and 7. When comparing the values of Day 5 with those of Nest-Building Day (Tab.1, 2), it can be seen, that the duration and frequency of all observed behaviours became less.

On Day 5, the hay racks were manipulated on average between 0.85 and 7.57 minutes and 6.33 and 37.33 times. The sows in S0 used the hay racks longest and most often, as on Nest-Building Day. At the same time, the S1 groups, used the racks the shortest and least frequently on average. Also, in all other observed behaviours, the sows in S0 had the highest duration and frequency, they were therefore the most active group on Day 5.

Tab. 6: Duration (min) of all observed behaviours on Day 5 in each PT x CP combination; F = Flügel-pen, S = SAWP-Pen, T = Trapez-pen; 0 = non-crated, 1 = crated

Day 5 - PTxCP/Duration						
PTxCP	**n**	**mean**	**sd**	**min**	**median**	**max**
All Behaviours						
F0	5	9.62	8.93	1.25	5.85	24.11
F1	4	4.52	2.54	1.16	4.97	6.98
S0	3	19.03	30.28	1.05	2.06	53.99
S1	7	4	5.02	0.14	1.23	12.24
T0	7	8.77	14.18	0.77	3.77	40.58
T1	3	6.58	8.49	0.53	2.92	16.29
Manipulation Rack						
F0	5	5.54	4.62	0.38	3.52	11.2
F1	4	4.29	2.35	1.16	4.65	6.69
S0	3	7.57	13	0	0.12	22.58
S1	7	0.85	1.08	0	0.4	3.13
T0	7	2.97	2.17	0.14	2.13	5.57
T1	3	1.77	1.35	0.25	2.21	2.85
Exploration Floor						
F0	5	2.03	2.42	0.22	1.31	6.2
F1	4	0.02	0.04	0	0	0.08
S0	3	9.38	14.5	0	2.06	26.07
S1	7	2.15	3.71	0	0.45	10.11
T0	7	5.22	12.39	0	0.61	33.27
T1	3	3.51	5.48	0.11	0.59	9.83
Manipulation Pen Elements						
F0	5	2.05	2.66	0.29	0.82	6.71
F1	4	0.21	0.26	0	0.15	0.55
S0	3	2.09	2.85	0	0.93	5.34
S1	7	1	1.31	0.06	0.48	3.8
T0	7	0.58	0.88	0	0.09	2.05
T1	3	1.3	2	0.11	1.17	3.61

Tab. 7: Frequency of all observed behaviours on Nest-Building Day in each PT x CP combination; F = Flügel-pen, S = SAWP-pen, T = Trapez-pen; 0 = non-crated, 1 = crated

Day 5 - PTxCP/Frequency						
PTxCP	**n**	**mean**	**sd**	**min**	**median**	**max**
All Behaviours						
F0	5	49.4	39.39	9	36	105
F1	4	32.25	21.88	6	32	59
S0	3	96.33	139.27	10	22	257
S1	7	21.86	22.42	2	14	66
T0	7	51	82.96	3	21	238
T1	3	30.67	35.36	5	16	71
Manipulation Rack						
F0	5	31.8	35.83	2	24	93
F1	4	29.5	20.07	6	28.5	55
S0	3	37.33	63.8	0	1	111
S1	7	6.33	5.28	1	5.5	16
T0	7	15.29	9.59	1	19	28
T1	3	13.67	12.58	2	12	27
Exploration Floor						
F0	5	10.8	11.14	3	9	30
F1	4	0.25	0.5	0	0	1
S0	3	43.67	57.64	0	22	109
S1	7	5.43	7.02	0	3	18
T0	7	29.43	66.12	0	3	179
T1	3	12.33	17.04	2	3	32
Manipulation Pen Elements						
F0	5	6.8	5.22	3	4	15
F1	4	2.5	3	0	2	6
S0	3	15.33	19.3	0	9	78
S1	7	11	10.83	1	10	32
T0	7	6.29	11.32	0	1	31
T1	3	4.67	6.35	1	1	12

Fig.17 compares the duration of all observed behaviours on Day 5, of crated and non-crated sows. Fig.18 compares the frequencies of all observed behaviours on Day 5, of crated and non-crated sows. The graphs illustrate, that in contrast to Nest-Building Day, all crated sows showed a lower duration and frequency than the non-crated animals, in all observed behaviours.

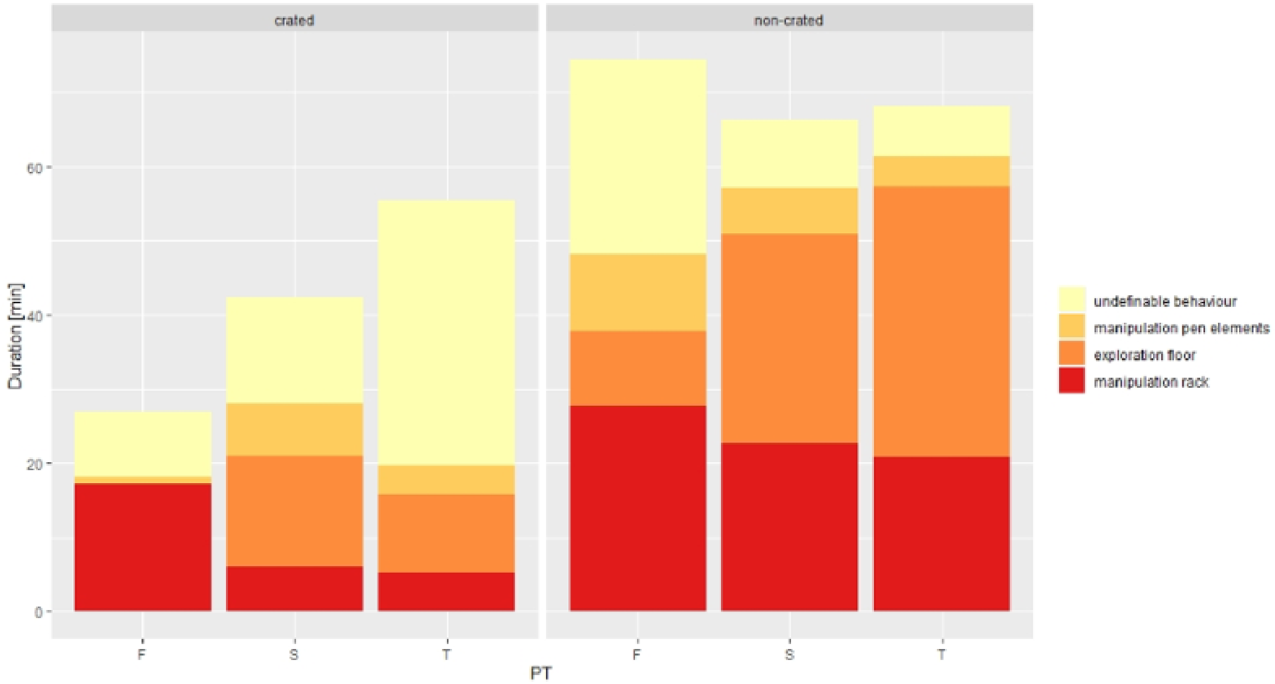

Fig. 17: Duration (min) of all observed behaviours in each pen type on Day 5: Flügel-pen (F), SWAP-pen (S), Trapez-pen (T); comparison between crated and non-crated sows

