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Social stress in large groups of dairy goats- Influence of presence of horns and introduction management of young goats

Doctoral thesis

submitted by
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Abstract

Animal production systems have been intensified in order to be more efficient and increase production, thus conditions for indoor housed goats differ largely from their natural habitat, e.g. limited resources, missing spatial structure, unstable herds. These conditions may lead to social stress and tension in herds, visible in increased adrenocortical activity, disturbance of feeding and resting behaviour, increased aggressive interactions and thus high risk of injuries. Low ranking animals in general are likely to suffer more under these conditions than high ranking ones. This effect may be even more pronounced in horned subordinate goats, as higher levels of social stress are assumed in horned goat herds compared to hornless ones.

The aim of the present study is to examine the influence of presence of horns (part one) and time of introduction of unfamiliar animals into groups of goats (part two) on behavioural and physiological parameters indicating social stress as well as on body condition and injuries.

The first part was conducted on two dairy goat farms in southern Germany each with hornless and horned goats (group size 75 to 86 goats)) kept in separate groups. Resting platforms were additionally installed on the other farm to investigate the effect of additional structures. Results revealed differences between groups, with hornless goats interacting more often agonistically in general and also more often with body contact and without success than horned goats. Distances at the feeding rack were smaller in hornless groups and horned goats were more often feeding at night. Rank did affect basic activity of groups differently, i.e. low ranking hornless goats were feeding more often than high ranking ones, while the opposite was observed in horned groups. Lying during feeding periods was more often seen in high ranking hornless goats than low ranking ones, while no differences in rank were seen in horned animals. Regarding body condition, groups did not differ consistently on both farms, but differences were minor. Occurrence of injuries did only differ between groups at the udder, with more horned goats being observed with udder injuries than hornless animals. In general animals were in better body condition and had fewer injuries, irrespective of presence of horns on one farm compared to the other. Adrenocortical activity did not differ within rank in relation to groups. Resting platforms were used frequently, irrespectively of rank and presence of horns. Results suggest that hornless goats are respecting social distances of dominant individuals less than horned goats, yet there are no indicators of increased social stress in (subordinate) horned compared to hornless goats. Due to the low number of groups and changes in group size results have to be interpreted with care. Differences between farms regarding body condition and injuries indicate the importance of (feeding) management in housing of dairy goats.

The second part of the present study compared social stress in young dairy goats after introduction into a herd of adult goats at two different reproductive periods at a research institute in Northern Germany. Parameters were observed during the first week after introduction. Goats were mostly horned; young goats were either reared with their mothers or artificially. Adult goats were kept in two groups, with 36 animals each. Young goats were introduced in groups of four during the dry period (i.e. all goats in the herd pregnant/dry) or after parturition (i.e. all animals with their kids/lactating). During the dry period young goats received more agonistic behaviours, adrenocortical activity was higher, feeding and lying behaviour was even less frequently observed compared to the latter period. Irrespective of period, introduced young goats had other young goats as neighbours above chance level, but this was even more distinct during the dry period. Type of rearing did not affect parameters. These results indicate that young goats experience less social stress when being introduced into a herd of adult dairy goats shortly after parturition with kids still present as compared to the dry period.

In conclusion there are no indications that (subordinate) horned goats are exposed to higher levels of social stress than hornless ones. Yet results are pointing toward the importance of management in order to reduce social stress in farm animals.

Keywords: goat, horns, management, mixing, behaviour, stress.

Zusammenfassung

Die Intensivierung tierischer Haltungssysteme zur Produktionssteigerung führt dazu, dass Ziegen in Ställen weitgehend andere Bedingungen vorfinden als in ihrem natürlichen Lebensraum, z.B. begrenzte Ressourcen, fehlende Raumstruktur, wechselnde Herdenzusammensetzung. Dies kann zu sozialem Stress in Herden führen, erkennbar durch erhöhte Nebennierenrindenaktivität (NNRA), Beeinträchtigung des Fress- und Liegeverhaltens, vermehrte aggressive Auseinandersetzungen in Verbindung mit erhöhtem Verletzungsrisiko. Sozialer Stress und dessen Begleiterscheinungen beeinflussen das Wohlbefinden, die Gesundheit und Leistung von Tieren nachteilig. Wobei wahrscheinlich rangniedere Tiere mehr darunter leiden als Höherrangige bzw. behornte rangniedrige Ziegen mehr als unbehornte, da in behornten Herden ein höheres soziales Stressniveau angenommen wird als in Unbehornten.

Ziel dieser Studie war es den Einfluss von Behornung (erster Teil) und Zeitpunkt der Eingliederung von unbekannten Tieren in bestehende Gruppen (zweiter Teil) auf sozialen Stress anhand von Verhaltens- und physiologische Parametern, Körperkondition und Verletzungen zu untersuchen.

Der erste Teil der Studie wurde auf zwei Milchziegenbetrieben (Vollerwerb) in Süddeutschland mit je einer hornlosen und einer behornten Gruppe (à 75/86 Tiere) pro Betrieb durchgeführt; wobei auf einem Betrieb Gruppen teilweise in Untergruppen von etwa 25 Tieren gehalten wurden. Auf dem anderen Betrieb wurden zusätzlich Liegenischen eingebaut. Ergebnisse zeigen, dass hornlose Ziegen öfter agonistisch im Allgemeinen und öfter mit Körperkontakt und ohne Erfolg interagierten als behornte Ziegen. Hornlose Tiere fraßen in geringeren Abständen und weniger oft nachts. Der Rang wirkte sich in den Gruppen unterschiedlich aus, so fraßen rangniedrige hornlose Tiere öfter als ranghohe, während bei behornten Ziegen das Gegenteil beobachtet wurde. Unterschiede in Körperkondition waren gering und nicht konsistent auf beiden Betrieben. Euterverletzungen wurden öfter bei behornten als bei unbehornten Tieren festgestellt. Die Tiere der beiden Betriebe unterschieden sich unabhängig von Behornung, mit einer besserer Körperkondition und weniger Verletzungen auf einem Betrieb als auf dem anderen. Die NNRA wurde nicht von der Behornung beeinflusst. Liegenischen wurden gut angenommen und unabhängig von Rang und Behornung genutzt. Die Ergebnisse deuten darauf hin, dass hornlose Ziegen die Individualdistanzen höherrangiger Tiere weniger respektieren als behornte Tiere, wobei keine Anzeichen von erhöhtem sozialen Stress in (rangniedrigen) behornten Tieren gefunden wurden. Die Ergebnisse müssen jedoch aufgrund der geringen Gruppenanzahl und unterschiedlicher Gruppengröße vorsichtig interpretiert werden. Unterschiede zwischen den Betrieben hinsichtlich Körperkondition und Verletzungen weisen auf die Wichtigkeit von (Fütterungs)management in der Ziegenhaltung hin.

Der zweite Teil der Studie verglich sozialen Stress von Jungziegen nach Eingliederung in eine Herde von mehrjährigen Milchziegen zu zwei unterschiedlichen Zeitpunkten auf einem Versuchsgut in Norddeutschland. Die Tiere waren größtenteils behornt; Jungziegen wurden entweder muttergebunden in der Herde oder in einer Kitzgruppe vom Menschen getränkt aufgezogen. Die mehrjährigen Ziegen wurden in zwei Gruppen, à 36 Tiere gehalten. Jungziegen wurden in Gruppen zu vier Tieren während der Trockenstehzeit (= alle Ziegen trächtig/nicht laktierend) bzw. kurz nach der Geburt (= Kitze in Herde/laktierend) eingegliedert und Parameter während der ersten Woche nach Eingliederung erhoben. In der Trockenstehzeit waren Jungziegen häufiger Ziel agonistischer Verhaltensweisen, die NNRA war höher, Fress- sowie Liegeaktivitäten wurden weniger oft beobachtet und Jungziegen hielten sich öfter neben anderen Jungziegen auf als während des zweiten Zeitpunkts. Die Art der Aufzucht beeinflusste die beobachteten Parameter nicht. Die Ergebnisse deuten darauf hin, dass für Jungziegen Eingliederungen kurz nach der Geburt, während Kitze noch in der Herde sind, mit weniger sozialem Stress verbunden ist, als in der Trockenstehphase.

Aufgrund der vorliegenden Ergebnisse unterscheiden sich behornte und hornlose Ziegenherden nicht hinsichtlich sozialen Stresses. Beide Teile der vorliegenden Studie unterstreichen die wichtige Bedeutung von Management bzw. zeigen die untergeordnete Rolle der Behornung in Bezug auf soziale Stressreduktion.

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1 General introduction

In industrial countries animal production systems have been intensified in order to be more efficient and to increase production (Miranda-de la Lama et al 2010) to meet demand. Increasing interest in industrial countries regarding goat milk and milk products may be related to a more diet conscious movement in society and an increasing amount of people facing allergic reactions to dairy products. Consequently alternatives to dairy products are looked for and dietary properties of goat products may be more appreciated. According to Park (1994) between 40 to 100% of patients allergic to cow milk proteins tolerate goat milk. Some properties of goat milk such as smaller fat globules, higher percent of short and medium chain fatty acids and softer curd formation of its proteins (Park et al 2007) are advantageous for higher digestibility and healthier lipid metabolism relative to cow milk (Park 1994, Raynal-Ljutovac et al 2008). These properties also result in lower total circulating cholesterol (Seaton et al 1986, Kasai et al 2003). Goat milk proteins are an important source of specific enzymes and peptides having positive effects on disease defence and control of microbial infections (Park et al 2007). Furthermore mineral and vitamin contents and iron bioavailability are stated to be mostly higher in goat milk than in cow milk (Park et al 1986, Park 1994, Park et al 2007). According to Raynal-Ljutovac et al (2008) these valuable properties are not only found in goat milk but also in goat cheese.

Not only dietary properties of goat milk and milk products may lead to increasing demand, but also the good ecological image of these products, especially in mountainous regions, as well as the assumption that goat farming is not as intensively practised as cow farming (Dubeuf et al 2004). From a farmers point of view goat milk production has also been of interest, because of higher prices than for dairy products mostly due to a niche market approach. In contrast to the dairy milk market within the European Union, the market for goat milk is not regulated (BGBl. II Nr. 209/2007), being also an incentive to start dairy goat farming.

Within the European Union most goats are found in Greece (4.8 million), followed by Spain (2.9 million) and France (1.3 million) (EUROSTAT 2010). In most countries the goat sector has grown continuously over the past ten years, in the Netherlands numbers more than doubled (1999 - 165,000; 2009 - 420,000 goats) (EUROSTAT 2010). The same development was seen in Austria, with herd sizes increasing as the numbers of dairy goats increased (STATISTIK AUSTRIA 2010 personal communication). Even though the goat population is rather small compared to other countries (2009 - 70,000 goats (STATISTIK AUSTRIA 2010), a third of the dairy goat population is kept in herds of 100 goats and more (STATISTIK AUSTRIA 2010 personal communication), indicating a similar development as found in other European countries (EUROSTAT 2010). This movement toward large scale and more intensive dairy goat farming is accompanied, among other things, by the intensification of breeding systems including feeding and genetic selection, leading to increasing milk yields (Pirisi et al 2007). In high yielding goats, however, rates of mortality and culling for health reasons are higher than in low yielding goats (Malher et al 2001).

In intensive dairy goat farming conditions for indoor housed goats differ largely from their natural habitat, e.g. limited resources, missing spatial structure. These intensive housing conditions may lead to social stress and tension in herds, visible in disturbance of feeding and resting behaviour and increased aggressive interactions (goats: Andersen and Bøe 2007, Jørgensen et al 2007) linked to a high risk of injuries (cattle: Menke et al 1999, Menke et al 2000). When additional spatial structure e.g. platforms, is offered positive effects on feeding, resting and agonistic behaviour were observed, i.e. feeding bouts were longer, fewer feeding and resting bouts were interrupted and aggression level was lower (Simantke et al 1997, Andersen and Bøe 2007, Aschwanden et al 2009a, Aschwanden et al 2009b, Ehrlenbruch et al 2010), indicating the importance of spatial structure for goats. Social stress and its implications are affecting welfare, health and performance of animals adversely (Stookey and Gonyou 1994, Hasegawa et al 1997, Schwarz and Sambraus 1997, Tuchscherer et al 1998, Andersen et al 1999, de Groot et al 2001, Raussi et al 2005, Bøe et al 2006, O´Driscoll et al 2006, Andersen and Bøe 2007, Fernandez et al 2007, von Keyserlingk et al 2008).

In order to minimise the risk of injuries on pen mates (Al-Sobayil 2007) some farmers in intensive dairy goat production focus on farming animals without horns (due to genetics or by human intervention). Further, in housed conditions horned goats are often associated with problems in the milking parlour and at the feeding rack (Mowlem 1988). Farmers also report that horned goats get stuck in fences and even strangle themselves. Yet there are other farmers preferring horned animals due to aesthetic and personal preferences (von Korn et al 2007), practising successful farming.

Horns in cattle, sheep and goats are special adaptations of the integument (skin). The os frontale forms the processus cornualis, which is the basis component of horns. In goats and sheep the processus cornualis is first formed as an isolated periosteal bone core, i.e. a secondary ossification centre, which is connected to the os frontale later in life (Habermehl 2005). The area of horn production is the corium, which encloses the processus cornualis (Gall 2001). Before the connection process takes place the processus cornualis including the horn producing cells is also referred to as horn bud. After about six months the pneumatisation of the processus cornualis begins, leading to a mostly hollow and aeriferous structure of the processus cornualis with increasing age and at that time the sinus frontalis is also expanding into the processus cornualis (Habermehl 2005).

Cattle, sheep and goats without horns can be either polled (genetically hornless), disbudded or dehorned. All animals without horns (genetically or by human intervention) will be referred to as hornless in this thesis. Disbudding describes the removal of horn buds, while dehorning is defined as the removal of horns including the processus cornualis after the connection process has taken place and the sinus frontalis is expanding in to the processus cornualis. Consequently the sinus frontalis is opened when cattle, sheep and goats are dehorned. If the horn and the processus cornualis but not the corium is removed, horns will resume growing (Hoffsis 1995, Gall 2001). Horn buds can be removed by chemical substances (caustic paste or acid) or application of heat (hot iron devices) destroying the horn producing cells, whereas methods applied in dehorning (e.g. horn shears, barnes dehorners, cutting wire) mostly used in cattle, excise them (Bengtsson et al 1996).

In cattle a number of studies have focussed on animals' reactions involved in disbudding and dehorning procedures with or without alleviation of pain (Stafford and Mellor 2005 a review). Physiologic, neuroendocrine and behavioural responses indicating pain and distress were observed during all disbudding/dehorning procedures irrespective of pain alleviation (Stafford and Mellor 2005). Severe complications have been described in cattle (Williams 1990, Smith and Sherman 1994, White 2004, AVMA 2010), e.g. caustic paste is able to destroy the calvarium underlying the horn bud, allowing bacteria to penetrate the brain (Smith and Sherman 1994), while insufficient application of heat may lead to scar formation and excessive burning to meningitis (Williams 1990, White 2004).