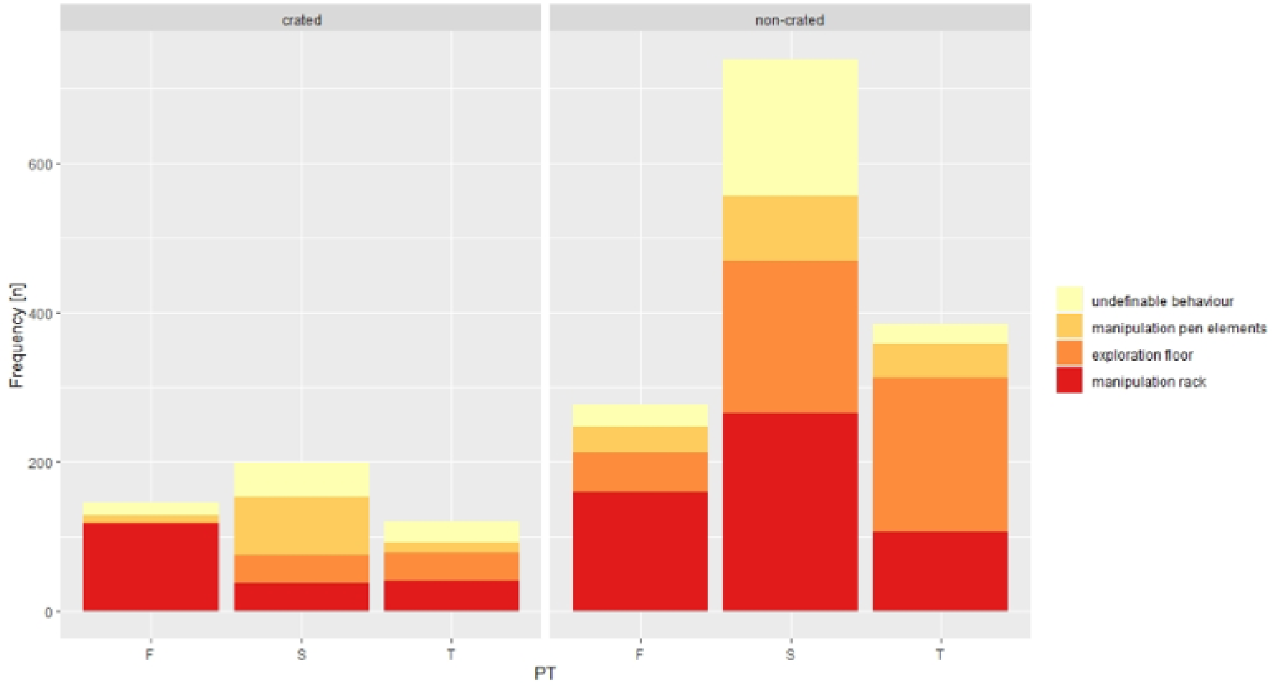

Fig. 18: Frequency (n) of all observed behaviours in each pen type on Day 5: Flügel-pen (F), SWAP-pen (S), Trapez-pen (T); comparison between crated and non-crated sows

To test the hypotheses that PT (F, S, T) and PT in combination with CP0 or CP1 influence the animals behavior on Day 5, the PT and all PT x CP combinations were compared. For "Manipulation Rack", the differences in both, duration and frequency, between the pen types were significant (p = 0.02 and p = 0.03). When comparing F with S, the differences in duration (p = 0.02) and frequency (p = 0.03) were also significant. The other results on this observation day were non-significant and can be found in Tab.8. The significant results show, that the pen type played an important role for the manipulation of the rack. Because of the crating, the sows showed no significant differences in any observed behavior on Day 5.

Tab. 8: p-Values and used tests from all observed behaviours (Duration and Frequency) on Day 5; PT = pen type, CP = crating period, PT x CP = pen type x crating period

Day 5	**Duration**		**Frequency**	
	Test	**p-Value**	**Test**	**p-Value**
All Behaviours				
PT	Kruskal-Wallis	0.4	ANOVA	0.68
CP	Wilcoxon	0.29	ANOVA	0.24
PTxCP	Kruskal-Wallis	0.75	ANOVA	0.77
Manipulation Rack				
PT	Kruskal-Wallis	**0.02**	Kruskal-Wallis	**0.03**
F>S	Dunns-test, bonferroni	**0.02**	Dunns-test, bonferroni	**0.03**
S:T	Dunns-test, bonferroni	0.4	Dunns-test, bonferroni	0.4
F:T	Dunns-test, bonferroni	0.6	Dunns-test bonferroni	0.7
CP	Wilcoxon	0.28	Wilcoxon	0.54
PTxCP	Kruskal-Wallis	0.16	Kruskal-Wallis	0.21
Exploration Floor				
PT	Kruskal-Wallis	0.77	Kruskal-Wallis	0.76
CP	Wilcoxon	0.15	Wilcoxon, bonferroni	0.05
PTxCP	Kruskal-Wallis	0.27	Kruskal-Wallis	0.22
Manipulation Pen Elements				
PT	Kruskal-Wallis	0.65	Kruskal-Wallis	0.25
CP	Wilcoxon	0.58	Wilcoxon	0.93
PTxCP	Kruskal-Wallis	0.34	Kruskal-Wallis	0.42

3.2 Hay Usage

In this chapter, the results of the hay usage are presented. Tables and boxplots are used for graphical presentation. The sample size (n), mean value (mean), standard deviation (sd), minimum (min), median and maximum (max) can be read from the tables. The applied statistical tests with the corresponding p-values from each observation day are also presented in tables.

3.2.1 All Observation Days

In order to assess hay usage over the entire period, the sows spent in the farrowing unit, all days, on which hay was weighted, were included for evaluation. The hypothesis, that the amount of hay, the sows use from Introduction Day until weaning, is fluctuating and does not remain the same over the entire course, was investigated. Hay was only used as nest-building material on the day of nest-building, on all other observation days, hay was available to the sows as exploration material.

Fig.19 shows the hay usage over the period for all observation days. On each observation day, the used quantities of all PT x CP combinations were included.

It can be seen, that after a high hay usage on the Introduction and Nest-Building Day, the usage of exploration material decreased sharply in the first two days after farrowing and increased again from the third day after birth until Week 4. The exact values are shown in Tab. 9.

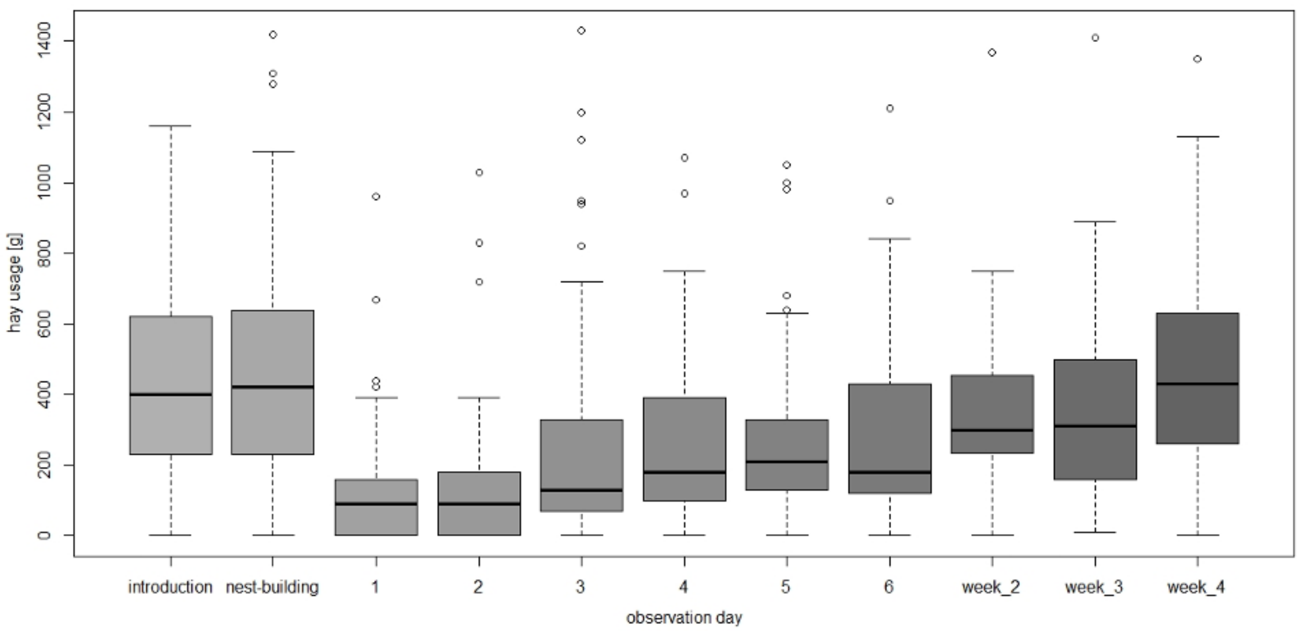

Fig. 19: Hay usage (g) on each observation day

Tab. 9: Hay usage (g) on each observation day

Hay Usage/Observation Day						
Observation Day	**n**	**mean**	**sd**	**min**	**median**	**max**
Introduction	57	422.63	270.51	0	400	1160
Nest-Building	57	461.23	339.33	0	420	1420
Farrowing	57	135.09	177.89	0	90	960
Day 1 post partum	57	139.82	200.21	0	90	1030
Day 2 post partum	57	272.11	332.48	0	130	1430
Day 3 post partum	57	269.3	250.61	0	180	1070
Day 4 post partum	57	266.49	246.33	0	210	1050
Day 5 post partum	57	293.68	274.34	0	180	1210
Day 6 post partum	45	257.33	220.78	0	200	790
Week 2	39	354.1	237.67	0	300	1370
Week 3	37	376.84	272.56	10	310	1410
Week 4	37	493.78	324.87	0	430	1350

Fig.20 shows the hay usage of non-crated sows (CP0), over the period of all observation days and Fig.21, presents the hay usage of crated sows (CP1) on selected observation days. Only on these selected days, sows were crated. By comparing the two graphs, hay usage of crated and non-crated sows can be compared over the time the animals spent in the farrowing unit and the hypotheses, that crated sows use less material, can be investigated.

On Nest-Building Day, the non-crated sows used 477.19 ± 275.45g and crated animals used 416.67 ± 402.6g hay. For both, non-crated and crated, exploration material usage dropped after Nest-Building Day. The non-crated sows needed on average between 70g and 470g of hay from the first to the fifth day after farrowing. The crated sows needed on average between 148 and 265g hay. Fig.20 and Fig.21 illustrate, that exploration material usage in CP0 increased slightly steeper after the first day after birth than in CP1.

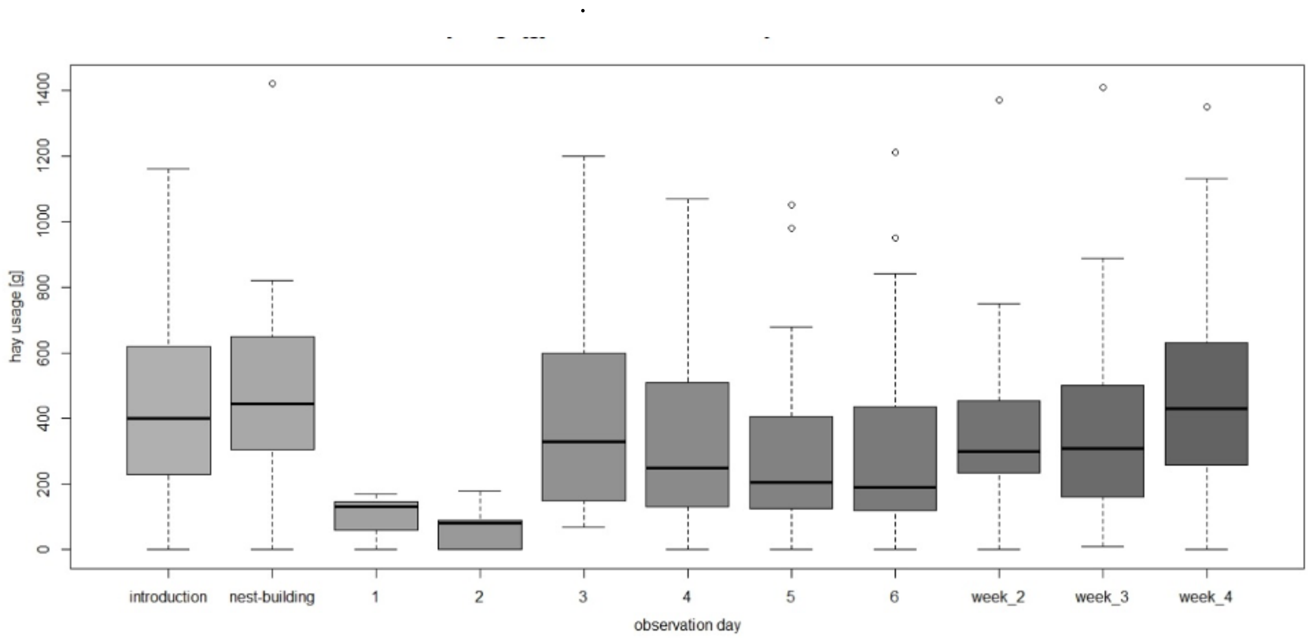

Fig. 20: Hay usage (g) on each observation day in non-crated sows

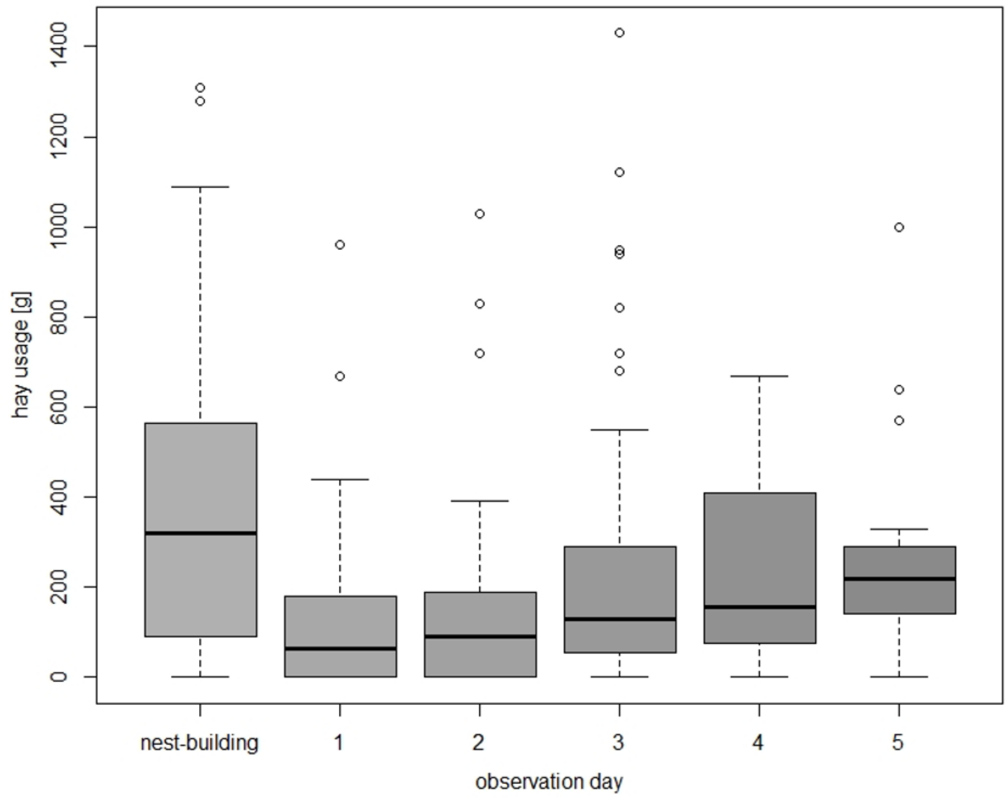

Fig. 21: Hay usage (g) for selected observation days in crated sows

As well, all PT x CP combinations were compared with each other over the course the sows spent in the farrowing unit. In contrast to Nest-Building Day, when CP0 and CP1 were decisive for evaluation, all CP (0, 3, 4, 6) used in this experiment must be considered, if hay usage is represented for the entire period. The exact description of the CP can be found in chapter 2.7. Crating Periods.

Fig.22 shows the hay usage of each PT (F, S, T), with each possible CP (0, 3, 4, 6). The exact values are presented in Tab.10.

The sows in F, consumed the most material in the farrowing pen, on average 430g. Of this, sows in F_6 most and in F_3 least. Sows in S needed, with an average usage of 244.9g, at least hay. Of this, sows in S_0 most and the sows in S_4 least.

Hay usage of the animals in T, was between F and S. Sows in T used in average 334g hay and the animals in T_0 used the highest and the sows in T_6 the lowest amount of it.

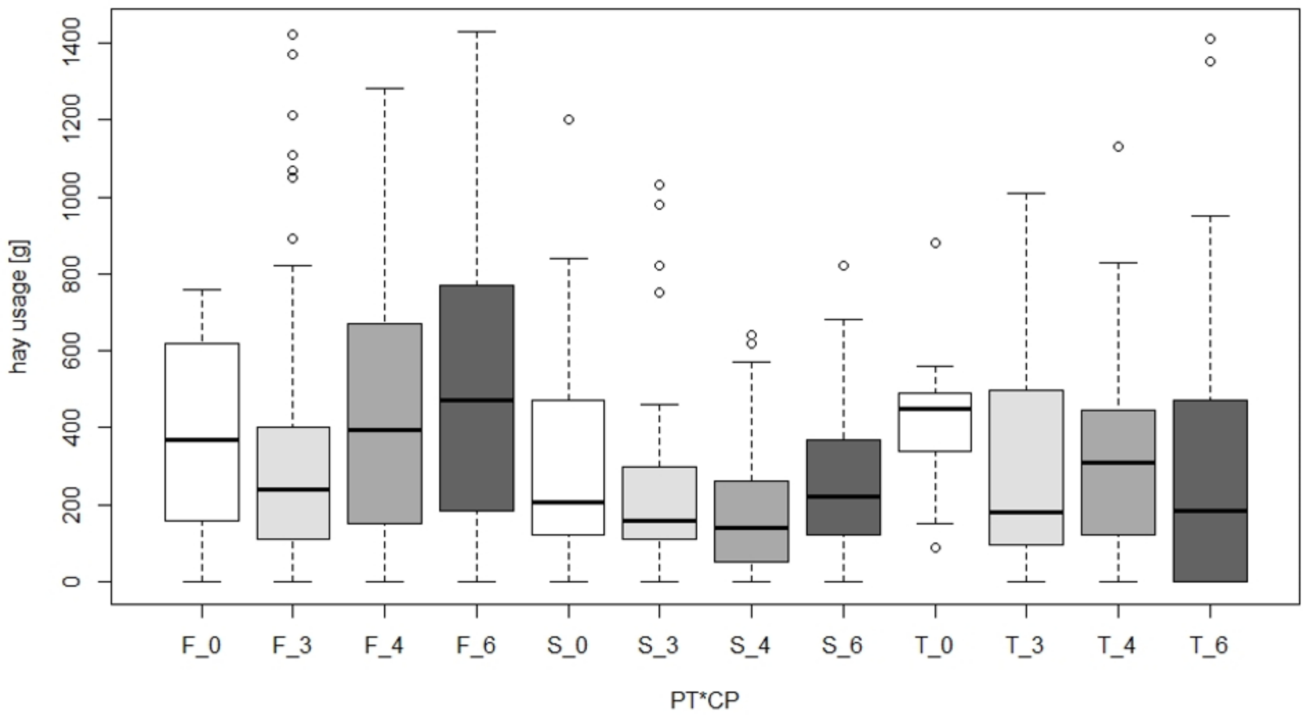

Fig. 22: Hay usage in each pen type (PT) in combination with each crating period (CP); F = Flügel-pen, S = SWAP-pen, T = Trapez-pen; CP 0, 3, 4, 6