In goats the dehorning of adult animals (Mobini 1991), and the disbudding of young goat kids is very critical, and complications can lead to even more serious consequences than in cattle. This is due to anatomic differences between goats and cattle such as large horn buds relative to head size, a thin os frontale, not yet developed frontal sinuses and consequently the cranial cavity being directly located below the horn bud and corium. These differences in anatomy favour brain damage in goats due to penetration of the os frontale, inflammation of the meninx and the occurrence of sinusitis, goat kids are also reported to die of disbudding complications (Trautwein 1994, Koller 2000, Gloning in press). If the horn producing cells are not removed completely during disbudding, which is more often observed in males as these cells are covering an even larger area than in females, distorted horns (scurs) will regrow (Gall 2001). According to farmers, distorted horns can grow towards the head of the animal and have to be regularly cut to prevent them from growing into the animal's scull. During disbudding/dehorning nerves are inevitably damaged and destroyed, which may result in neuroma (tumour growth of nerve cells and fibres occurring at the end of an injured nerve fibre), associated with chronic pain (Anthony et al 2005) and/or paraesthesia (numbness, tingling, pricking, burning of the skin without an objective cause). Neuroma have been reported to develop after beak trimming in poultry (Breward et al 1985), tail docking in pigs (Simonsen et al 1991) and cattle (Barnett et al 1999, Eicher et al 2006). Therefore goats may also experience chronic pain and paraesthesia as long term effects after disbudding and dehorning procedures, respectively.

As horns are inherited with polledness being dominant (Long and Gregory 1978), breeding of polled livestock has often been discussed as an alternative to disbudding and dehorning. In goats, however, selecting and breeding toward polledness is associated with fertility problems in both sexes (Schneeberger and Stranzinger 2003). In homozygous polled animals a section in the DNS is missing, disturbing the function of genes controlling the development of sexual organs. This results in infertile males, due to tormentum seminis and females being born with male sexual organs (hermaphrodites), being also infertile (Pailhoux et al 2001). These fertility problems are observed in 25% of the offspring, if both mating partners are polled (genetically hornless). Therefore either the male or female has to be horned, to obtain fully fertile offspring (Schneeberger and Stranzinger 2003). Due to this effect selecting and breeding polled goat herds is not a favourable option in dealing with the presence of horns.

As disbudding and dehorning is very critical and associated with high risks in goats, and breeding toward polled goat herds is linked with fertility problems, the farming of horned animals, as well as differences in e.g. behaviour between hornless and horned herds are going to be a much discussed subject. Goat research on presence of horns by comparing hornless and horned goat herds/individuals, was mainly done in experimental settings by comparing hornless and horned individuals (Aschwanden et al 2008b, Aschwanden et al 2009b) and small herds with a group size of maximum nine goats (Müller 2006, Aschwanden et al 2008a, Aschwanden et al 2009a). Loretz et al (2004) investigated small groups of hornless and horned goats (group size ten individuals) in an on-farm situation and to my knowledge only Keil and Sambraus (1996) observed large groups of horned and hornless goats (group size 100 individuals) in an on-farm location. According to Loretz et al (2004) hornless goats maintained larger distances at the feeding rack than horned ones, contradicting Aschwanden et al (2008a), who did not find any influence of presence of horns on social distances. Feeding bouts were longer in hornless goats, distances among lying animals and duration of lying, however, did not differ between hornless and horned animals (Loretz et al 2004, Aschwanden et al 2009a). Regarding agonistic behaviour during feeding and lying periods no effect of horns could be proved (Loretz et al 2004). Basic activity, milking order and distribution in the barn took place irrespective of presence of horns (Keil and Sambraus 1996). Heart rate and heart rate variability in different feeding situations and during social separation also did not differ between hornless and horned animals (Aschwanden et al 2008b).

As already mentioned housing conditions in intensive dairy goat farming are possibly leading to social stress and tension in herds. This development is likely to affect low ranking animals more than high ranking ones, as dominant individuals are gaining prior access to limited resources (Barroso et al 2000). The consequences of intensive farming may be even more severe for subordinate horned goats, due to a stricter dominance hierarchy in horned compared to hornless goats (Keil and Sambraus 1996), possibly resulting in larger differences between dominance classes (low, middle, high) in horned herds (Loretz et al 2004). Whether hornless and horned herds are actually experiencing different levels of social stress under alike conditions remains unclear and has not been investigated yet.

Another side effect of intensification of dairy goat farming among limited resources and missing spatial structure is the mixing of (unfamiliar) animals leading to instability in herds. For example during lactation animals are grouped according to milk yield allowing feeding due to performance. During mating season regrouping takes place to ensure selective mating, avoid inbreeding and also improve performance influenced by genetics. In dairy cattle and dairy goat farming calves and goat kids are reared separately from their mothers, due to economic reasons, and are introduced into the adult herd again after several years or months of separation either during pregnancy or lactation. As farm animals are social species forming a dominance hierarchy within the group (Addison and Baker 1982, Bogner and Grauvogl 1984, Keil and Sambraus 1996, Barroso et al 2000, Coté and Festa-Bianchet 2001) introducing new members into a herd disrupts the social structure and requires the establishment of new dominance relationships. The latter leads to an increase of agonistic behaviour (goats: Addison and Baker 1982, Alley and Fordham 1994, Fernandez et al 2007, Andersen et al 2008; cattle: Kondo et al 1984, Hasegawa et al 1997, von Keyserlingk et al 2008; pigs: Meese and Ewbank 1973, Jensen 1994) and thus higher risk of injuries (cattle: Menke et al 1999, Menke et al 2000). Regrouping also leads to lower milk production in goats (Fernandez et al 2007), reduced growth (Stookey and Gonyou 1994) and suppressed immune response in pigs (Tuchscherer et al 1998, de Groot et al 2001). These reactions point toward higher levels of social stress (e.g. Bøe et al 2006, Jørgensen et al 2007) when regrouping takes place.

The level of stress during integration, however, may depend on different animal-related and management factors. Regarding animal-related factors the early social environment and previous social experiences may influence the way animals deal with regrouping situations and encounters with unfamiliar animals. Research in cattle indicates differences between artificially reared animals and those raised by their mothers with respect to social behaviour and their position within the dominance hierarchy later in life (Le Neindre 1991). Regarding management, the number of introduced animals affected aggression toward introduced heifers and behavioural signs of stress of introduced heifers (Knierim 1999, Menke et al 2000). Different reproduction stages (pregnancy, lactation) may also affect responses, due to a different hormonal status in pregnancy and lactation, respectively (Gall 2001). Hormones are a major mechanism ensuring coordination between individuals (Adkins-Regan 2005) influencing, among other factors, social behaviour (Hurnik et al 1975). Schwarz and Sambraus (1997) reported on an observation in one dairy goat herd where social agonistic interactions were more frequent when one group of young goats was introduced into a herd during pregnancy compared to a group introduced after parturition. Some dairy goat farmers, as well as dairy farmers, report reduced fights when grouping animals shortly after parturition compared to other reproduction stages.

In general social stress and its implications, which may be experienced by animals in intensive production systems, are affecting welfare, health and performance of animals adversely as described earlier. Therefore it should be of paramount importance for farmers to reduce social stress in their animal herds by adequate management in general, e.g. providing additional structure and considering the timing of introducing unfamiliar animals into already existing herds.

In order to increase welfare in Austrian farm animals the disbudding of dairy goats was prohibited by the animal protection act (BGBl.II 485/2004) as from January 2005. This caused major discussions among goat farmers, due to expected problems of housing horned animals as explained earlier. Scientific data on social behaviour and housing conditions in goats is rather scarce and has mostly been carried out in small groups and in experimental set ups. Currently there is no research on social stress and injuries and their influencing factors in large herds of dairy goats. As the dairy goat sector is moving towards intensification and animals are likely to be kept in large groups, knowledge on relations between social behaviour, environment and injuries is of paramount importance. As scientific data on this subject was (partly) incomplete and assumptions regarding the farming of horned animals were not based on objective and quantified data, the government responded by modifying the animal protection act and allowing the disbudding of female goats under certain conditions until the 31st of December 2010 (amendment of animal protection act BGBl. 530/2006).

Contemporarily a research project (Housing of horned and hornless dairy goats in large groups, project number 100191) was started at the University of Veterinary Medicine, Vienna, Austria in cooperation with the University of Natural Resources and Life Sciences, Vienna, Austria; Institute of Organic Farming (Johann Heinrich von Thünen Institute, Federal

Research Institute for Rural Areas, Forestry and Fisheries), Trenthorst, Germany; Leibniz Institute for Farm Animal Biology, Dummerstorf, Germany and Agroscope Reckenholz-Tänikon Research Station, Tänikon, Switzerland. The aims of this project were to gather scientific and quantitative information on social stress and injuries in hornless and horned dairy goats and identify how social stress and injuries are linked with housing conditions and presence of horns. Furthermore economic data regarding finances and labour in hornless and horned groups of dairy goats was collected. Results of this project should provide a sound basis for advising and decision making in relation to farming hornless and horned dairy goats considering animal welfare.

This doctoral thesis formed part of the research project (project number 100191) investigating social stress in large groups of hornless and horned dairy goats under the same housing and management conditions in an on-farm situation. Parameters indicating social stress, i.e. behavioural (social behaviour, feeding, standing and lying activity, feeding place occupation) and physiological parameters (adrenocortical activity measured by faecal cortisol metabolites and milk cortisol), as well as body condition and injuries were analysed.

Changes in housing conditions toward the natural habitat of goats, e.g. additional spatial structure provided by platforms, may attenuate and eliminate, respectively, possible differences between hornless and horned groups. As several studies found positive effects of structural modifications on feeding, lying and social behaviour (Simantke et al 1997, Andersen and Bøe 2007, Aschwanden et al 2009a, Aschwanden et al 2009b, Jørgensen and Bøe 2009, Ehrlenbruch et al 2010) resting platforms were additionally installed and the parameters described above were compared between groups of hornless and horned goats.

Furthermore it was the aim to gather information on a common procedure in dairy goat farming, i.e. introducing young goats into an already existing herd of adult goats. As described earlier kids are reared separately from adult animals on most dairy goat farms and are introduced into the adult herd again after several months of separation, leading to social stress in animals. Previous studies have described how adverse effects of mixing animals can be reduced by management (Le Neindre 1991, Schwarz and Sambraus 1997, Knierim 1999, Menke et al. 2000). The present experiment focused on different times of introduction and rearing methods in relation to social stress reduction for introduced animals. Young dairy goats were introduced into a herd of adult dairy goats either during the dry period of the herd (i.e. both young and adult goats in the herd being pregnant) or after parturition (i.e. all animals were with their kids). The introduced animals had been reared differently, either artificially or with their mothers. Animals used for this experiment were mainly horned. Behavioural (social behaviour, feeding, standing and lying activity, neighbours) and physiological reactions (adrenocortical activity measured by faecal cortisol metabolites), as well as body condition and injuries of introduced animals were recorded.

The general aim of this thesis was to investigate potential sources causing social stress in dairy goats, as for example the presence of horns and mixing of unfamiliar animals. Furthermore options to reduce social stress and thus improve dairy goat husbandry should be provided.

2 Influence of presence of horns and additional resting platforms on behaviour, adrenocortical activity, body condition and injuries in large groups of hornless and horned dairy goats

2.1 Introduction

In intensive dairy goat farming the majority of animals are hornless (genetically or by human intervention), as the farming of horned goats is often considered critical regarding injuries to pen mates (Al-Sobayil 2007). In housed conditions horned goats are often associated with problems in the milking parlour and feeding at the rack (Mowlem 1988) and are more likely to destroy facilities (Al-Sobayil 2007). Furthermore it is assumed that in horned herds low ranking animals are exposed to higher levels of social stress than in hornless ones, due to a stricter dominance hierarchy in horned herds (Keil and Sambraus 1996, Loretz et al 2004). The housing of horned goats is a much debated issue among farmers. Research on behaviour and physiological parameters comparing hornless and horned goat herds, however, is scarce and was mainly performed in experimental set ups with individuals (Aschwanden et al 2008b, Aschwanden et al 2009b) or small groups with up to nine individuals, respectively, (Müller 2006, Aschwanden et al 2008a, Aschwanden et al 2009a). Loretz et al (2004) investigated small groups of hornless and horned goats (group size ten individuals) in an on-farm situation, to my knowledge only Keil and Sambraus (1996) observed large groups (group size 100 individuals) in an on-farm situation.

According to research hornless and horned animals differed in feeding behaviour, with hornless goats maintaining larger distances at the feeding rack than horned ones (Loretz et al 2004) contradicting Aschwanden et al (2008a), who did not find any influence of presence of horns on social distances at the feeding rack. In her study relations between animals (amicable, neutral or antagonistic) and age of grouping (kids or adults) affected freely chosen distances at the feeding rack (Aschwanden et al 2008a). Feeding bouts were longer in hornless goats (Loretz et al 2004, Aschwanden et al 2009a). Distances among lying animals and duration of lying, however, did not differ between hornless and horned goats (Loretz et al 2004, Aschwanden et al 2009a). According to Loretz et al (2004) agonistic behaviour during feeding and lying periods was not affected in an on-farm situation by presence of horns, contradicting results of Aschwanden et al (2009a) in an experimental setting. Aschwanden et al (2009a) tested effects of different housing situations by comparing original versus enriched versus restored situations. Results show that horned goats were less often receiving displacements when resting in enriched and restored situations than hornless goats (Aschwanden et al 2009a). Feeding, standing and resting behaviour, milking order and distribution in the barn took place irrespective of presence of horns (Keil and Sambraus 1996). Baseline cardiac activity (i.e. heart rate and heart rate variability) and cardiac reactivity (differences between baseline and test values) during different feeding situations also did not differ between hornless and horned goats (Aschwanden et al 2008b).

An existing dominance hierarchy could be observed irrespective of horn status, though the ratio of contradictory rank relations was higher in hornless goats than in horned ones, suggesting a less stable rank order (Keil and Sambraus 1996). This supports Loretz et al (2004) mentioning minor differences between dominance classes (low, middle, high) in hornless goats compared to horned goats, possibly due to the missing signalling effect of horns (Sambraus 1978), indicated by distribution patterns of hornless goats at the feeding rack. Müller (2006) found that agonistic interactions without body contact account for 40% (hornless) and 75% (horned), respectively, of the total agonistic behaviour. These results also indicate differences in dominance hierarchies pertaining to presence of horns, as according to Süss and Andreae (1984) stable hierarchies can be maintained by threats.

Whether effects of rank on behavioural and physiological parameters are more pronounced in horned than hornless herds has not been investigated yet.

The consequences of rank, e.g. access to feed and lying space, are likely to be more serious for low ranking animals, due to dominant ones gaining prior access to limited resources (Barroso et al 2000). A more clearly established rank order in horned compared to hornless goats (Keil and Sambraus 1996) and therefore possibly larger differences between dominance classes (low, middle, high) (Loretz et al 2004), may consolidate consequences and social stress in low ranking horned goats.

Rank in general affected feeding and lying behaviours, social behaviour and physiological parameters in goats (Sambraus 1971, Gräser-Hermann 2001, Loretz et al 2004, Andersen and Bøe 2007, Aschwanden et al 2008b, Aschwanden et al 2009a). Feeding and lying times are shorter in low and middle ranking animals compared to high ranking ones (Loretz et al 2004, Andersen and Bøe 2007, Aschwanden et al 2009a). Number of received displacements when feeding or resting was highest in low ranking goats (Aschwanden et al 2009a) and most attractive lying areas were taken by dominant individuals (Sambraus 1971, Gräser-Hermann 2001). Baseline cardiac activity (i.e. heart rate and heart rate variability) was also related to the rank of the animal, with higher levels of heart rate variability and lower levels of heart rate in high ranking goats compared to low ranking ones (Aschwanden et al 2008b). During feeding situations heart rate variability (differences between baseline and test values) was lower in low ranking goats at the far compared to the near feeding distance, yet in high ranking animals lower values at the near than at the far feeding distance were observed (Aschwanden et al 2008b).