Tab. 10: Hay usage (g) for each pen type (PT) x crating period (CP) combination

Hay Usage/Crating Period x Pen Type (CPxPT)						
CPxPT	**n**	**mean**	**sd**	**min**	**median**	**max**
F0	26	460	348.08	0	425	1470
F3	78	318.97	318.28	0	230	1420
F4	41	431.71	353.55	0	430	1280
F6	38	510.53	396.4	0	485	1430
S0	23	331.74	304.07	0	210	1200
S3	47	246.38	249.4	0	160	1030
S4	71	166.48	151.39	0	140	640
S6	78	235	176.35	0	195	820
T0	11	425.45	209.35	90	450	880
T3	77	302.25	274.63	0	180	1010
T4	67	325.07	239.89	0	300	1130
T6	59	283.22	336.12	0	180	1410

The hypothesis, that the PT influences the hay usage during the period the sow spends in the farrowing unit, can be confirmed. There were significant differences ($p = 0.002$) in hay usage because of the PT. When comparing F with S, the sows in F used significantly more ($p = 0.002$) hay than the animals in S. The differences between F and T ($p = 0.15$) and S and T ($p = 0.13$) were non-significant. The differences in hay usage because of the CP were non-significant ($p = 0.61$). Parity of the sow and treatment had no significant effect on hay usage. The coefficients with estimates and lsmeans can be found in the appendix.

Based on the results of this thesis, a quantity of hay, which is adequate as nesting or exploration material, over the hole period the sows spend in the farrowing unit, can be determined. It is important, that this quantity is sufficient for all sows in different housing conditions, both, on the Nest-Building Day and over the rest of the period. Therefore, this amount is defined, based on the maximum amount of hay used in all pen types. With the results of this study, 1430g hay can be defined as an adequate amount of nest-building and exploration material.

3.2.2 Nest-Building Day

Hay usage on Nest-Building Day was compared between the PT and is shown in Fig.23.
It can be seen, that in F, with an average of 681.03g, the most hay was used for nest-building. Sows in S and T used on average 336.21 and 365.42g. This means, sows in F spent approximately twice as much nest-building material as the sows in S and T.
Nevertheless, the differences between F and S ($p = 0.065$), F and T ($p = 0.21$) and T and S ($p = 1$) were non-significant.

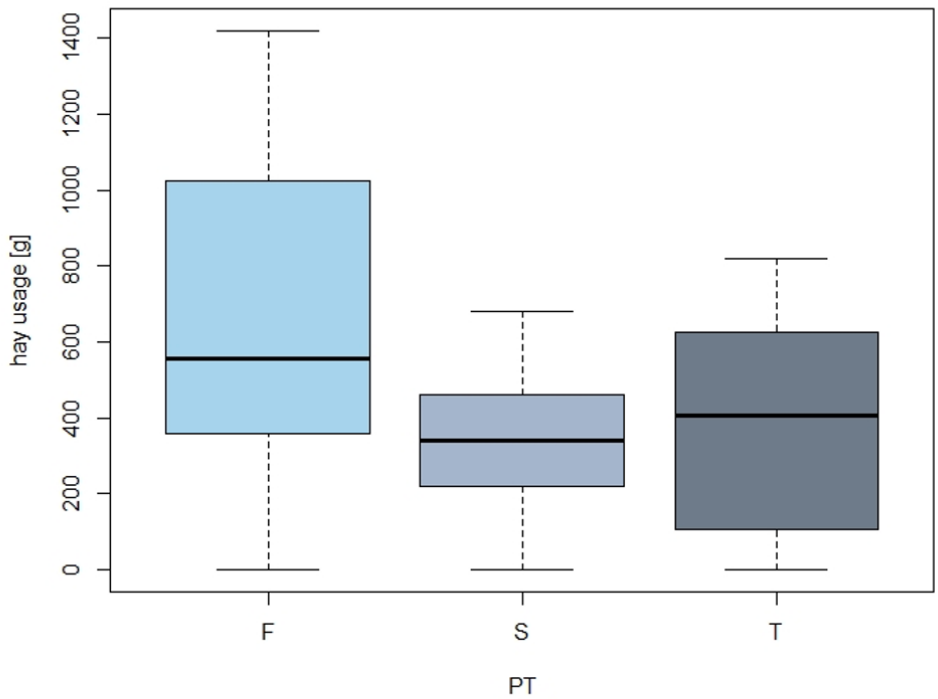

Fig. 23: Hay usage (g) on Nest-Building Day; comparison between the pen types: F = Flügel-pen, S = SWAP-pen, T = Trapez-pen

The hypothesis, that the crating of the sow affects hay usage and non-crated sows need more nest-building material than crated sows, was investigated. Hay usage on Nest-Building Day was compared between crated and non-crated sows. Fig.24 compares the usage of hay between crated and non-crated sows on Nest-Building Day. Crated sows used on average 440.87g and non-crated animals used on average 480g hay. The hypothesis, that crating of the

sow affects hay usage and non-crated sows need more nest-building material than crated sows, was tested. The difference proved to be non-significant (p = 0.07).
That means, crated and non-crated sows showed no significant difference in hay usage during nest-building.

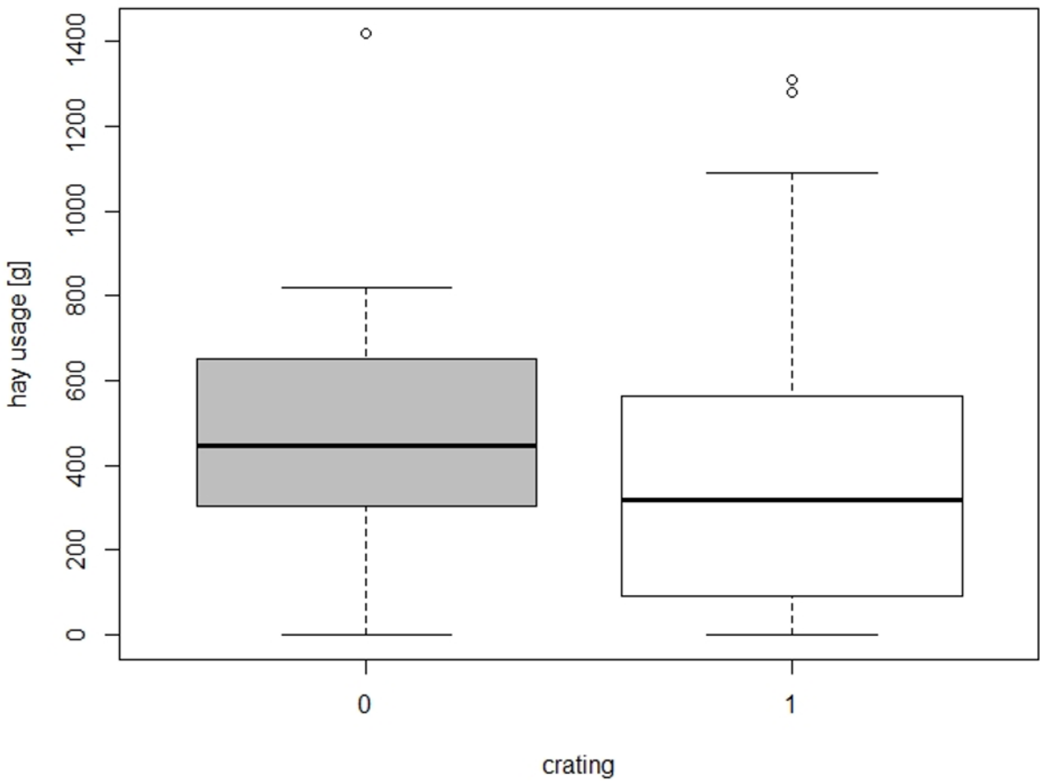

Fig. 24: Hay usage (g) on Nest-Building Day; comparison between crated and non-crated sows

Furthermore, hay usage of each PT x CP combination was determined and compared with each other. The exact values can be found in Tab.11. The results are shown in Fig.25. It can be seen, that sows in F1, with an average amount of 824.29g, used the most hay. Sows in F0, T0 and S0, used on average between 429.09g and 537.78g hay. Sows in S1 used on average 243.33g and the animals in T1 255g hay. That means, in F, the crated sows used more hay and in S and T the non-crated animals used more nest-building material.