The aim of this study is to look at differences between large groups of hornless and horned dairy goats regarding behavioural (social behaviour, feeding, lying and standing activity, feeding place occupation) and physiological parameters (adrenocortical activity measured by faecal cortisol metabolites and milk cortisol), indicating social stress, as well as body condition and injuries in an on-farm situation. Changes in housing conditions toward the natural habitat of goats e.g. additional spatial structure by providing platforms, may attenuate and eliminate, respectively, possible differences between hornless and horned groups. As several studies found positive effects of structural modifications on feeding, lying and social behaviour (Simantke et al 1997, Andersen and Bøe 2007, Aschwanden et al 2009a, Aschwanden et al 2009b, Jørgensen and Bøe 2009, Ehrlenbruch et al 2010) resting platforms were additionally installed and described parameters between groups compared.

The following hypotheses were tested:

- *levels of agonistic interactions in total are expected to be lower in horned goat groups compared to hornless groups, due to a more clearly established dominance hierarchy in horned herds.*
- *levels of agonistic interactions with body contact are also expected to be lower in horned goat groups compared to hornless groups, due to horned low ranking goats respecting social distances of higher ranking goats more.*
- *horned goats are expected to feed at larger distances than hornless goats, due to horned low ranking goats respecting social distances of higher ranking goats more.*
- *horned goats are expected to have more often lower BCS than hornless goats, due to feeding at larger distances and therefore allowing not all horned goats to feed sufficiently.*
- *types of injuries are expected to differ between horned and hornless goats, as horns are causing different types of injuries compared to horn buds (sharp versus blunt trauma) and hornless goats are expected to interact agonistically more often with contact than horned ones.*

- *adrenocortical activity is expected to be higher in low ranking horned than hornless goats, due to dominance classes being more clearly established in horned herds, resulting in low ranking horned animals not gaining sufficient access to resources and therefore increasing stress levels in low ranking horned goats.*
- *differences in parameters between low and high ranking goats are expected to be more distinct in horned groups, due to a more clearly established dominance hierarchy in horned herds and horned low ranking goats respecting social distances of higher ranking goats more.*
- *resting platforms are expected to be used frequently, reduce social conflicts and therefore stress, by offering additional space and allowing especially low and middle ranking animals to retreat from dominant individuals.*

2.2 Methods

2.2.1 Animals, housing and management

The experiment was performed on two commercial dairy goat farms located in Southern Germany from February to July 2008. These two farms were keeping hornless and horned goats in separate groups under similar conditions irrespective of this experiment and were therefore chosen for this study.

On farm1 172 goats formed the lactating herd (German Improved Fawn breed) with average milk yields of 740kg/animal/year (3.7% fat and 3.3% protein) and average age of 5.0±2.7 years (range: one to eleven years). The animals were housed in a deep litter system. Hornless goats were kept in four small groups (86 goats in total) and horned animals in one large group (86 goats) with an elevated feeding area in relation to the feeding platform and metal palisade feed barriers (width 37cm). Space allowances and feeding places per animal were similar but not identical for hornless and horned animals (three small groups: 1.4m², one small group: 1.7m²/animal and feeding places/animal 1.00, 1.04, 1.09, 1.10; large group: 1.6m²/animal and 1.30 feeding places/animal). The four small groups were separated by iron bar elements and each group (small and large) had access to at least one drinking trough and mineral blocks. Animals were fed with hay and silage in the morning and evening after milking (8.00am, 6.00pm) and remaining feed was pushed towards the feed barrier at midday (12.00pm), concentrate was given in the milking parlour (700g/animal/day). Milking took place in the morning and in the evening for about two hours in a twelve aside milking parlour. On this farm milk was produced during winter, therefore mating took place between May and July.

On farm2 150 goats (mixed breed, no data on herd characteristics available) formed the lactating herd, hornless and horned goats were kept in two separate groups of 75 animals each (1.7 m²/animal and 1.30 feeding places/animal). As on farm1 animals were housed in a deep litter system. Feed was provided with a conveyor belt, which was not elevated in relation to the feeding platform, metal palisade feed barriers (width 33cm) separated feeding area and feeding platform. TMR (total mixed ration including hay, silage and water) was fed after milking (8.00am) and concentrate was given in the milking parlour (400g/animal/day). Goats were milked in the morning and evening for about two hours in a rotary milking parlour for 30 animals. On farm2 mating periods (October-December) differed from farm1, due to different periods of milk production. As the experiment took place on farm1 first, goats on farm1 were in their last third of lactation, while goats on farm2 were in mid lactation when being part of the study.

2.2.2 Experimental design

At the beginning of the experiment on farm1 hornless goats were kept in four small groups and horned animals in one large group (Fig. 1). During the experimental period on farm1 two regroupings took place (Tab. 21 in Appendix), with hornless goats being in one large group and the horned ones split into four small groups (first regrouping) and after the second regrouping the initial situation was established again (hornless in four small groups, horned in one large group). Groups always consisted of either only hornless or horned animals. Group composition at the beginning of the experiment and after the second regrouping differed within the small groups.

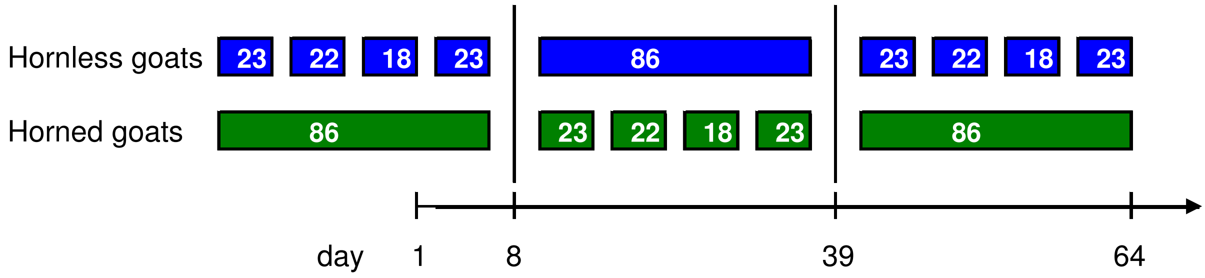

Fig. 1: Experimental design on farm1. Boxes indicate group sizes of hornless and horned goats, numbers in boxes refer to number of animals within each group and time axis refers to beginning (day1), first and second regrouping (day8 and 39) and end of experimental period (day64).

On farm2 five wooden resting platforms were installed in both groups for four weeks: lying area on one platform 0.60x1.80m and on four platforms of 0.60x2.60m each, (see Fig. 2 below and Fig. 3, Tab. 23 in Appendix). According to observations in this study a maximum of 14 animals, i.e. about 20% of the herd (two goats on the shorter platform, three on each of the four longer platforms), could rest on platforms provided in the present study. Group composition did not change throughout the experimental period, with the exception of the death of three horned animals (circumstances unknown), reducing group size of horned goats to 72 individuals. Hornless group size remained 75 animals. As parameters recorded for these three animals were excluded completely from analysis, numbers in Fig. 3 are referring to numbers of goats used for analysis only.

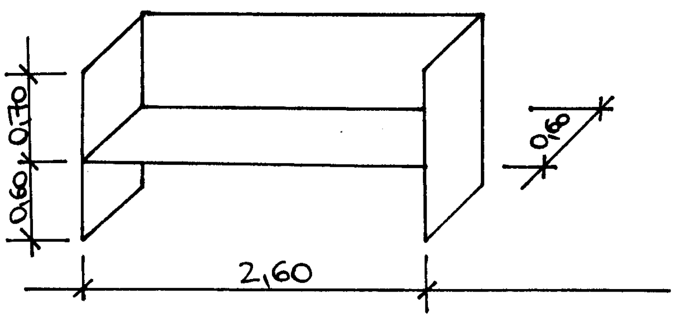

Fig. 2: Resting platforms on farm2, measurements are given in metres.

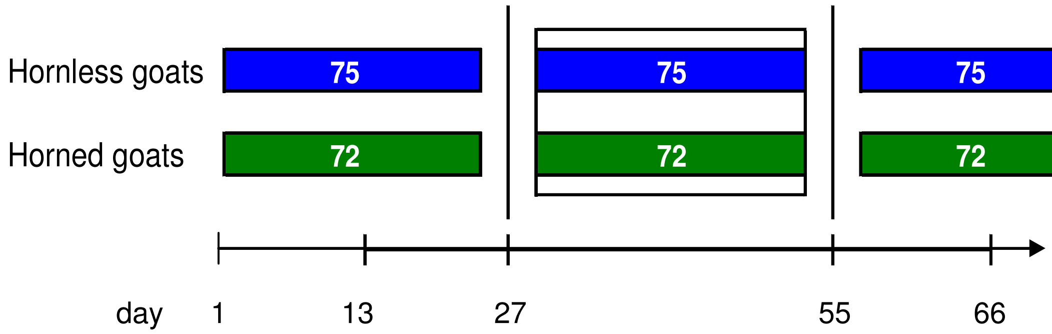

Fig. 3: Experimental design on farm2. Boxes indicate groups of hornless and horned goats, numbers in boxes refer to number of animals within each group and the black line framing green and blue boxes represents the period with resting platforms installed. Time axis refers to beginning (day1) of experimental period, focal animal determination (until day13), installation and removal of resting platforms (day27 and 55) and end of experimental period (day66).

2.2.2.1 Selection of focal animals

For the recording of certain parameters focal animals were chosen on both farms. On farm1 60 focal animals (30 hornless, 30 horned) were selected at random due to a compact time schedule. In the milking parlour every second and third animal, respectively, was chosen as a focal animal and individually marked with different coloured collars and animal markers on their sides and back. Number of focal animals in small groups ranged between six and ten (four small groups either with six, seven (twice) or ten focal animals, i.e. 30 focal animals in total) and in the large group 30 focal goats were chosen. Number of focal animals in small and large group(s) did not change throughout the experimental period.

On farm2 focal animals were chosen according to rank. Calculation of the dominance index (see below) was based on twelve days of direct observation of social agonistic behaviours (for more details see 2.2.3.1) before the experimental period started (Tab. 23 in Appendix). Observations started after feeding (9.00-12.00am, 3.00-5.00pm) and changed in a balanced way between hornless and horned groups by focusing on sections in the pen, where animals were active, i.e. interacting. 60 focal animals (30 hornless, 30 horned, ten lowest, ten middle, ten highest ranking animals) were selected before the experimental period started (Tab. 24 in Appendix). Animals whose dominance index was based on two or less interactions, as well those with injuries such as lameness during the twelve day observation period were not chosen as focal animals (Tab. 24 in Appendix). The dominance index of low ranking animals ranged between 0.00-0.15 (hornless) and 0.00-0.13 (horned), of middle ranking ones 0.33-0.56 (hornless) and 0.31-0.36 (horned) and of high ranking goats between 0.80-1.00 (hornless) and 0.55-0.81 (horned).

To gain information on rank of focal animals chosen at random before the experimental period on farm1, social behaviours observed throughout the experimental period were used to calculate the index of success for these focal animals. The index of success for the ten low ranking animals ranged between 0.05-0.34 (hornless) and 0.09-0.36 (horned), for the ten middle ranking ones between 0.38-0.67 (hornless) and 0.39-0.64 (horned) and for the ten high ranking goats between 0.70-0.92 (hornless) and 0.70-0.94 (horned) on farm1 (Tab. 22 in Appendix).

For better comparability and consistency of certain parameters between farm1 and 2, the index of success, rather than the dominance index was included in analysis on farm2. The index of success for low ranking animals ranged between 0.00-0.13 (hornless) and 0.05-0.13 (horned), for middle ranking ones between 0.29-0.60 (hornless) and 0.25-0.40 (horned) and for high ranking goats between 0.77-1.00 (hornless) and 0.41-0.78 (horned) on farm2 (Tab.

24 in Appendix). Correlations between the dominance index and index of success for focal animals were between r_s+0.830, p=0.000 in the hornless group and r_s+0.853, p=0.000 in the horned one.

For an analysis of parameters the index of success was used, by assigning animals to three dominance classes (low, middle, high) according to their index of success (Tab. 22, Tab. 24 both in Appendix).

Calculation of the dominance index and index of success, respectively, were as follows:

Dominance index = number of subordinate animals/number subordinate animals + number of dominant animals

Index of success = number of successful interactions (actor)/number of successful interactions (actor) + number of successful interactions (receiver)

2.2.3 Behavioural observations

2.2.3.1 Social behaviour

For comparison of hornless and horned groups social behaviour was observed by direct observation in the afternoon on both farms. On farm1 observation times were between 1.00-4.00pm with 128min net observation time and on farm2 between 2.30-5.00pm 64min net observation time for each group (hornless and horned) on 18 days in farm1 and 32 days in farm2.

On both farms observation took place over four observation periods.

On farm1 social behaviour was recorded on five days before first regrouping (1), three days after three weeks of first regrouping (2), five days after four weeks of first regrouping (3), five days after four weeks of second regrouping (4), i.e. in total 18 days (Tab. 21 in Appendix). On farm2 observations took place on eight days before resting platforms were installed (1), eight days immediately after installation of platforms (2), eight days after four weeks of installation of platforms (3) and on eight days after platforms were removed (4), i.e. in total 32 days (Tab. 23 in Appendix).

For observation pens were divided into segments (farm1: twelve feeding places per segment, eight segments in each group; farm2: 23-28 feeding places per segment, four segments in each group) and each segment was observed for eight min. Before and after each observation number of animals within the segment were counted. On farm1 social behaviour in groups of goats was observed in parallel by two people. Observers changed between groups in a balanced way. On farm2, however, observations of groups were done by one person in succession, starting with a different group and segment each day. All behaviours within the respective segments were observed by continuous behaviour sampling. For each interaction actor (goat initiating interaction) and receiver (goat being target of interaction) were recorded. For all agonistic interactions success was noted down, except for ‘clash’ and ‘push’ (see below), which was only recorded when successful and ‘avoid’ (see below), which was only recorded when occurring. An interaction was defined as successful when the receiver left its place after the interaction took place.

The minimum bout length for socio-positive behaviours to be recorded was three seconds, if the behaviour paused for more than ten seconds a new event was recorded. In goats lying with body contact is also considered a socio-positive interaction of high importance (Schino 1998, Tønnesen et al 2008). Recording of this behaviour took place with the observation of basic activity on farm2.

The following agonistic behaviours were recorded:

Butt: A goat hits any part of the body of another goat, except the head, with her forehead/horn base, but without an upward swing.

Horn kick: A goat performs a quick upward swing with her head and hits another one with the end of her horns or - in hornless goats - forehead. All extremities of the other goat stay on the ground.

Lift: A goat performs a quick upward swing with her head and hits the body of another goat with the end of her horns or - in hornless goats - forehead and lifts the receiver partly or totally. At least one extremity of the receiving goat loses contact with the ground.

Stroke: When animals are feeding or standing close interactions of little intensity occur, these are sideways head movements toward the neighbouring goat. In horned animals often only the horns of the involved animals are touching. This movement is similar to a butt or kick due to the proximity of the animals but not as intense.

Bite: A goat bites another one at any part of the body, except the vulva or anus.

Push: A goat pushes another one away from the feeding barrier using her shoulder or neck/head.

Threat: A goat directs her horns, displays another threatening posture, indicates biting, or moves her head or body quickly towards another goat.

Avoid: A goat retreats, if another one is approaching. In case of feeding she leaves her feeding space without any visible agonistic behaviour demonstrated by the approaching goat. The avoiding movement itself can be either slow or fast.

Clash: Both goats face each other and strike forward, making contact either with their horns or - in hornless goats - forehead; the animals may rear onto their hind legs before clashing.

The following socio-positive interactions were recorded:

Lick, nibble: A goat licks or nibbles at the body of another goat, except vulva or anus, using her tongue, teeth or lips.

Rub: Slow cautious rubbing of the head at any body part of another goat, except vulva or anus. The receiving goat does not withdraw.

For further analysis interactions were grouped into the following five classes and all behaviours were converted into interaction/animal and hour and calculated for each observation period and farm:

ago total: sum of butt, horn kick, lift, stroke, bite, push, threat, avoid and clash irrespective of success.

ago with body contact: sum of butt, horn kick, lift, stroke, bite, push and clash irrespective of success.

ago without body contact: sum of threats irrespective of success and avoid.

ago with displacement: sum of butt, horn kick, lift, stroke, bite, push, threat and clash with success and avoid.

ago without displacement: sum of butt, horn kick, lift, stroke, bite, push, threat and clash without success.

positive total: sum of lick, nibble and rub.

2.2.3.2 Basic activity

Basic activity was only recorded on farm2 (Tab. 23 in Appendix). Activities of every focal animal were noted down, while others (i.e. non focal animals) were counted carrying out respective activities.

Basic activity was observed for 48h four times during the experimental period (before resting platforms (1), immediately after installation (2), four weeks after installation (3), after removal of platforms (4)) using scan sampling with ten min intervals between hornless and horned groups, i.e. 20min intervals between scans within respective groups. To be able to observe animals at night lighting in the barn was used and was switched on two days before each observation to allow the animals to adapt.

Behaviour of goats was recorded as either standing, feeding (= head in feeding barrier), lying or lying with contact (= touching of the body of one or more other goats). In the period with resting platforms installed it was noted down in addition, if the basic activity (standing, lying, lying with contact) was performed on top, under resting platforms or in the other area of the pen.

Basic activity of focal animals in the pen or in context with platforms was analysed for the total observation time (48h), for the feeding period (two hours just after TMR was fed) and the night period (9.00pm-5.00am). Standing, feeding and lying, i.e. lying including lying with contact, was calculated for all periods. Lying with contact, i.e. lying with contact only, was calculated for 48h and night periods. Due to relevance and occurrence lying with contact was not looked at in the feeding period (median 0.0% (range 0.0-57)).

For analysis basic activity of every focal animal was calculated in relation to scans of the respective periods, i.e. the number of scans where a focal animal was standing, feeding, lying or lying with contact in the respective period / number of scans for the respective period × 100.

The use of resting platforms was analysed over 48h by looking at activities of all animals (focal and non focal animals) related to resting platforms immediately after installation and four weeks later. The percentage of animals standing, lying and lying with contact on top and under resting platforms per scan was calculated over 48h, i.e. sum of all animals standing, lying, lying with contact on top and under resting platforms per scan / total number of animals per scan × 100.

Individual use of resting platforms was based on activities of focal animals only related to platforms immediately after installation and four weeks later in relation to scans over 48h periods, i.e. the number of scans where a focal animal was standing, lying, lying with contact on top and under resting platforms over 48h / number of scans over 48h × 100.

2.2.3.3 Feeding place occupancy

The observation of feeding place occupancy was linked to the collection of data on social behaviour on farm2 on 32 days throughout the experimental period (Tab. 23 in Appendix), by using scan sampling. For this purpose it was noted down which feeding place was empty or occupied, respectively, in hornless and horned groups. Feeding place occupation was noted down six times after feeding per group throughout the day (time after feeding: immediately, five min and ten min after fresh feed was provided (0), 1h (1), 4h (4) and 5h (5) later).

For further analysis the occurrence of 0, 1, 2 and ≥3 empty feeding places between individual goats were counted and related to the total number of animals feeding, i.e. number of empty feeding places (0, 1, 2 and ≥3) per scan / number of animals feeding per scan × 100. For the first observations (immediately, five and ten min after fresh feed was provided) means for empty feeding places (0, 1, 2 and ≥3) were calculated. Scans with less than ten animals feeding and days with irregularities in feeding were excluded leaving 28 days and 131 scans in total for analysis. For descriptive analysis median, minimum and maximum of goats feeding at different times after fresh feed was given (0, 1, 4, 5h) were calculated for each of these 28 days.

2.2.4 Body condition and injuries

Goats were examined three times during the experimental period on farm1 (before first regrouping (1) and four weeks after first and second regrouping (2 and 3)) and four times on farm2 (before resting platforms (1), one and four week(s) after installation of platforms (2 and 3) and after removal of platforms (4)), (Tab. 21, Tab. 23 both in Appendix).

Body condition score (BCS ranging from 1 to 5) was taken from the lumbar spine (BCS lumbar) and sternum (BCS sternal) (Hervieu and Mohrand-Fehr 1999) on focal animals only.

With injuries, the inspection of goats was divided into examination of the abdominal side including the udder (examination abdomen) and the rest of the body including head, back and body sides (examination body). The abdominal side and udder were only examined on focal animals and visually inspected by using a hand mirror and a torch. The rest of the body was examined on all animals, visually inspected and manually scanned (palpation).

In the case of occurrence of injuries a description of the type of injury was recorded:

- type of injury: crust, deep lesion, scar, swelling, callus
- size: >3cm, 1-3cm, <1cm
- shape: horizontal, vertical, v/l shaped, circular, punctual
- location:
  examination abdomen: thorax (ventral), abdomen (ventral), udder
  examination body: head, horn base, ears, neck, thorax (dorsal), abdomen (dorsal), pelvis, tail, front and hind limbs.

For further analysis the following classes of injuries were calculated:

Injuries udder (total): sum of crust, deep lesion, scar and swelling at the udder irrespective of size and shape.

Injuries body (total): sum of crust, deep lesion, scar, swelling and callus irrespective of size, shape and location found in examination body.

In examination abdomen injuries were only found at the udder, therefore only injuries at the udder were analysed. Frequency of injuries was pooled into four categories, summarizing number of injuries per animal (0- no injuries, 1- one or two injuries, 2- three to five injuries, 3- six to ten injuries, 4- eleven to 30 injuries). For statistical analysis of injuries throughout the total experimental period results on examinations for individual animals were summed up, i.e. each animal was counted three times (farm1) and four times (farm2), respectively.

2.2.5 Adrenocortical activity

The analysis was based on faecal and milk samples of focal goats taken during evening milking on both farms between 5.00-7.00pm. Samples were taken on two successive days four times on each farm. Sampling periods were in accordance with observation periods on both farms (Tab. 21, Tab. 23 both in Appendix) (farm1: before first regrouping (1), three weeks after first regrouping (2), four weeks after first regrouping (3) and four weeks after second regrouping (4); farm2: before resting platforms (1), one week after installation (2), four weeks after installation (3) and after removal of platforms (4)). For faecal samples about 1g was taken rectally and stored at -20℃ after samples of all goats were collected. Samples were later thawed and after an extraction procedure (0.5g faeces with 5ml of 80% methanol (Palme and Möstl 1997)) the concentration of cortisol metabolites was determined using a group specific 11-oxoaetiocholanolone enzyme-immunoassay (EIA), first described by Möstl et al (2002). This EIA has been successfully validated for measuring adrenocortical activity in goats (Kleinsasser et al 2010).

Concentrations of cortisol in foremilk and composite milk seem to be highly correlated, yet cortisol flux may differ between these two compartments (Verkerk et al 1998). Therefore composite milk (6ml) was collected for analysis of milk cortisol and deep frozen. Samples were later thawed and centrifuged, 500µl skimmed milk per sample were extracted with 5ml diethyl-ether and dissolved in 0.5 assay puffer. Thereafter, cortisol concentration was determined using an enzyme-immunoassay (Palme and Möstl 1997).

2.2.6 Statistical analyses

Social behaviour was analysed for differences between hornless and horned groups with univariate variance analysis (UNIANOVA) together for both farms as frequency of social interactions was available only on a group level. Farm (1, 2), group (hornless, horned) and farm*group were used as fixed factors. For each of the social behavioural classes (ago total, ago with body contact, ago without body contact, ago with displacement, ago without displacement, positive total) four values per farm (frequency of interactions/animal and hour in each of the four observation periods) were included.

Basic activity, cortisol metabolites in faeces and cortisol in milk were available for focal animals on an individual goat level and were thus analysed for each farm separately with a general linear mixed model (GLMM) (PASW Statistics 17.0). Basic activity data were available only for farm2. In the model for basic activity, group (hornless, horned), observation period, dominance class (low, middle, high), group*observation period, group*dominance class were included as fixed factors. The focal animal within the respective group was chosen as a random effect. Observation period on farm2 refers to before resting platforms (1), immediately after installation (2), four weeks after installation (3) and after removal of platforms (4). The model for cortisol (metabolites) on farm1 included group, sampling period, dominance class, group size (small, large) and group*dominance class as fixed effects, the focal animal within the respective group as a random effect and day of sampling was included as a repeated measure. Age and day of lactation were used as covariates. Sampling period on farm1 refers to before first regrouping (1), three weeks after first regrouping (2), four weeks after first regrouping (3) and four weeks after second regrouping (4). The model for cortisol (metabolites) on farm2 included group, sampling period, dominance class, group*sampling period, group*dominance class as fixed effects, the focal animal within the respective group as a random effect and day of sampling was included as a repeated measure. Sampling period on farm2 refers to before resting platforms (1), one week after installation (2), four weeks after installation (3) and after removal of platforms (4).

On farm2 feeding place occupancy was recorded and analysed with a general linear model (GLM) including group, observation period, group*observation period and time after feeding (0, 1, 4, 5h after feed was offered).

Not significant random effects and interactions were step by step excluded (random effects $p>0.05$, interactions $p>0.1$). Residuals were checked graphically for normal distribution, homogeneity of variance and outliers. In order to fulfil essential criteria in residuum analysis data was transformed where necessary.

Whether groups differed in body condition (BCS lumbar and sternal) and classes of injuries (injuries body (total), injuries udder (total)) throughout the experimental period was tested in cross classified tables with a Chi^2 test after Pearson (≥80% of cells expecting numbers >5) or Fisher exact test (≥80% of cells expecting numbers >5), respectively. Standardized residua were used to determine cells differing significantly (standardized residuum ≥ $|1|$). In case of differences throughout the experimental period ($p<0.05$) body condition and classes of injuries were analysed for observation periods. Single type of injuries pooled into classes of injuries were analysed also separately in case of differences in the class variable ($p<0.05$).

2.3 Results

2.3.1 Social behaviour

Statistical analysis for all agonistic behavioural classes indicated no significant influence of farm ($p>0.05$, Tab. 1). Socio-positive interactions, however, were more often observed on farm1 than 2 (positive total $p<0.05$, Fig. 4, Tab. 1).

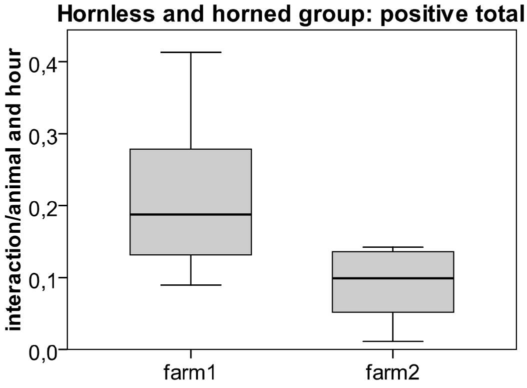

Fig. 4: Frequency of socio-positive interactions on farm1 and 2 in the hornless and horned group given in interaction/animal/hour, based on observed data, N=2.

Hornless goats were interacting more often agonistically (ago total, $p<0.05$), more often without body contact (ago without body contact, $p<0.05$), and without displacement (ago without displacement, $p<0.05$, Tab. 1, Fig. 5). Hornless animals also tended to interact more often with body contact than horned ones (ago with body contact, $p=0.062$, Fig. 5). Other behavioural classes were not affected by presence of horns ($p>0.05$, Tab. 1). The interaction farm*group was included in the model but did not influence behavioural classes ($p>0.1$) therefore p-values and F-values are not shown in Tab. 1.

Tab. 1: Results of UNIANOVA for social behaviour. P-values and F-values are given for fixed variables farm (1, 2) and group (hornless, horned). Transformations performed with response variables for statistical analysis are indicated in brackets, N=2.

	Farm		group	
behavioural class	F-value	p-value	F-value	p-value
ago total (LG10)	0.408	0.534	8.398	**0.012**
ago with body contact	1.400	0.257	4.160	*0.062*
ago without body contact (LG10)	0.048	0.831	11.211	**0.005**
ago with displacement (LG10)	0.584	0.458	0.854	0.372
ago without displacement (LG10)	1.000	0.335	20.545	**0.001**
positive total (LG10)	7.860	**0.015**	0.003	0.958

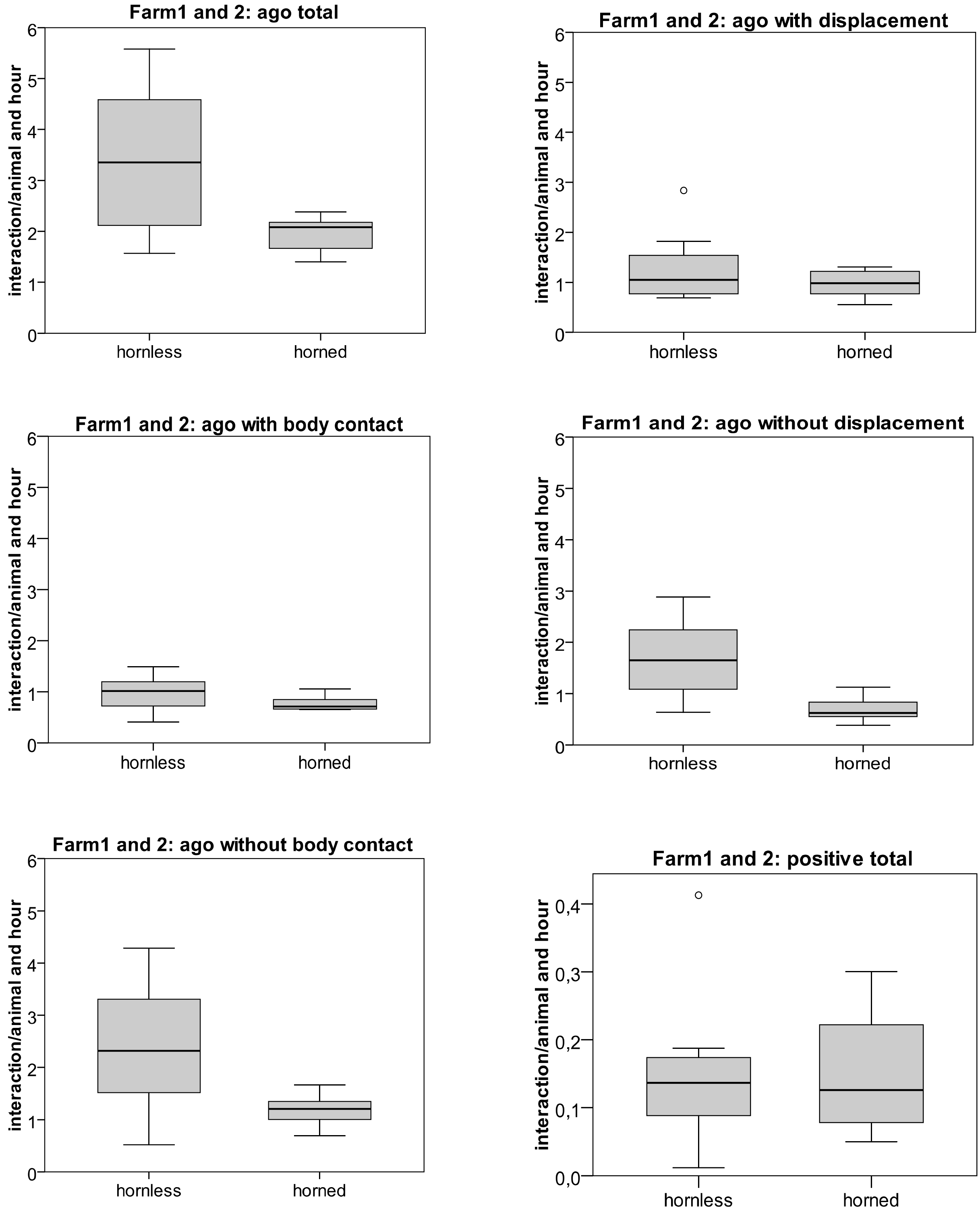

Fig. 5: Frequency of behavioural classes on farm 1 and 2 in the hornless and horned group given in interaction/animal/hour, based on observed data, N=2.