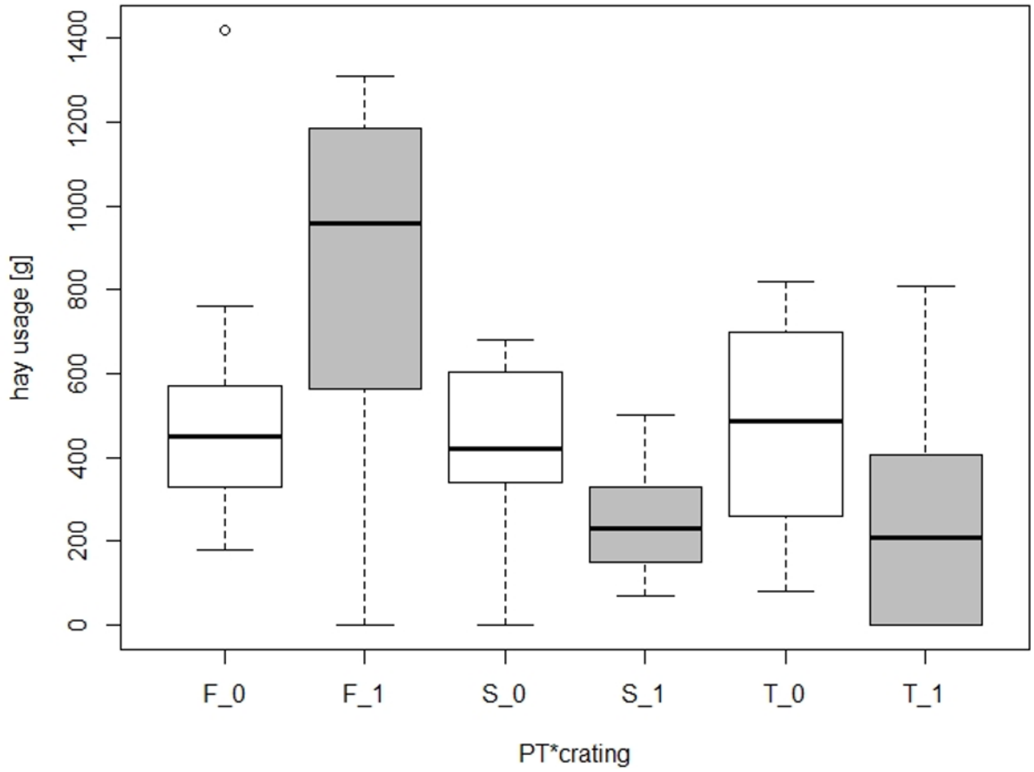

Fig. 25: Hay usage (g) for each pen type (PT) in combination with non-crated (0) and crated (1) sows; F = Flügel-pen, S = SWAP-pen, T = Trapez-pen

Tab. 11: Hay usage (g) for each pen type (PT) in combination with non-crated (0) and crated (1) sows; F = Flügel-pen, S = SWAP-pen, T = Trapez-pen

Hay Usage Nest-Building Day / PT x CP						
PT x CP	**n**	**mean**	**sd**	**min**	**median**	**max**
F0	9	537.78	378.08	180	450	1420
F1	7	824.29	474.44	0	960	1310
S0	11	429.1	203.44	0	420	680
S1	9	243.33	142.39	70	230	500
F0	12	475.83	258.68	80	485	820
F1	8	255	286.01	0	210	810

The differences between the PT x CP combinations proved to be significant ($p = 0.02$). The PT x CP combinations compared in pairs, showed one significant difference: F1 < S1 ($p = 0,03$).

The hypothesis, that non-crated sows consume more nest-building material than crated animals cannot be confirmed. There were no significant differences between crated and non-crated sows. However, the pen type played a significant role for the hay usage on Nest-Building Day. Sows in the F used significantly more hay than the animal in S and T. The PT x CP combination played a significant role for hay usage as well and influenced the amount of hay, which was used on Nest-Building Day.

4.Discussion

The three pen types F, S and T differ in size and floor conditions. The hypothesis, that the pen type has an influence on behaviour and hay usage, was tested by comparing the three pen types. Sows in S, which was the largest pen, with a total of 6m2, showed the highest activity on Nest-Building Day. Domesticated sows show a wide range of behaviour in the nest-building phase, 24 hours before birth. This includes burrowing, rooting, scratching and the search for nest-building materials. In farrowing pens, the animals only have few possibilities to show these behaviours because of lack of space, no or inappropriate material, or both (Yun et al. 2013). Movement and activity are very important aspects of nest-building behaviour and it is assumed, that little space and no opportunity for movement, impede the use of enrichment and nest-building material (Jarvis et al. 2006). Since the size and the available space in the pen influence the nesting-behaviour, this could be the explanation, why sows in S were most active on Nest-Building Day. Nevertheless, the behavioural differences because of the pen type were non-significant. This result is consistent with those of a study, looking at the effects of the pen on sow behaviour. In this study, only a small effect of the pen on the activity of the sow was found (Vanheukelom et al. 2012). It has to be mentioned, that the sample size in this experiment was small and with a larger sample size, possibly other effects regarding the behaviour of the animals, could have been observed.

For hay usage, the pen type played a significant role. The sows in F consumed significantly more hay than the animals in T and S. Reason for the different hay usage and use of the rack could have been the different floor design in the three pen types. The exact plans of the pens are shown in chapter 2.2. The small size of concrete floor ($0.96m^2$) and the placement of the hay rack above the slatted floor, could have been responsible for the high hay usage in F. Hay, falling from the hay rack, was immediately lost through the slats, or the animals lost the material, when they manipulated it from the small solid area to the slats. That means, sows in F needed more hay, because they lost it through the slats and had to manipulate the rack more often. Sows in the S used the least amount of hay. The area of concrete floor in this pen may have had an influence on the hay usage in S. The solid area in S had a total size of $3.5m^2$ and the rack was not mounted above the slats. This means, hay, falling on the floor, did not fall

into the slats and the animals could spread and move the nest-building material around the concrete floor, without losing it easily. Hay lying on the floor, stayed available as nest-building material for the sows. This could have been the reason, why sows in S were the most active group on Nest-Building Day but did not manipulate the rack the most.
When comparing the behaviour of the different PT x CP combinations on Nest-Building Day, the sows in S0 were the most active group overall. Sows in S0 showed a higher activity in all observed behaviours, than animals in S1. Here, the available space, could have played a role again.
When comparing hay usage of the PT x CP combinations on Nest-Building Day, it can be seen that the sows in S0 and T0 used more hay than the sows in S1 and T1. Reason for this could have been the pen floor again. The non-crated animals had the possibility to spread and move the hay through the whole pen, so more was lost through the slatted floor. The crated animals could not move away from the concrete floor-area. For sows in F, animals in F1 used more hay than the animals in F0. However, the results were non-significant.
Also, the position of the crate with the hay rack, could have influenced the duration and frequency "Manipulation Rack" and the hay usage. In F, the racks were the least manipulated on Introduction Day. The low manipulation in the F could have resuled from the position of the rack Fig.6. In F, the sows had to enter the open crate to reach the rack. Due to the position of the crate in the pen, the sows could not reach the rack, that was mounted to the crate, in one step, because it was to narrow. Once they reached the rack, the crate restricted their movement. Furthermore, when the sows were active in the area behind the crate, the rack was not in their field of vision. These factors may have made the rack less attractive to the sows in the F, than for sows in the S and T. However, the hay rack was used most often and longest on Nest-Building Day and Day 5, by the animals in the F. Therefore it could be, that sows in F needed more time to discover and get used to the hay rack, as it was out of sight and not as easy to reach, as in S and T.

Because of the limited space in crates, sows in two studies, showed less activity and a lower variety of behaviour then non-crated sows in pens in the pre-birth phase (Damm et al. 2003, Zhang et al. 2020). The fact, that limited space has a negative impact of on nest-building behaviour, led to the hypothesis that crated sows, who have less space and pour opportunities for movement, are less active on Nest-Building Day, show fewer nest-building episodes and use less hay as nest-building and exploration material than non-crated sows.

The difference between crated and non-crated sows in terms of nest-building behaviour and hay usage on Nest-Building Day was investigated in this study. The results of the comparison between non-crated and crated sows could not confirm the hypothesis above, as no significant differences in nesting behaviour and hay usage were found due to crating. Again, the small sample size of this study must be mentioned. With a larger sample size, other effects of crating on hay usage and behaviour, might have been observed on Nest-Building Day.

These results emphasize the importance of offering the same amount of hay, to crated and non-crated sows, for nest-building. Nest-building behaviour is an instinct, that is carried out with or without nest-building material and is always directed towards the available material or pen elements (Jensen 1993). However, the type of provided material will have an impact on the course of nest-building. Nest-building behaviour can be divided into a first phase, initiated by hormonal changes and a second, material-oriented phase. The first phase consists of searching the right place for nesting, burrowing, scratching and digging a nest. The second phase is characterized by collecting and arranging nest-building material and is mainly influenced by external stimuli and feedback from nest-building material and the nest itself. This feedback is necessary for the sow, to complete the procedure of nest-building. This means, if there is no material available, the nesting phase can be prolonged or interrupted and results in an increase of plasma cortisol level, which is a stress indicator and can be linked to interrupted nest-building and a lack of nest-building material. Prolonged birth phase, increased piglet mortality and complications during lactation, can be results of stress (Jensen 1993, Wischner et al. 2009).

When looking at the behaviour and hay usage of the sows over the entire period, parallels with the behaviour of free-ranging domestic pigs were observable. Despite the restricted conditions in the pen and especially in the crate. The increase in activity and hay usage during the days before nest-building and on Nest-Building Day, the decrease in activity and hay usage in the first days after birth and the slow increase in interest in exploration and movement in the weeks after birth, could be observed in both, conventional sows in pens and crates and free-ranging domesticated pigs (Jensen 1986).

Pigs are curious by nature and explore unknown things (Studnitz et al. 2007). The activity of the animals and the usage of hay on Introduction Day was correspondingly high, because introduction into the pen, meant a change to a new environment and the hay in the rack was an unknown exploration material for the sows. The connection between the sow's need for exploration and the unattractiveness of the housing conditions, is well known. This means, the reaction to new objects is stronger, if the animals are kept in a low irritant environment. (Weerd und Day 2009)

On Introduction Day, sows in the S were most active and used the hay rack most intensively of all pen types. Even though this result was non-significant, S are the largest pens and as mentioned earlier in the text, a larger pen facilitates movement and the use of exploration material.

On Day 5, the activity of all groups decreased to the minimum from all observation days. Free-ranging domestic pigs were observed in the days after birth. It was found that the sow did not leave the nest during the first two days after birth, i.e. spent 100% of the time in the nest and was busy suckling the piglets and very slowly became active again after birth (Jensen 1986). This also fits very well with the results we found. On the day of farrowing and the first day after birth, hay usage reached its minimum. Also, on Day 5, the sows in S were the most active overall. Again, the size of the pen might have had an influence, but the results were not significant. In "Manipulation Rack", the sows in F, in contrast to the Introduction Day, used the rack most, although the animals in F showed the least activity overall. For the use of the rack on the fifth day post-partum, the pen type played a significant role for duration and frequency.

In Week 2&3 and Week 4, again, no significant differences between the crating periods were found. For the pen types, a significant difference between T and S was found in Week 4. "Exploration Floor" was shown more often by sows in T than by animals in S. In general, activity of the animals and also hay usage increased again in all groups and all behaviours were shown longer and more often again. The behaviour of the pigs in this experiment, corresponded to the behaviour of animals in a natural environment, because in pigs in an outdoor enclosure, it was observed that the mother and the offspring were very strongly bound to the nest place in the first nine days post-partum, after this period the nest was left again more often and with a larger radius and also the activity of the sow increased again (Jensen 1986).

An adequate amount of hay, which must be available to sows for nest-building and during the whole farrowing phase, could be defined with the results of this work. The maximum hay usage over the whole period was 1430g. This value was reached on the second day post-partum. There must be enough hay available for each individual at all times. Therefore, 1430g can be assumed as an adequate amount of hay for the time the sow spends in the farrowing unit. This quantity ensures that sows have sufficient nest-building or exploration material available in each pen type and with each PT x CP combination from the Introduction Day until weaning. This means that 1500g can be recommended, as a realistic and practically usable amount of hay, which is available to the animals for the entire lactation period as nest-building or exploration material.

The results of this study clearly show, that there are fluctuations in the animals' behaviour and hay usage over the period of lactation. These fluctuations can also be observed in wild boars and domesticated pigs in a natural environment with sufficient space and material. These fluctuations are caused by the instinctive processes during the period from nest-building to weaning. The results emphasize, that despite domestication of pigs and the changed conditions in conventional pig production, behavioural patterns, that are very close to those of pigs in their natural environment, are shown. The husbandry does not influence the need to build a nest and explore the environment by digging and sniffing (Jensen 1993, Studnitz et al. 2007).

It is obvious that crating restricts the sow's movement more, than keeping her in a pen without crating. However, this does not mean that the sow is less active in the crate, has a reduced urge to build a nest, or requires less nest-building and exploration material. On the contrary, keeping sows in a crate with no material for nest-building or exploration causes more stress and stereotypes in the animals because their urge to explore and build a nest is directed against pen elements or the crate (Bulens et al. 2014). Since stress has been shown to affect the reproductive performance of sows, it is important to emphasize, that the ability to build a nest during the nest-building phase and to have access to exploration materials during lactation, not only improves animal welfare, but also contributes to economic pig production (Wischner et al. 2009)

5.Summary

This study compares the difference in behaviour and hay usage of crated and non-crated sows, in different farrowing pens, on Nest-Building Day and over the whole housing period the sows spend in the farrowing unit. Furthermore, a quantity of hay is defined which is sufficient as nest-building material or exploration material.

The data collection was carried out at the Medau pig farm of the University of Veterinary Medicine Vienna, within the Pro-Sau project from 01.12.2013 to 10.07.2017.

The duration and frequency of defined behaviors were documented by video observation on defined observation days. The behavioural differences between 44 sows, in three different pen types (Flügel-pen, SWAP-pen, Trapez-pen), crated or non-crated, were determined for each observation day.

For analyzing the behaviour, the collected data from all video observation days were analyzed separately from each other. A p-value ≤ 0.05 was considered statistically significant. On Nest-Building Day and Day 5 after farrowing, a two-way ANOVA with pen type and crating as independent factors was applied for variables with normally distributed data. For non-normally distributed data, the effects of the two factors were determined separately. A Kruskal-Wallis test was applied to identify the overall pen type effect and the interaction between pen type and crating. Pairwise comparisons were performed testing using Dunn test with Bonferroni correction if p was <0.1. A two-sided Wilcoxon rank-sum test was used to compare crated with non-crated sows, followed by a one-sided test if p was <0.1.

Hay was offered in a hay rack, as nest-building and activity material, for sows in three different pen types (Flügel-pen, SWAP-pen, Trapez-pen) and four different crating periods (0, 3, 4, 6). The hay was refilled and weighed two times a day, during the whole lactation period, sows spent in the farrowing unit. Thus, a statement could be made about the difference between the amount of hay offered and used.

Hay usage from 54 sows was analyzed with a general linear model using function *lm* from package *lme4.* As not all sows were observed on all observation days, only data from Introduction Day, Nest-Building Day and days 1-6 postpartum were included. Mean hay usage per day was defined as response variable. In order to reach normal distribution of the

residuals, data were log10 transformed. Pen type, confinement period and treatment (0/1) were defined as categorical fixed effects in the model, while parity was included as linear fixed effect. A significance cut off of 5% was employed and p-values for pairwise comparisons were adjusted using Tukey's method.

The differences in behaviour and hay usage of crated and non-crated sows were not significant on all observation days.

Due to the PT, differences in behaviour were observed. For example, on Day 5, sows in F manipulated the hay rack significantly longer and more often than sows in S. In Week 4, sows in T explored the pen floor significantly longer than sows in S.

Sows in F needed significantly more exploration material than the animals in S and T over the whole period the sows spent in the farrowing unit. Also, on Nest-Building Day, sows in F used significantly more nest-building material than the animals in S and T. Significant differences in hay usage were also found between the different PT x CP on Nest-Building Day.

In this thesis a quantity of hay could be determined, which is adequate for sows over the whole period in the farrowing unit and in different pen types. The amount of 1430g can be assumed as an adequate amount of hay, for the time the sow spends in the farrowing unit. This quantity ensures, that sows have sufficient nest-building or exploration material available in each pen type and with each PT x CP combination, from the introduction day until weaning.

The results of this study show, that crated sows neither showed less nest-building behaviour on Nest-Building Day and activity over the remaining time in the farrowing unit, nor used less nest-building and activity material than non-crated sows. The pen types, which differ in size, floor conditions and arrangement of the pen elements, had a greater influence on the behavior of the animals and hay usage, than the crating.