2.3.2 Basic activity and use of resting platforms

Basic activity was only recorded on farm2. The variables group, i.e. presence of horns, and dominance class according to group affected most parameters, except standing and lying over 48h and lying at night. All basic activities, but lying over 48h differed throughout the observation period (Tab. 2, Fig. 6, Fig. 7, Fig. 8).

Analysis of **feeding** during 48h observations showed that the interaction of group*dominance class affected this parameter ($p<0.05$, Fig. 9). The percentage of scans where animals were feeding was higher in the hornless group than in the horned group assigned to the low dominance class. In the high dominance class, however, the opposite was observed, with higher levels of feeding in horned than hornless goats ($p<0.05$, Fig. 9). two hours after fresh feed was given, there was also an interaction between group and dominance class according to analysis of data. Percent of scans with animals feeding was highest in the hornless group of the low dominance class and lowest in the high dominance class, while in the horned group this was reversed ($p<0.05$, Fig. 9), being comparable to feeding over 48h. At night no interaction of group*dominance class for feeding activity was found, but percentage of scans with animals feeding was higher in the low dominance class compared to the high dominance class ($p<0.05$, Fig. 8). Yet at night there was an interaction tendency between group and observation period ($p=0.056$, Tab. 2). Percent of scans where feeding was observed was lowest in hornless goats before installation of platforms (period1) and after they had been available for four weeks (period3), in horned goats lowest levels were also seen in the first period, but not in the third one (Tab. 3). Over 48h and two hours after fresh feed was given feeding activities differed according to observation period ($p<0.05$, Tab. 3), with slightly alternating levels over 48h, but no clear development could be seen across periods. Percent of scans with goats feeding after fresh feed was given, however, was lowest immediately after installation of platforms (period1) and highest before and four weeks after installation (period3 and 4) (Tab. 3).

Regarding **standing** activity, levels tended to be higher in the hornless group compared to the horned group at night ($p=0.089$, Fig. 7), while no effect of presence of horns was seen in 48h periods ($p>0.05$, Tab. 2). The interactions of group*dominance class and group*observation period did not affect standing activity in 48h and night periods ($p>0.05$, Tab. 2), yet two hours after fresh feed was given group*dominance class affected standing levels in tendency ($p=0.063$, Fig. 9). Percent of scans with animals standing was lower in hornless goats assigned to the low and middle dominance class than in horned goats, with larger differences between groups in the middle dominance class. In the high dominance class no difference between hornless and horned goats was seen. Regarding the interaction group*observation period ($p<0.05$, Tab. 3) higher levels of standing were seen in the horned group compared to the hornless one after platforms had been available for four weeks (period3). Other periods did not differ. Percentage of scans with goats standing was influenced at night periods and in tendency at 48h periods by observation period only ($p=0.064$ (48h), $p<0.05$ (night), Tab. 2). Over 48h standing activity tended to vary somewhat across observation periods, but no clear development could be seen ($p=0.064$, Tab. 3), at night, however, levels increased toward the end of the observation period ($p<0.05$, Tab. 3).

According to analysis of **lying** activity, i.e. lying including lying with contact, no effect of presence of horns (group) was found at 48h and night periods ($p<0.05$). The interactions group*observation period and group*dominance class did not affect lying activity in these periods ($p<0.05$, Tab. 2). In the feeding period, however, percentage of scans with animals lying was influenced by the interaction group*dominance class. In the hornless group levels increased with dominance class, with lowest levels in the low dominance class and highest levels in the high dominance class ($p<0.05$, Fig. 9). In the horned group, however, lying activity did not change across classes. Levels of lying activity at night were increasing with dominance classes ($p<0.05$, Fig. 8), being in accordance with results on hornless goats at feeding periods. Percent of scans with goats lying after fresh feed was given differed in tendency, in groups across the observation period (group*observation period $p=0.064$, Tab. 3). In the hornless group levels were highest immediately after installation of platforms (period2) and lowest after they had been available for four weeks (period3), while levels before and after platforms were similar (period1 and 4); in the horned group, however, levels did not differ across the observation period (Tab. 3). At night percent of scans where goats were lying decreased toward the end of the observation period, with highest levels before installation of resting platforms (period1) and lowest ones after removal of platforms (period4) ($p<0.05$, Tab. 3).

Regarding **lying with contact**, i.e. lying with contact only, this parameter was analysed for 48h and night periods, but not after feeding due to relevance and occurrence (two hours after fresh feed was given median 0.0% (0.0-57)). Results for analysed periods show that the interaction group*dominance class tended to affect 48h ($p=0.062$) and night periods ($p=0.090$, Tab. 2). Percent of scans with goats lying with contact over 48h was higher in hornless than horned goats assigned to the low dominance class, while in the middle dominance class the opposite was recorded. Differences between groups in the high dominance class were minor, with slightly higher levels in hornless goats compared to horned ones over 48h (Fig. 9). Results on lying with contact at night are in line with 48h observations, except that levels between groups did not differ in the high dominance class (Fig. 9). Levels of lying with contact over 48h and at night were also influenced by observation period ($p<0.05$, Tab. 3), with lower levels when resting platforms were available (period2 and 3) over 48h (Tab. 3), percentage of lying animals, however, was not affected by observation period ($p>0.05$, Tab. 2). At night levels of lying with contact decreased by half immediately after resting platforms were installed (period2), being in line with results over 48h periods, after platforms had been available for four weeks (period3), however, levels returned to before installation level (Tab. 3). Highest levels of lying with contact at night were observed after platforms were removed (Tab. 3). Lying activity at night differed also during observation periods, as already described, but levels are not in line with lying with contact ($p<0.05$, Tab. 3).

Tab. 2: Results of the GLMM analysis for basic activity on farm2. P-values and F-values are given for fixed variables group (hornless, horned), observation period (before resting platforms (1), immediately after installation (2), four weeks after installation (3), after removal of platforms (4)), dominance class (low, middle, high) based on the index of success and the interactions group*observation period and group*dominance class (if p<0.1). Lying with contact was not analysed for the feeding period, due to low occurrence. Transformations performed with response variables for statistical analysis are indicated in brackets, N=120.

	F-value	p-value	F-value	p-value	F-value	p-value	F-value	p-value
48h	feeding		standing (LG10)		lying		lying with contact (SQRT)	
group	0.312	0.579	1.133	0.292	2.379	0.129	0.002	0.963
observation period	13.693	**0.000**	2.466	*0.064*	1.973	0.120	21.871	**0.000**
dominance class	0.249	0.780	0.486	0.618	1.072	0.349	4.070	**0.023**
group*observation period	-	-	-	-	-	-	-	-
group*dominance class	10.016	**0.000**	-	-	-	-	2.937	*0.062*
feeding	feeding		Standing		lying		lying with contact (SQRT)	
group	0.800	0.375	6.176	**0.016**	0.960	0.332	-	-
observation period	23.643	**0.000**	9.224	**0.000**	3.587	**0.014**	-	-
dominance class	0.593	0.556	3.403	**0.041**	1.120	0.334	-	-
group*observation period	-	-	3.616	**0.013**	2.436	*0.064*	-	-
group*dominance class	10.506	**0.000**	2.904	*0.063*	4.677	**0.013**	-	-
night	feeding (SQRT)		standing (SQRT)		lying		lying with contact (SQRT)	
group	14.339	**0.000**	3.003	*0.089*	2.301	0.135	0.482	0.490
observation period	10.316	**0.000**	16.190	**0.000**	18.176	**0.000**	17.208	**0.000**
dominance class	10.198	**0.000**	0.985	0.380	8.005	**0.001**	2.470	*0.094*
group*observation period	2.546	*0.056*	-	-	-	-	-	-
group*dominance class	-	-	-	-	-	-	2.514	*0.090*

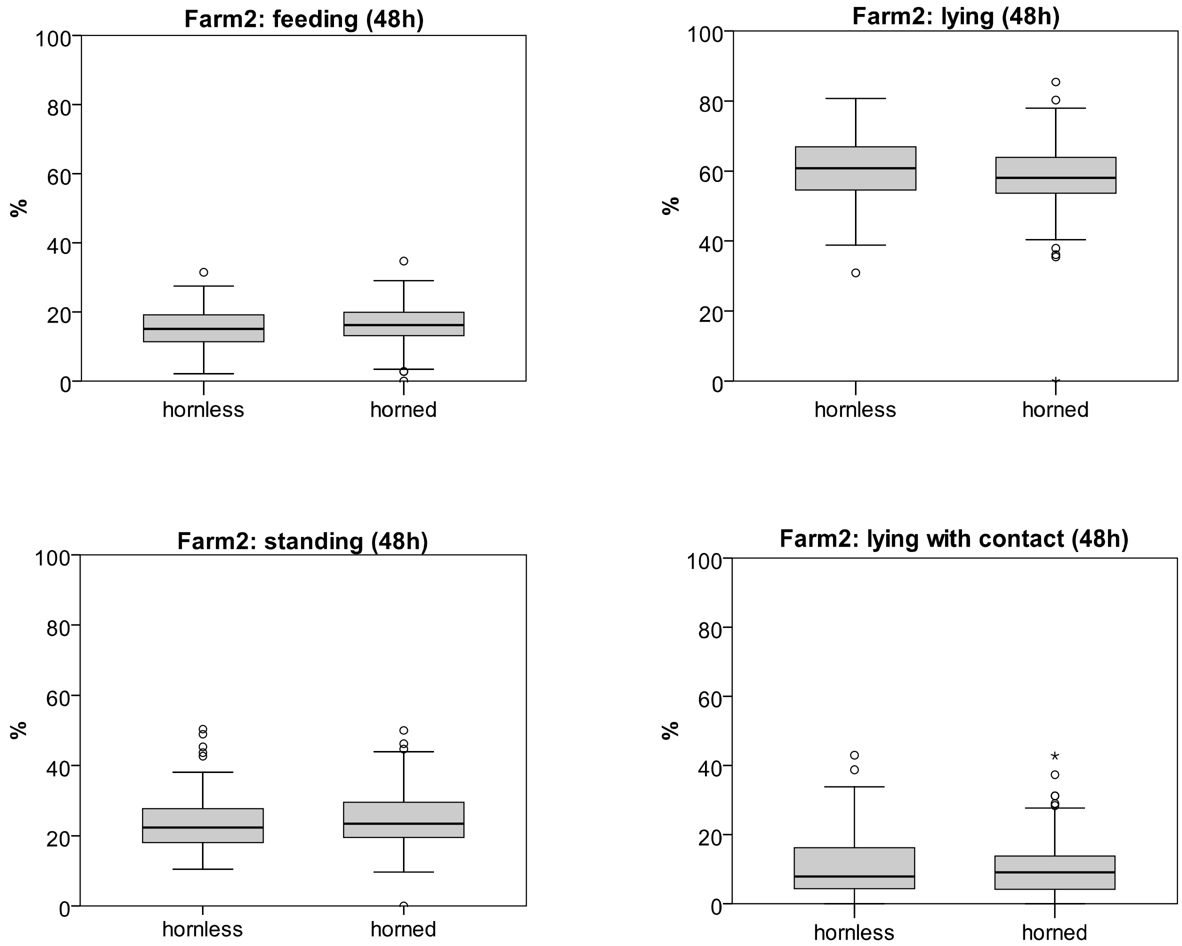

Fig. 6: Percentage of scans over 48h in which respective basic activities were observed in individual hornless and horned focal animals, based on observed data, N=120.

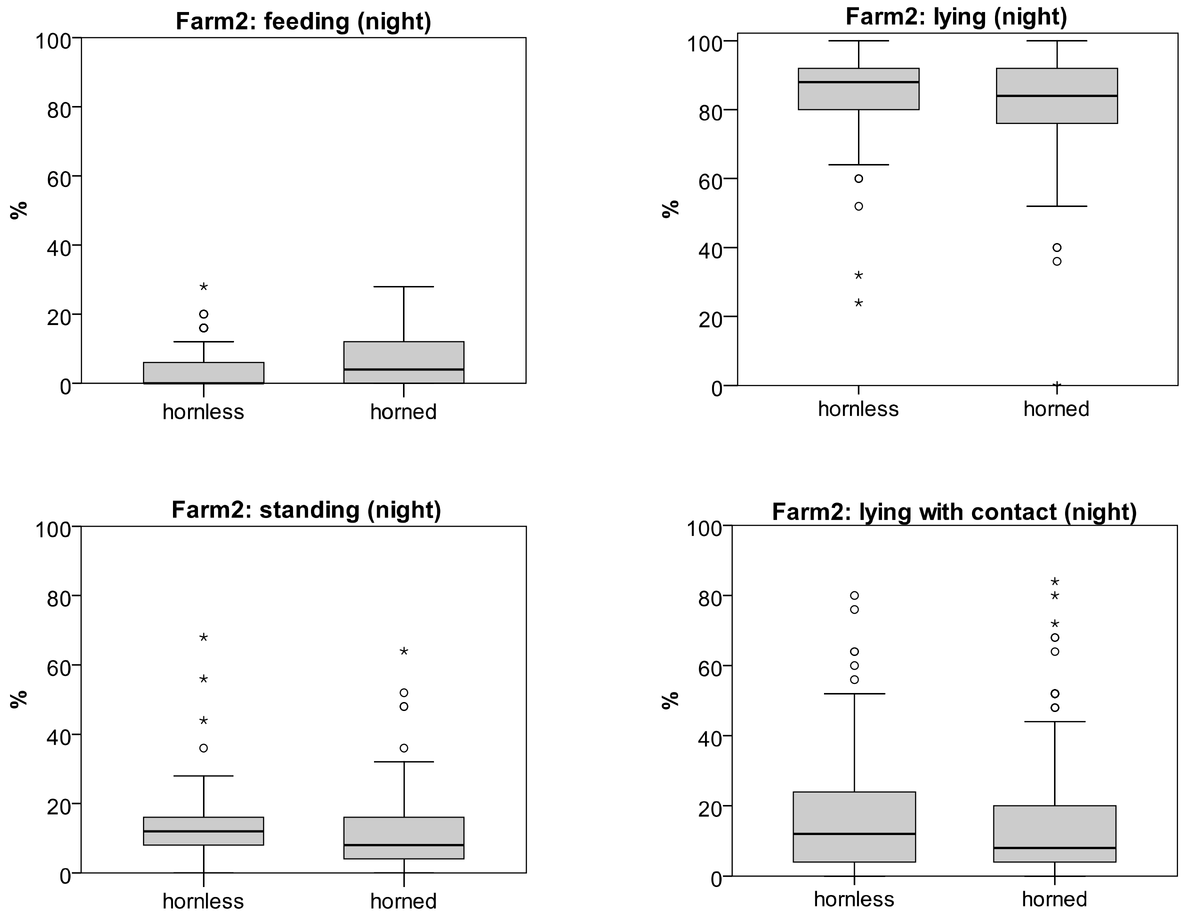

Fig. 7: Percentage of scans during night observations in which respective basic activities were observed in individual hornless and horned focal animals, based on observed data, N=120.