6. Zusammenfassung

In dieser Arbeit wird der Unterschied im Heuverbrauch und Verhalten, von freien und fixierten Sauen, in drei Abferkelbuchten, am Nestbautag und über die gesamte Haltungsperiode in der Bucht miteinander verglichen. Des Weiteren wird eine Menge Heu definiert, die sowohl am Nestbautag als auch über den gesamten Zeitraum der Laktation, als Nestbaumaterial bzw. Beschäftigungsmaterial ausreicht.

Die Datengewinnung erfolgte im Schweinebetrieb Medau der Veterinärmedizinischen Universität Wien, im Rahmen des Pro-Sau Projekts vom 01.12.2013 bis 10.07.2017.
Die Dauer und Häufigkeit definierter Verhaltensweisen wurden an jedem Beobachtungstag durch Videobeobachtung dokumentiert. An jedem Beobachtungstag wurden die Verhaltensunterschiede zwischen den 44 Sauen in drei verschiedenen Buchtentypen (Flügelbucht, SWAP-pen, Trapezbucht), fixiert oder nicht fixiert, dokumentiert.
Zur Analyse des Verhaltens, wurden die gesammelten Daten von allen Videobeobachtungstagen getrennt voneinander analysiert. Ein p-Wert $\leq$ 0,05 wurde als statistisch signifikant betrachtet. Am Nestbau-Tag und am Tag 5 nach dem Abferkeln, wurde für Variablen mit normalverteilten Daten, eine zweiseitige ANOVA, mit Buchtentyp und Fixierungsvariante als unabhängige Faktoren, durchgeführt. Für nicht normalverteilte Daten wurden die Auswirkungen der beiden Faktoren getrennt bestimmt. Ein Kruskal-Wallis-Test wurde angewandt, um den Gesamteffekt des Buchtentyps und die Interaktion zwischen Buchtentyp und Fixierungsvariante zu ermitteln. Es wurden paarweise Vergleiche durchgeführt, wobei der Dunn-Test mit Bonferroni-Korrektur verwendet wurde, wenn p <0,1 war. Ein zweiseitiger Wilcoxon-Rangsummentest wurde zum Vergleich von Sauen in der Box mit Sauen in Nicht-Kastenhaltung verwendet, gefolgt von einem einseitigen Test, wenn p < 0,1 war.
Heu wurde in einer Heuraufe, als Nestbau- und Erkundungsmaterial, für Sauen in den drei verschiedenen Buchtentypen (F, S, T) und vier verschiedenen Fixierungsvarianten angeboten. Das Heu wurde während der gesamten Laktationsperiode, die die Sauen in der Abferkelung verbrachten, zweimal täglich aufgefüllt und gewogen. So konnte eine Aussage über den Unterschied zwischen der angebotenen Heumenge und der Heunutzung der Sauen in den verschiedenen Buchtentypen (F, S, T) und CP gemacht werden.

Die Heunutzung von 54 Sauen wurde mit einem allgemeinen linearen Modell unter Verwendung der Funktion lm aus dem Paket lme4 analysiert. Da nicht alle Sauen an allen Beobachtungstagen beobachtet wurden, wurden nur die Daten des Einführungstages, des Nestbau-Tages und der Tage 1-6 postpartum einbezogen. Die mittlere Heunutzung pro Tag wurde als Response-Variable definiert. Um eine Normalverteilung der Residuen zu erreichen, wurden die Daten log10-transformiert. Buchtentyp, Fixierungsvariante und Behandlung (0/1) wurden als kategorisch fixierte Effekte im Modell definiert, während Parität als linear fixierter Effekt eingeschlossen wurde. Es wurde ein Signifikanz-Cut-off von 5% angewandt und die p-Werte für paarweise Vergleiche wurden mit der Tukey-Methode angepasst.

Aufgrund des PT wurden Unterschiede im Verhalten beobachtet. Zum Beispiel manipulierten Sauen in F am Tag 5 die Heuraufe signifikant länger und öfter, als Sauen in S. In Woche 4 erkundeten Sauen in T den Boden der Bucht signifikant länger, als Sauen in S.

Sauen in F benötigten über den gesamten Zeitraum, den die Sauen in der Abferkelbucht verbrachten, signifikant mehr Erkundungsmaterial als die Tiere in S und T. Auch am Nestbau-Tag verwendeten die Sauen in F signifikant mehr Nestbaumaterial, als die Tiere in S und T. Signifikante Unterschiede in der Heuverwendung wurden auch zwischen den verschiedenen PT x CP am Nestbau-Tag festgestellt.

In dieser Arbeit konnte eine Heumenge ermittelt werden, die für Sauen über den gesamten Zeitraum in der Abferkelung und in unterschiedlichen Buchtentypen ausreichend ist. Die Menge von 1430 g kann als angemessene Menge Heu angenommen werden. Diese Menge stellt sicher, dass die Sauen in jeder Bucht und mit jeder PT x CP Kombination, vom Einstallen bis zum Absetzen, ausreichend Nestbau- oder Erkundungsmaterial zur Verfügung haben.

Die Ergebnisse dieser Studie zeigen, dass fixierte Sauen weder ein geringeres Nestbauverhalten am Nestbau-Tag und weniger Aktivität während der verbleibenden Zeit in der Abferkelbucht zeigten noch weniger Nestbau- und Erkundungsmaterial verbrauchten, als nicht fixierte Sauen. Die Buchtentypen, die sich in Größe, Bodenbeschaffenheit und Anordnung der Buchtenelemente unterscheiden, hatten einen größeren Einfluss auf das Verhalten der Tiere und die Heuverwendung als die Fixierungsvariante.

7. List of Abbreviations

CP	crating periods
EU	European Union
F	Flügel-pen
Fig.	Figure
LK	Austrian Chamber of Agriculture (Landwirtschaftskammer)
hCG	human chorionic gonadotropin
ITT	Institute of Animal Welfare Science
PMSG	Pregnant Mare Serum Gonadotropin
PRRS	Porcine Reproductive Respiratory Syndrome
PT	Pen type
S	SWAP-pen
T	Trapez-pen
Tab.	Table
TGD	Tiergesundheitsdienst

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9. List of Tables

10. List of Figures

11. Appendix – Additional Tables

Tab. 12: Duration (min) of all observed behaviours in each pen type on Introduction Day

Introduction/Duration						
	n	mean	sd	min	median	max
All Behaviours						
Flügel-pen	7	9.99	5.71	3.44	7.7	19.59
SWAP-pen	6	23.49	18.16	4.96	16	55.62
Trapez-pen	7	16.38	16.47	4.4	8.39	51.03
Manipulation Rack						
Flügel-pen	7	5.4	1.83	3.44	5.1	8.93
SWAP-pen	6	17.95	10.13	4.62	14.81	33.02
Trapez-pen	7	10.72	7.52	2.64	8.13	20.31
Exploration Floor						
Flügel-pen	7	2.8	3.59	0	1.86	9.29
SWAP-pen	6	3.48	7.63	0	0.41	19.03
Trapez-pen	7	4.51	10.23	0	0.28	27.6
Manipulation Pen Elements						
Flügel-pen	7	1.8	1.75	0	1.96	4.31
SWAP-pen	6	2.06	4	0	0.2	10.1
Trapez-pen	7	1.14	1.74	0	0.92	4.96

Tab. 13: Frequency of all observed behaviours in each pen type on Introduction Day

Introduction/Frequency						
	n	mean	sd	min	median	max
All Behaviours						
Flügel-pen	7	54.43	24.91	26	52	96
SWAP-pen	6	74.33	76.98	14	33.75	226
Trapez-pen	7	73.86	79.7	23	33	250
Manipulation Rack						
Flügel-pen	7	30.86	5.15	23	32	37
SWAP-pen	6	47.5	28.17	13	50.5	92
Trapez-pen	7	47	31.02	16	50	102
Exploration Floor						
Flügel-pen	7	11.43	15.49	0	7	42
SWAP-pen	6	£	27.1	0	3.5	69
Trapez-pen	7	16.14	34.45	0	1	93
Manipulation Pen Elements						
Flügel-pen	7	12.14	10.12	0	16	25
SWAP-pen	6	12.83	25.62	0	3	65

Tab. 14: p-Values and used tests from all observed behaviours (Duration and Frequency) on Introduction Day; F: Flügel-pen, S: SWAP-pen, T: Trapez-pen

Introduction	Duration		Frequency	
	Test	p-Value	Test	p-Value
All Behaviours	Kruskal-Wallis	0.29	Kruskal-Wallis	0.92
F:S	Dunns-test, bonferroni	0.34		
T:S	Dunns-test, bonferroni	1		
F:T	Dunns-test, bonferroni	1		
Manipulation Rack	Kruskal-Wallis	0.09	Kruskal-Wallis	0.68
S:F	Dunns-test, bonferroni	0.09		
T:S	Dunns-test, bonferroni	0.76		
F:T	Dunns-test, bonferroni	0.84		
Exploration Floor	Kruskal-Wallis	0.96	Kruskal-Wallis	0.9
Manipulation Pen Elements	Kruskal-Wallis	0.73	Kruskal-Wallis	0.63