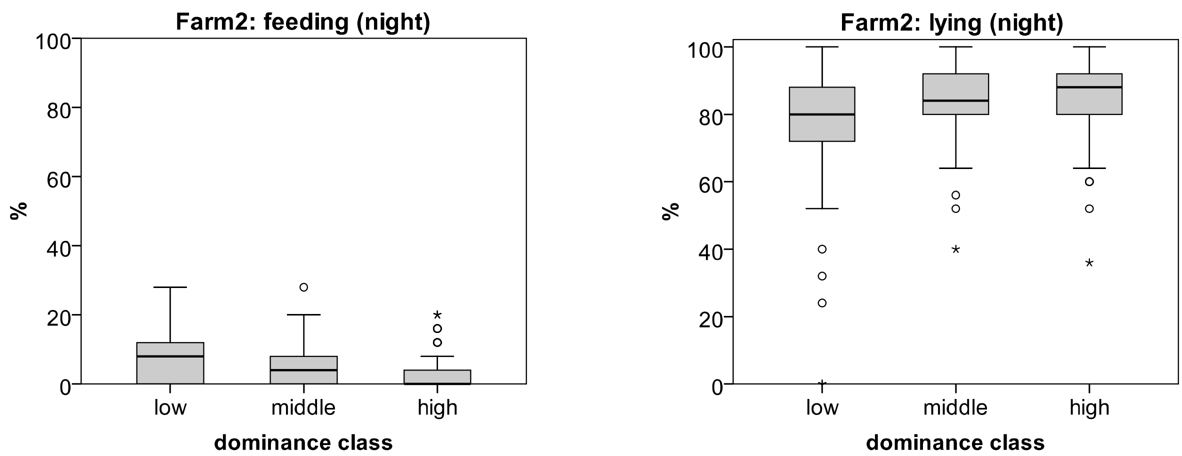

Fig. 8: Percentage of scans during night observations in which respective basic activities were observed related to dominance class (low, middle, high) based on the index of success based on observed data, N=120.

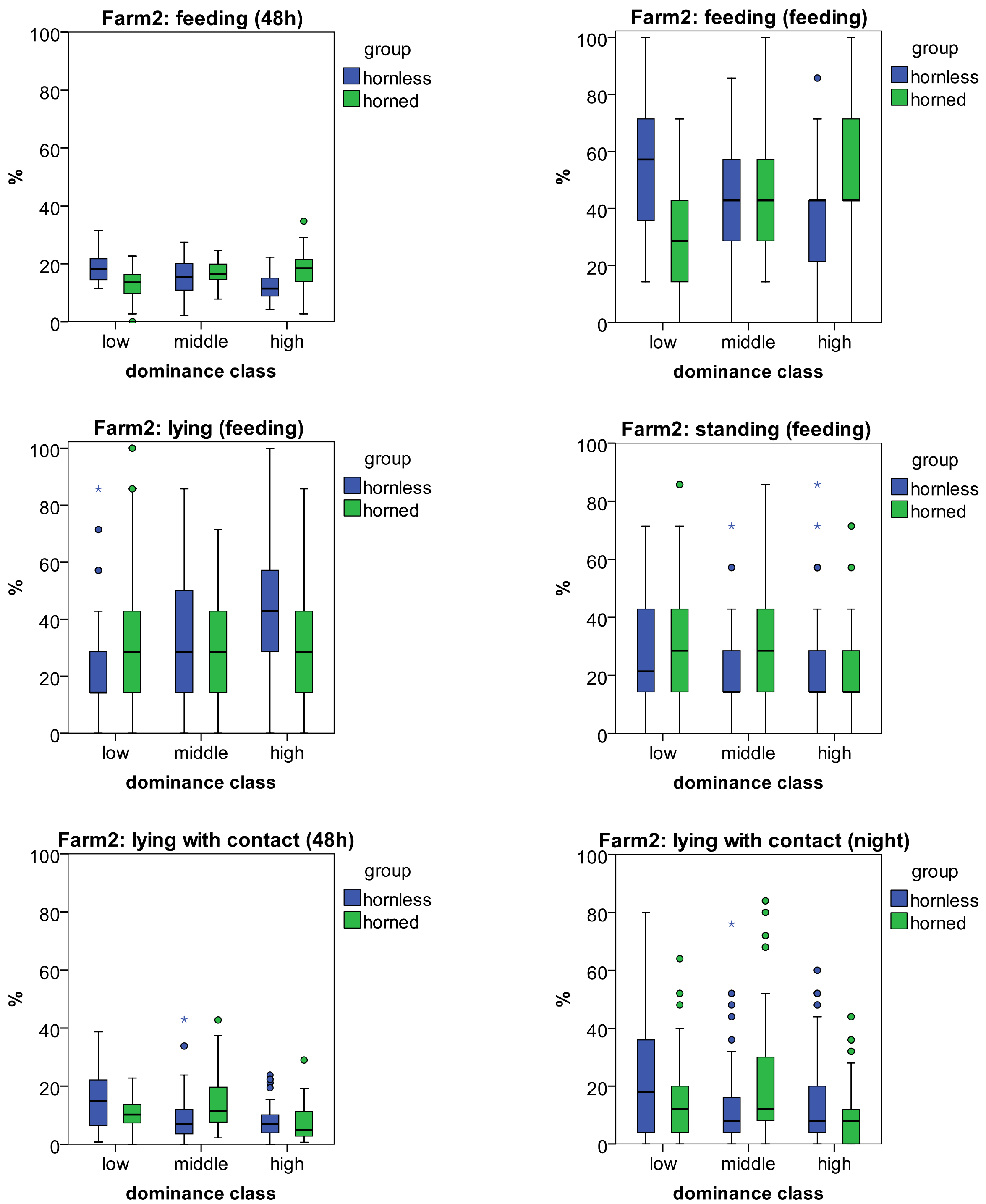

Fig. 9: Percentage of scans during different observation periods (48h, feeding, night) in which respective basic activities were observed related to dominance class (low, middle, high) based on the index of success and to group of goats (hornless, horned). Figure is based on observed data, N=120.

Tab. 3: Median and range (minimum-maximum) of basic activities on farm2 are given in percent of scans in which respective activities were observed during observation periods (before resting platforms (period1), immediately after installation (period2), four weeks after installation (period3), after removal of platforms (period4)) based on observed data. Median and range are given additionally for groups (hornless, horned), if groups differed in statistical analysis (Tab. 2), N=120.

	period1	period2	period3	period4
48h				
feeding	15.9 (4.2-29.0)	14.0 (2.1-34.7)	17.6 (4.2-31.4)	15.5 (0.0-27.5)
standing	24.4 (11.9-44.6)	23.9 (11.8-50)	21.4 (9.8-42.6)	22.6 (0.0-50.3)
lying	58.3 (35.5-77.3)	61.3 (36.1-85.4)	57.5 (40.9-80.3)	58.8 (0.0-77.9)
lying with contact	10.2 (0.0-42.9)	5.0 (0.6-27.1)	8.4 (0.7-37.3)	11.3 (0.0-42.7)
Feeding				
feeding	49.8 (0.0-100)	34.8 (0.0-71.4)	49.8 (0.0-85.7)	40.8 (0.0-100)
standing	14.2 (0.0-85.7)	28.5 (0.0-85.7)	14.2 (0.0-85.7)	28.5 (0.0-85.7)
- hornless	14.3 (0.0-71.4)	28.6 (0.0-71.4)	14.3 (0.0-57.1)	28.6 (0.0-85.7)
- horned	14.3 (0.0-85.7)	28.6 (0.0-85.7)	28.6 (0.0-85.7)	28.6 (0.0-71.4)
lying	28.6 (0.0-100.0)	28.6 (0.0-100)	28.6 (0.0-85.7)	28.6 (0.0-85.7)
- hornless	28.6 (0.0-85.7)	42.9 (0.0-100)	21.4 (0.0-71.4)	28.6 (0.0-85.7)
- horned	28.6 (0.0-100)	28.6 (0.0-100)	28.6 (0.0-85.7)	28.6 (0.0-85.7)
Night				
feeding	0.0 (0.0-28.0)	4.0 (0.0-20.0)	4.0 (0.0-28.0)	8.0 (0.0-28.0)
- hornless	0.0 (0.0-20.0)	4.0 (0.0-16.0)	2.0 (0.0-20.0)	4.0 (0.0-28.0)
- horned	4.0 (0.0-28.0)	4.0 (0.0-20.0)	8.0 (0.0-28.0)	8.0 (0.0-28.0)
standing	8.0 (0.0-64.0)	10.0 (0.0-36.0)	12.0 (0.0-68.0)	12.0 (0.0-56.0)
lying	92.0 (36.0-100)	84.0 (60.0-100)	84.0 (24.0-100)	80.0 (0.0-100)
lying with contact	12.0 (0.0-84.0)	6.0 (0.0-44.0)	12.0 (0.0-56.0)	16.0 (0.0-64.0)

Regarding descriptive analysis of **use of resting platforms** percentage of animals standing on platforms or lying on top of them per scan was highest (Tab. 4, Tab. 5). Standing levels changed little between observation period2 and 3. However, percentage of goats lying on top per scan after four weeks of installation was higher than at the beginning (Tab. 4, Tab. 5). Lying below platforms or lying with contact on top at any period was seldom recorded; lying with contact under platforms was not observed at all and is therefore not shown in tables below. Percent of hornless goats lying on top per scan was numerically slightly lower than in horned goats (Tab. 4, Tab. 5).

Individual variation in the use of platforms given in percent of scans over 48h by focal animals showed activities related to platforms was rather large (Tab. 6, Tab. 7), ranging from 0% to 35% in the hornless group and 0% and 55% in the horned group, respectively. When the index of success and activities related to platforms (mean of activities observed immediately after installation and after platforms were available for four weeks) were correlated, percentage of scans with focal animals lying with contact on top of platforms was higher in low than high ranking animals (r_s-0.134, p=0.039, N=60), while no correlations were found for other activities (p>0.05). When groups were analysed separately, levels of lying with contact on top of platforms were also higher in the hornless group in low ranking goats (r_s-0.207, p=0.023, N=30). Other activities did not correlate with the index of success (p>0.05). In the horned group, however, none of the activities related to platforms were affected by rank (r_s-0.017 to r_s-0.100, p>0.05, N=30).

Tab. 4: Use of resting platforms over 48h observations immediately after installation (period2) based on observed data of all animals (focal and non focal) in the hornless (N=75) and horned group (N=72). Data is given in percent of animals e.g. standing on top of a platform, per scan over 48h.

	standing on top of platform		lying on top of platform		lying under platform		lying on top of platform with contact	
	hornless	Horned	hornless	horned	hornless	horned	hornless	horned
median	1.3	2.6	3.5	4.0	0.0	0.0	0.0	0.0
minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
maximum	9.0	10.0	10.0	12.0	1.0	0.0	3.0	3.0
percentile 25	0.0	1.3	1.3	2.6	0.0	0.0	0.0	0.0
75	3.7	4.4	5.1	5.9	0.0	0.0	0.0	0.0

Tab. 5: Use of resting platforms over 48h observations four weeks after installation (period3) based on observed data of all animals (focal and non focal) in the hornless (N=75) and horned group (N=72). Data is given in percent of animals e.g. standing on top of a platform, per scan over 48h.

	standing on top of platform		lying on top of platform		lying under platform		lying on top of platform with contact	
	hornless	Horned	hornless	horned	hornless	horned	hornless	horned
median	1.3	1.3	6.3	6.7	0.0	0.0	0.0	0.0
minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
maximum	8.0	11.0	12.0	16.0	1.0	1.0	5.0	7.0
percentile 25	0.0	0.0	3.9	4.1	0.0	0.0	0.0	0.0
75	3.9	4.0	7.7	9.4	0.0	0.0	0.0	0.0

Tab. 6: Use of resting platforms over 48h observations immediately after installation (period2) based on observed data of individual hornless and horned focal animals (N=30). Data is given in percent of scans an animal is e.g. standing on top of a platform over 48h.

	standing on top of platform		lying on top of platform		lying under platform		lying on top of platform with contact	
	hornless	Horned	hornless	horned	hornless	horned	hornless	horned
median	2.1	2.4	0.7	0.7	0.0	0.0	0.0	0.0
minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
maximum	14.0	24.0	35.0	45.0	0.0	0.0	0.0	1.0
percentile 25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75	5.5	5.7	6.0	5.3	0.0	0.0	0.0	0.0

Tab. 7: Use of resting platforms over 48h observations four weeks after installation (period3) based on observed data of individual hornless and horned focal animals (N=30). Data is given in percent of scans an animal is e.g. standing on top of a platform over 48h.

	standing on top of platform		lying on top of platform		lying under platform		lying on top of platform with contact	
	hornless	Horned	hornless	horned	hornless	horned	hornless	horned
median	0.7	1.4	0.0	4.6	0.0	0.0	0.0	0.0
minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
maximum	7.0	23.0	55.0	35.0	0.0	0.0	1.0	5.0
percentile 25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75	2.8	3.7	5.7	15.0	0.0	0.0	0.7	1.6

2.3.3 Feeding place occupancy

This parameter was only recorded on farm2. Descriptive analysis of number of animals feeding after fresh feed was given showed that most goats were feeding immediately after fresh feed was provided with higher numbers in the hornless group (54 (27-70)) than the horned group (45 (10-60)). The hours after fresh feed was given (1, 4 and 5h) the number of feeding animals declined and was similar in the hornless group (1h: 21 (12-36), 4h: 18 (11-32), 5h: 19 (10-30) and the horned one (1h: 20 (10-32), 4h: 18 (10-26), 5h: 20 (9-28)).

Statistical analysis on distances at the feeding rack showed that animals in the hornless group were feeding next to each other (distance = 0) more often than animals in the horned group irrespective of time after fresh feed was given ($p<0.05$, Tab. 8, Fig. 10). Regarding feeding with one empty feeding place in between, differences were only seen immediately after fresh feed was given (horned animals fed more often at this distance) and then levelled off the hours after feeding ($p<0.05$, Fig. 10). Groups of goats also differed in feeding at larger distances (distance = 2, ≥ 3), with higher numbers in the horned group than in the hornless one ($p<0.05$, Fig. 10). The number of goats feeding at larger distances (distance = 2, ≥ 3) increased with the time after fresh feed was given ($p<0.05$, Fig. 10). Observation period was also affecting and tended to affect the distances at the feeding rack (Tab. 8). Number of goats feeding next to each other (distance = 0) were highest four weeks after platforms were installed (period3) and after removal of platforms (period4, $p<0.05$, Fig. 11). Animals feeding with one place in between also tended to differ throughout observation periods ($p=0.074$), but differences were minor. Number of goats feeding at larger distances increased slightly immediately after platforms were installed (period2, distance = 2, ≥ 3) and after they were removed again (period4, distance ≥ 3, $p<0.05$, Fig. 11).

Tab. 8: Results of GLM analysis of feeding place occupancy (i.e. distance at feeding rack). P-values are given for fixed variables group (hornless, horned), time after feeding (immediately after fresh feed was provided (0), 1h (1), 4h (4) and 5h (5) after provision of fresh feed), observation period (before resting platforms (1), immediately after installation (2), four weeks after installation (3), after removal of platforms (4)) and the interaction group*time after feeding (if p<0.1). Transformations performed with response variables for statistical analysis are indicated in brackets. N=75 (hornless group), N=72 (horned group).

	distance at feeding rack = 0	distance at feeding rack = 1	distance at feeding rack = 2 (LG10)	distance at feeding rack ≥ 3 (LG10)
	p-value	p-value	p-value	p-value
group	**0.000**	0.124	**0.000**	**0.000**
time after feeding	**0.000**	**0.000**	**0.000**	**0.000**
observation period	**0.000**	*0.074*	**0.026**	**0.000**
group*time after feeding	**0.002**	**0.000**	-	-

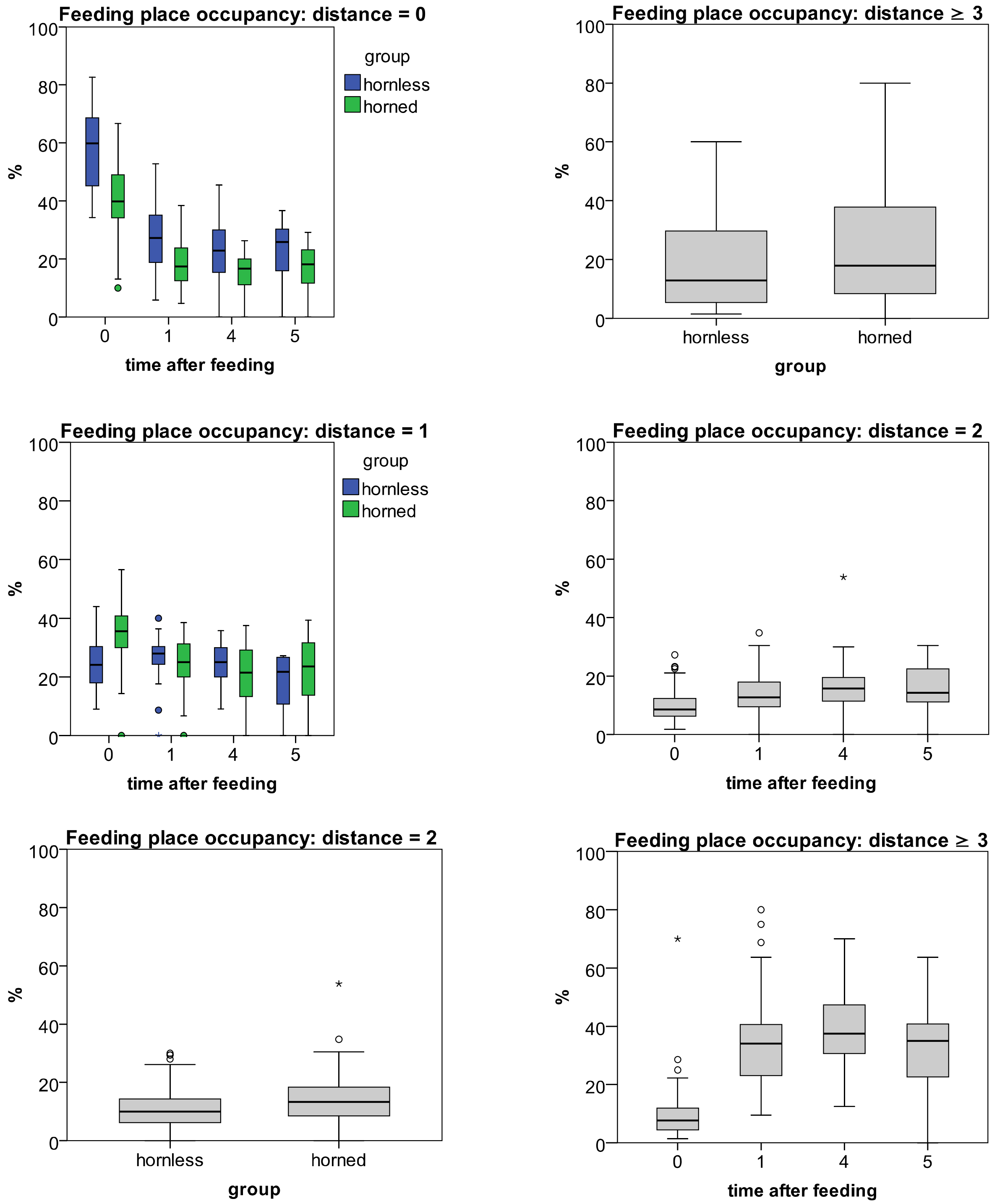

Fig. 10: Hornless and horned animals feeding (distance = 0, 1) related to time after feeding (immediately after feeding (0), 1h (1), 4h (4) and 5h (5) after feeding). Groups of goats feeding (hornless, horned) and numbers feeding related to time after feeding, shown for larger distances at the feeding rack (distance = 2, ≥ 3). Numbers are given in percent and based on observed data, N=75 (hornless group), N=72 (horned group).

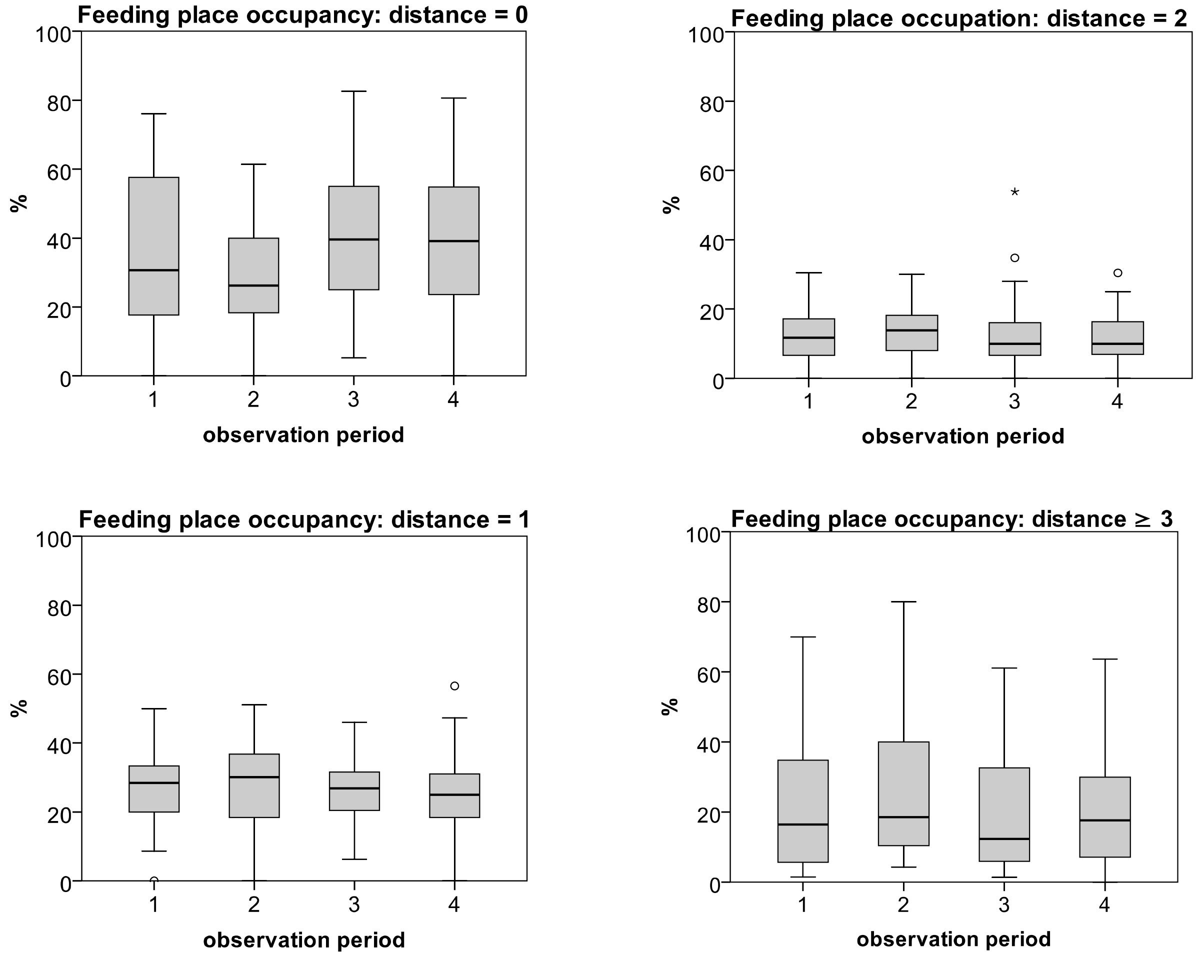

Fig. 11: Goats feeding at different distances (distance = 0, 1, 2, ≥ 3) related to observation period (before resting platforms (1), immediately after installation (2), four weeks after installation (3), after removal of platforms (4)). Numbers are given in percent and based on observed data, N=75 (hornless group), N=72 (horned group).

2.3.4 Body condition and injuries

On farm1 groups of goats did not differ in body condition regarding BCS lumbar ($p>0.05$, Tab. 9). Regarding BCS sternal, groups of animals differed ($p<0.05$) with more hornless and less horned goats scoring 2.0 than expected, while less hornless and more horned goats scored 4.0 than expected (standardized residuum $\geq |1|$, Tab. 9). On farm2 less hornless animals tended to be scored 4.5 in BCS lumbar than horned ones ($p=0.051$, Tab. 9). BCS sternal, however, was not affected by presence of horns ($p>0.05$, Tab. 9). When all examination periods were looked at separately presence of horns did not affect BCS lumbar (farm2) and BCS sternal (farm1) (data not shown, $p>0.05$).

When the index of success was taken into account, goats with a higher index of success were generally scored higher than ones with a lower index of success, irrespective of BCS and farm (farm1: BCS lumbar r_s+0.175, $p=0.019$, BCS sternal r_s+0.359, $p=0.000$; farm2: BCS lumbar r_s+0.401, $p=0.000$, BCS sternal r_s+0.488, $p=0.000$). In hornless goats a higher index of success also resulted in higher BCS (BCS lumbar and sternal), irrespective of farm (farm1: BCS lumbar r_s+0.293, $p=0.005$, BCS sternal r_s+0.457, $p=0.000$; farm2: BCS lumbar r_s+0.404, $p=0.000$, BCS sternal r_s+0.506, $p=0.000$). On farm2 the same results were seen in horned animals (farm2: BCS lumbar r_s+0.380, $p=0.000$, BCS sternal r_s+0.469, $p=0.000$), on farm1 a higher index of success, however, did not clearly lead to higher BCS in horned animals (farm1: BCS lumbar r_s+0.078, $p=0.468$, BCS sternal r_s+0.253, $p=0.017$)

Numerically the majority of animals had higher scores on farm1 than on farm2, irrespective of BCS and horn status (Tab. 9).

Tab. 9: Body condition scores (BCS lumbar, BCS sternal) on farm1 and 2 summarized throughout the experimental period according to BCS and group (hornless, horned), analysed with Fisher Exact test. Numbers in hornless/horned columns refer to number of animals observed (bold) and expected (not bold) with respective BCS, while numbers in brackets indicate standardized residua obtained from Fisher Exact test. N=90 (farm1), N=120 (farm2).

		farm1			farm2		
	score	hornless	horned	p-value	hornless	horned	p-value
BCS lumbar	1.5	**1**/0.5 (+ 0.7)	**0**/0.5 (- 0.7)	0.166	**3**/2.0 (+ 0.7)	**1**/2.0 (- 0.7)	*0.051*
	2.0	**1**/0.5 (+ 0.7)	**0**/0.5 (- 0.7)		**21**/18.2 (+ 0.6)	**15**/17.8 (- 0.7)	
	2.5	**5**/7.0 (- 0.8)	**9**/7.0 (+ 0.8)		**62**/60 (+ 0.3)	**58**/58 (- 0.3)	
	3.0	**50**/44.5 (+ 0.8)	**39**/44.5 (- 0.8)		**30**/31.0 (- 0.2)	**32**/30.0 (+ 0.2)	
	3.5	**28**/29.5 (- 0.3)	**32**/29.5 (+ 0.3)		**1**/5.0 (- 1.8)	**9**/5.0 (+ 1.8)	
	4.0	**4**/7.0 (- 1.1)	**10**/7.0 (+ 1.2)		**3**/2.5 (+ 0.3)	**2**/2.5 (- 0.3)	
	4.5	**1**/0.5 (+ 0.7)	**0**/0.5 (- 0.7)		**0**/1.5 (- 1.2)	**3**/1.5 (+ 1.2)	
BCS sternal	2.0	**7**/4.0 (+ 1.5)	**1**/4.0 (- 1.5)	**0.007**	**3**/3.5 (- 0.3)	**4**/3.5 (+ 0.3)	0.669
	2.5	**6**/4.0 (+ 1.0)	**2**/4.0 (- 1.0)		**30**/25.3 (+ 0.9)	**21**/24.7 (- 0.9)	

3.0	**31**/37.2 (- 1.0)	**44**/36.8 (+ 1.0)	**72**/72.9 (- 0.1)	**73**/71.1 (+ 0.1)
3.5	**33**/27.5 (+ 1.0)	**22**/27.5 (- 1.0)	**12**/14.0 (- 0.6)	**17**/14.0 (+ 0.6)
4.0	**7**/11.5 (- 1.3)	**16**/11.5 (+ 1.3)	**2**/2.5 (- 0.3)	**4**/3.5 (+ 0.3)
4.5	**6**/4.5 (+ 0.7)	**3**/4.5 (- 0.7)	**1**/1.5 (- 0.4)	**2**/1.5 (+ 0.4)
5.0	**0**/1.0 (- 1.0)	**2**/1.0 (+ 1.0)	**0**	**0**

Hornless and horned groups of goats did not differ throughout the experimental period regarding ‘injuries body (total)’ on both farms (p>0.05, Tab. 10). On farm1 approximately a third of the examined goats did not have any injuries. The majority of goats with injuries were assigned to class1, i.e. one or two injuries, while few animals were observed with three to five injuries (class2) and none with more than five injuries (class3, class4) (Tab. 10). On farm2 approximately a quarter of the examined animals was assigned to class0, i.e. no injuries, and to class2, i.e. three to five injuries. The majority of goats had only one or two injuries (class1) and few goats had more than five injuries (class3, class4) on farm2 (Tab. 10).

When parameters pooled into ‘injuries body (total)’ are looked at separately by descriptive analysis, numbers of injuries in hornless and horned groups of goats were similar on farm1 (Tab. 12). Regarding type of injury on farm1, numbers of scars (most of them found on ears) accounted for most, followed by swellings, calluses and crusts (Tab. 12). On farm2, the number of hornless goats with scars was numerically lower, but numbers with swellings and crusts was numerically higher than for horned animals.

Injuries around the abdominal area were only found on the udder and they (injuries udder (total)) differed between groups (p<0.05, Tab. 10). More hornless goats were examined without udder injuries than expected on both farms (Tab. 10). When injuries udder (total) were analysed for examination periods, hornless and horned groups of goats differed or tended to, respectively, at all periods on both farms (p=0.000-0.074, Tab. 11). On both farms more hornless goats were examined without udder injuries than expected at most periods, except for farm1 only before first regrouping and four weeks after second regrouping and for farm2 before installation of platforms, where numbers of hornless goats with injuries were higher than expected in one and/or two classes (Tab. 11). Analysis of single parameters pooled into injuries udder (total) for examination periods showed that results for crusts were in line with results for injuries udder (total) (data not shown, farm1: period1 p=0.043, period2 p=0.025, period3 p=0.065; farm2: period1 p=0.000, period2 p=0.003, period3 p=0.000, period4 p=0.000).