Tab. 15: Duration (min) of all observed behaviours in each pen type on Nest-Building Day

Nest-Building/Duration						
	n	mean	sd	min	median	max
All Behaviours						
Flügel-pen	9	38.92	39.48	1.1	33.04	130.95
SWAP-pen	8	39.58	43.07	8.52	15.99	109.67
Trapez-pen	12	35.01	31.22	3.73	22.97	95.13
Manipulation Rack						
Flügel-pen	9	7.19	6.08	0.39	4.78	19.19
SWAP-pen	8	6.75	6	0.26	5.46	18.95
Trapez-pen	12	5.84	5.79	0.67	4.1	20.37
Exploration Floor						
Flügel-pen	9	13.83	19.13	0	3.4	53.96
SWAP-pen	8	9.41	14.96	0.34	5.52	45.9
Trapez-pen	11	15.69	17.47	1.18	6.66	57.5
Manipulation Pen Elements						
Flügel-pen	9	17.89	19.13	0	9.13	57.8
SWAP-pen	8	23.42	31.74	4.78	8.21	90.15
Trapez-pen	11	16.13	15.9	1.87	11.39	55.54

Tab. 16: Frequency of all observed behaviours in each pen type on Nest-Building Day

Nest-Building/Frequency						
	n	mean	sd	min	median	max
All Behaviours						
Flügel-pen	9	184.22	210.82	4	90	672
SWAP-pen	8	200.75	247.31	34	76.5	737
Trapez-pen	12	182.5	172.87	14	135.5	597
Manipulation Rack						
Flügel-pen	9	39.33	36.09	2	30	107
SWAP-pen	8	36.13	35.67	3	21.5	89
Trapez-pen	12	33.08	35.37	4	18.5	126
Exploration Floor						
Flügel-pen	8	58.5	84.24	0	23	248
SWAP-pen	8	58.5	96.83	3	25.5	294
Trapez-pen	11	80.36	77.54	10	54	251
Manipulation Pen Elements						
Flügel-pen	9	92.89	102.03	0	49	317
SWAP-pen	8	106.13	136.26	21	43.5	381
Trapez-pen	11	82.64	78.31	14	68	271

Tab. 17: Duration of all observed behaviours in each pen type in Week 2&3

Week 2 & 3/Duration						
	n	mean	sd	min	median	max
All Behaviours						
Flügel-pen	5	12.5	12.24	2.89	6.83	31.96
SWAP-pen	4	16.23	11.4	6.34	16.2	26.16
Trapez-pen	6	10.65	11.17	1.55	7.05	32.6
Manipulation Rack						
Flügel-pen	5	7.39	7.98	0.6	5.6	20.05
SWAP-pen	4	10.08	10.72	2.96	5.77	25.81
Trapez-pen	6	5.35	3.76	1.28	4.06	10.13
Exploration Floor						
Flügel-pen	5	4.17	4.93	0	1.47	11.88
SWAP-pen	4	3.58	4.46	0.24	1.97	10.15
Trapez-pen	6	3.92	7.62	0	0.69	19.35
Manipulation Pen Elements						
Flügel-pen	5	0.95	0.89	0	1.1	1.85
SWAP-pen	4	2.57	3.7	0	1.11	8.06
Trapez-pen	6	1.37	1.41	0	0.99	3.12

Tab. 18: Frequency of all observed behaviours in each pen type in Week 2&3

Week 2 & 3/Frequency						
	n	**mean**	**sd**	**min**	**median**	**max**
All Behaviours						
Flügel-pen	5	53	44.86	16	36	128
SWAP-pen	4	62.25	43.11	33	45.5	125
Trapez-pen	6	69.33	105.97	17	29.5	285
Manipulation Rack						
Flügel-pen	5	33	36.86	8	13	95
SWAP-pen	4	31	18.8	12	29	54
Trapez-pen	6	25.33	24.67	8	16.5	74
Exploration Floor						
Flügel-pen	5	12.8	12.6	0	14	32
SWAP-pen	4	16	16.02	2	11.5	39
Trapez-pen	6	30	59.67	0	4.5	151
Manipulation Pen Elements						
Flügel-pen	5	7.2	7.66	0	5	18
SWAP-pen	4	15.25	22.23	0	6.5	48
Trapez-pen	6	14	22.96	0	6	60

Tab. 19: p-Values and used tests from all observed behaviours (Duration and Frequency) in Week 2&3

Week 2 & 3	**Duration**		**Frequency**	
	Test	**p-Value**	**Test**	**p-Value**
All Behaviours	Kruskal-Wallis	0.73	Kruskal-Wallis	0.6
Manipulation Rack	Kruskal-Wallis	0.86	Kruskal-Wallis	0.74
Exploration Floor	Kruskal-Wallis	0.74	Kruskal-Wallis	0.9
Manipulation Pen Elements	Kruskal-Wallis	0.93	Kruskal-Wallis	0.99

Tab. 20: Duration of all observed behaviours in each pen type in Week 4

Week 4/Duration						
	n	mean	sd	min	median	max
All Behaviours						
Flügel-pen	8	12.19	11.81	0	7.11	32.59
SWAP-pen	7	5.01	3.91	0	4.67	9.2
Trapez-pen	7	11.36	15.88	0.44	7.61	45.61
Manipulation Rack						
Flügel-pen	8	6.08	6.77	0	4.35	17.12
SWAP-pen	7	4.4	3.8	0	3.21	9.2
Trapez-pen	7	5.23	4.55	0.18	7.06	12.01
Exploration Floor						
Flügel-pen	8	4.36	5.44	0	2.14	12.69
SWAP-pen	7	0.16	0.34	0	0.03	0.94
Trapez-pen	7	5.04	12.04	0	0.26	32.31
Manipulation Pen Elements						
Flügel-pen	8	1.75	1.76	0	1.76	5
SWAP-pen	7	0.45	0.39	0	0.38	0.95
Trapez-pen	7	1.1	1.79	0.21	0.32	5.12

Tab. 21: Frequency of all observed behaviours in each pen type in Week 4

Week 4/Frequency						
	n	mean	sd	min	median	max
All Behaviours						
Flügel-pen	8	46.13	43.89	0	33	104
SWAP-pen	7	23.86	19.14	0	29	51
Trapez-pen	7	69.57	114.53	6	33	325
Manipulation Rack						
Flügel-pen	8	24.75	26.09	0	20.5	73
SWAP-pen	5	22.2	17.3	0	29	40
Trapez-pen	6	34.17	32.11	2	31.5	89
Exploration Floor						
Flügel-pen	8	11.25	14.56	0	5.5	35
SWAP-pen	7	1.86	3.63	0	1	10
Trapez-pen	7	25.57	58.9	0	3	159
Manipulation Pen Elements						
Flügel-pen	8	10.13	11.12	0	5	27
SWAP-pen	7	6.14	7.11	0	3	20
Trapez-pen	7	14.71	27.49	3	4	77

Tab. 22: p-Values and used tests from all observed behaviours (Duration and Frequency) in Week 4; F: Flügel-pen, S: SWAP-pen, T: Trapez-pen

Week 4	Duration		Frequency	
	Test	p-Value	Test	p-Value
All Behaviours	Kruskal-Wallis	0.72	Kruskal-Wallis	0.61
Manipulation Rack	Kruskal-Wallis	0.92	Kruskal-Wallis	0.69
Exploration Floor	Kruskal-Wallis	0.14	Kruskal-Wallis	0.28
F:S	Wilcoxon. Alt "greater"	0.09		
T>S	Wilcoxon. Alt "greater"	0.02		
F:T	Wilcoxon	0.91		
Manipulation Pen Elements	Kruskal-Wallis	0.62	Kruskal-Wallis	0.78

Tab. 23 ANOVA – Coefficients; PT: pen type, CP3,4,6: crating period 3, 4, 6; S: SWAP-pen, T: Trapez-pen; Std. Error: standard error

Coefficients			
	Estimate	Std. Error	t-value
Intercept	2.55	0.12	21.96
PTS	-0.28	0.07	-3.74
PTT	-0.14	0.07	-1.91
CP3	-0.08	0.12	-0.64
CP4	-0.06	0.12	-0.48
CP6	0.02	0.12	0.16
Parity	0.02	0.02	1.02
Treatment 1	-0.07	0.06	-1.05

Tab. 24 ANOVA – lsmeans; PT: pen types, F: Flügel-pen, S: SWAP-pen, T: Trapez-pen

lsmeans					
PT	response	SE	df	lower. CL	upper. CL
F	345.17	43.82	45	267.3	445.73
S	181.22	23.51	45	139.56	235.32
T	251.55	31.78	45	195.04	324.45