Single parameters summed up as injuries udder (total) were descriptively analysed and hornless and horned groups of goats differed numerically (Tab. 12). Number of hornless goats with crusts was numerically lower than in horned goats on both farms, especially in class1 (one or two crusts) on farm1 and class2 to 4 (three to 30 crusts) on farm2, respectively. Number of hornless goats with scars was also lower than in horned goats on both farms (Tab. 12). On both farms crusts were accounting for most injuries, followed by scars; swellings were not found that often. Two deep lesions were recorded on farm2 on two horned goats before resting platforms were installed (shape horizontal, size 1-3cm) and one week after installation (shape circular, size <1cm) (Tab. 12).

Irrespective of injury location and horn status the number of injured animals was numerically higher on farm2 than farm1.

Tab. 10: Injuries on farm1 and 2 summarized throughout the experimental period according to classes, summarizing number of injuries per animal (0- no injuries, 1- one or two injuries, 2- three to five injuries, 3- six to ten injuries, 4- eleven to 30 injuries) and group (hornless, horned), analysed with Chi² test after Pearson. Numbers in hornless/horned columns refer to number of animals observed (bold) and expected (not bold) within respective classes of injuries, while numbers in brackets indicate standardized residua obtained from Chi² test after Pearson. Injuries body (total): N=90 (farm1), N=120 (farm2), injuries udder (total): N=258 (hornless and horned groups on farm1), N=300 (hornless group on farm2) and N=288 (horned group on farm2).

		farm1			farm2		
	class	hornless	horned	p-value	hornless	horned	p-value
injuries body (total)	0	**35**/33.5 (+ 0.3)	**32**/33.5 (- 0.3)	0.497	**31**/30.5 (0.0)	**30**/30.5 (0.0)	0.119
	1	**51**/50.5 (+ 0.1)	**50**/50.5 (- 0.1)		**63**/56.0 (+ 0.9)	**49**/55.0 (- 0.9)	
	2	**4**/6.0 (- 0.8)	**8**/6.0 (+ 0.8)		**19**/26 (- 1.4)	**34**/26 (+ 1.4)	
	3	0	0		**7**/6.5 (+ 0.2)	**6**/6.5 (- 0.2)	
	4	0	0		**0**/0.5 (- 0.7)	**1**/0.5 (+ 0.7)	
injuries udder (total)	0	**151**/137.5 (+ 1.2)	**124**/137.5 (- 1.2)	**0.001**	**234**/191.5 (+ 3,1)	**140**/182.5 (- 3,2)	**0.000**
	1	**48**/67.5 (- 2.4)	**87**/67.5 (+ 2.4)		**46**/45.5 (+ 0.1)	**43**/43.5 (- 0.1)	
	2	**36**/33.5 (+ 0.4)	**31**/33.5 (- 0.4)		**13**/27.0 (- 2.7)	**40**/26.0 (+ 2.8)	
	3	**12**/12.5 (- 0.1)	**13**/12.5 (+ 0.1)		**7**/20.0 (- 2.3)	**32**/19.0 (+ 2.3)	
	4	**11**/7.0 (+ 1.0)	**3**/7.0 (- 1.0)		**0**/17.0 (- 4.1)	**33**/16.0 (+ 4.1)	

Tab. 11: Injuries udder (total) on farm1 and 2 given for examination periods (farm1: before first regrouping (1) and four weeks after first and second regrouping (2, 3)); farm2: before resting platforms (1), one and four week(s) after installation of platforms (2, 3) and after removal of platforms (4)) and group (hornless, horned) analysed with Chi² test after Pearson. Classes are summarizing number of injuries per animal (0- no injuries, 1- one or two injuries, 2- three to five injuries, 3- six to ten injuries, 4- eleven to 30 injuries). Numbers in hornless/horned columns refer to number of animals observed (bold) and expected (not bold) within respective classes of injuries, while numbers in brackets indicate standardized residua obtained from Chi² test after Pearson. Injuries udder (total): N=86 (hornless and horned groups on farm1), N=75 (hornless group on farm2) and N=72 (horned group on farm2).

		farm1			farm2		
examination period	class	hornless	horned	p-value	hornless	horned	p-value
1	0	**50**/53.5 (- 0.5)	**57**/53.5 (+ 0.5)	**0.023**	**57**/53.0 (+ 0.9)	**42**/49.0 (- 0.9)	**0.000**
	1	**17**/20.0 (- 0.7)	**23**/20.0 (+ 0.7)		**15**/12.0 (+ 1.2)	**7**/11.0 (- 1.2)	
	2	**14**/8.5 (+ 1.9)	**3**/8.5 (- 1.9)		**3**/3.5 (- 0.3)	**4**/3.5 (+ 0.3)	
	3	**3**/3.0 (0.0)	**3**/3.0 (0.0)		**0**/4.0 (- 2.0)	**8**/4.0 (+ 2.0)	
	4	**2**/1.0 (+ 1.0)	**0**/1.0 (- 1.0)		**0**/5.5 (- 2.4)	**11**/5.5 (+ 2.4)	
2	0	**58**/47.5 (+ 1.5)	**37**/47.5 (- 1.5)	**0.001**	**59**/48.0 (+ 1.6)	**36**/47.0 (- 1.6)	**0.001**
	1	**15**/26.0 (- 2.2)	**37**/26.0 (+ 2.2)		**12**/15.5 (- 0.9)	**18**/15.5 (+ 0.9)	
	2	**10**/10.5 (- 0.2)	**11**/10.5 (+ 0.2)		**3**/6.0 (- 1.2)	**9**/6.0 (+ 1.2)	
	3	**2**/1.5 (+ 0.4)	**1**/1.5 (- 0.4)		**1**/3.0 (- 1.2)	**5**/3.0 (+ 1.2)	
	4	**1**/0.5 (+ 0.7)	**0**/0.5 (- 0.7)		**0**/2.0 (- 1.4)	**4**/2.0 (+ 1.4)	
3	0	**43**/36.5 (+ 1.1)	**30**/36.5 (- 1.1)	*0.074*	**57**/47.5 (+ 1.4)	**36**/46.5 (- 1.4)	**0.000**
	1	**16**/21.5 (- 1.2)	**27**/21.5 (+ 1.2)		**12**/11.0 (+ 0.3)	**10**/11.0 (- 0.3)	
	2	**12**/14.5 (- 0.7)	**17**/14.5 (+ 0.7)		**4**/6.5 (- 1.0)	**9**/6.5 (+ 1.0)	
	3	**7**/8.0 (- 0.4)	**9**/8.0 (+ 0.4)		**2**/6.5 (- 1.8)	**11**/6.5 (+ 1.8)	
	4	**8**/5.5 (+ 1.1)	**3**/5.5 (- 1.1)		**0**/3.0 (- 1.7)	**6**/3.0 (+ 1.7)	
4	0	-	-		**59**/43.0 (+ 2.6)	**25**/40.0 (- 2.6)	**0.000**
	1	-	-		**6**/6.5 (- 0.3)	**8**/6.5 (+ 0.3)	
	2	-	-		**3**/11.0 (- 2.5)	**19**/10.0 (+ 2.5)	
	3	-	-		**4**/6.0 (- 0.9)	**8**/6.0 (+ 0.9)	
	4	-	-		**0**/6.5 (- 2.5)	**12**/6.5 (+ 2.5)	

Tab. 12: Injuries on farm1 and 2 summarized throughout the experimental period according to classes, summarizing number of injuries per animal (0- no injuries, 1- one or two injuries, 2- three to five injuries, 3- six to ten injuries, 4- eleven to 30 injuries) and horn status. Numbers in hornless/horned columns refer to number of animals found within respective classes, e.g. 85 hornless goats with no crusts (body) on farm1. Numbers in brackets regarding scars (body) refer to number of animals found with scars on ears. All injuries (body): N=90 (farm1), N=120 (farm2), all injuries (udder): N=258 (hornless and horned groups on farm1), N=300 (hornless group on farm2) and N=288 (horned group on farm2).

		farm1		farm2	
	class	hornless	horned	hornless	horned
crust (body)	0	85	85	87	101
	1	5	5	26	15
	2	0	0	5	3
	3	0	0	2	1
deep lesion (body)	0	90	90	120	120
scar (body)	0	64 (70)	65 (68)	83 (61)	55 (86)
	1	26 (20)	24 (21)	30 (49)	54 (30)
	2	0	1 (1)	6 (9)	10 (4)
	3	0	0	1 (1)	1
swelling (body)	0	76	80	87	100
	1	14	10	31	18
	2	0	0	2	2
callus (body)	0	81	80	118	119
	1	9	10	2	1
crust (udder)	0	162	142	257	167
	1	37	72	23	20
	2	36	29	13	40
	3	12	12	7	32
	4	11	3	0	29
deep lesion (udder)	0	258	258	300	286
	1	0	0	0	2
scar (udder)	0	248	236	277	245
	1	10	22	23	40
	2	0	0	0	3
swelling (udder)	0	254	252	295	287
	1	4	6	5	1

2.3.5 Adrenocortical activity

Adrenocortical activity only tended to differ between groups on farm1, with slightly higher cortisol levels in milk in the hornless group compared to the horned group (p=0.057, Tab. 13). Otherwise no differences between groups were found on farm1 and 2 (p>0.05, Fig. 12) Sampling period affected faecal and milk samples on both farms (p<0.05, Tab. 13). Alternating levels in faeces and steadily rising ones in milk were observed throughout sampling periods on farm1 (Fig. 13). On farm2 concentrations in faeces and milk did not differ much between periods (Fig. 13), though highest levels were found in faeces before resting platforms were installed (period1) and in milk after platforms were available for four weeks (period3) (Fig. 13). The index of success only tended to affect milk cortisol levels on farm2 (p=0.094), with slightly lower levels in goats assigned to the high dominance class (Fig. 15). The interaction group*dominance class was included in the model, but did not influence cortisol(metabolite) levels in milk and faeces (p>0.1, Fig. 16), therefore p-values and F-values are not shown in Tab. 13. Group size (only relevant on farm1) did not influence cortisol(metabolite) concentrations in faecal and milk samples (p>0.05). Data on age of animals was only available on farm1 and according to analysis cortisol concentrations in milk increased with age of animals (p<0.05, Fig. 14).

Tab. 13: Results for GLMM analysis of faecal and milk samples. P-values and F-values are given for the fixed variables group (hornless, horned), sampling period (farm1: before first regrouping (1), three weeks after first regrouping (2), four weeks after first regrouping (3) and four weeks after second regrouping (4); farm2: before resting platforms (1), one week after installation (2), four weeks after installation (3) and after removal of platforms (4)) and dominance class (low, middle, high) based on the index of success. Group size (small, large)) and animal age were only relevant and available, respectively, on farm1, therefore values are missing for farm2. Transformations performed with response variables for statistical analysis are indicated in brackets, each farm: N=60.

	cortisol metabolites in faeces - farm1 (LG10)		cortisol in milk - farm1 (LG10)		cortisol metabolites in faeces - farm2 (LG10)		cortisol in milk - farm2 (LG10)	
	F-value	p-value	F-value	p-value	F-value	p-value	F-value	p-value
group	2.010	0.160	3.729	*0.057*	0.796	0.376	0.163	0.688
sampling period	30.517	**0.000**	21.763	**0.000**	27.067	**0.000**	14.588	**0.000**
dominance class	0.618	0.434	0.102	0.751	0.990	0.378	2.464	*0.094*
group size	1.049	0.309	0.313	0.577	-	-	-	-
age	7.653	**0.007**	-	-	-	-	-	-

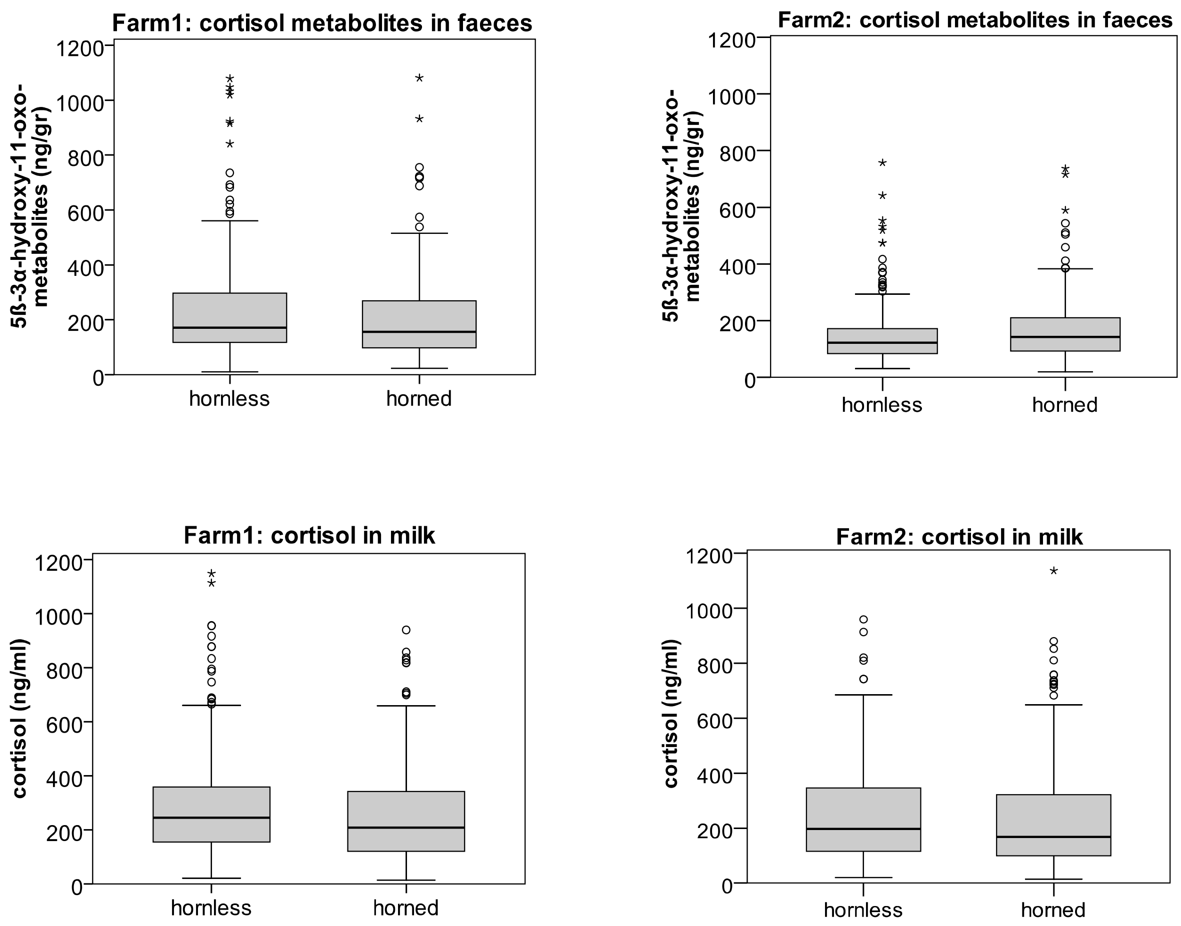

Fig. 12: Concentration of cortisol metabolites in faeces (ng/gr) and cortisol in milk (ng/ml) related to group (hornless, horned) shown for farm1 and farm2, based on observed data. For each farm: N=60.

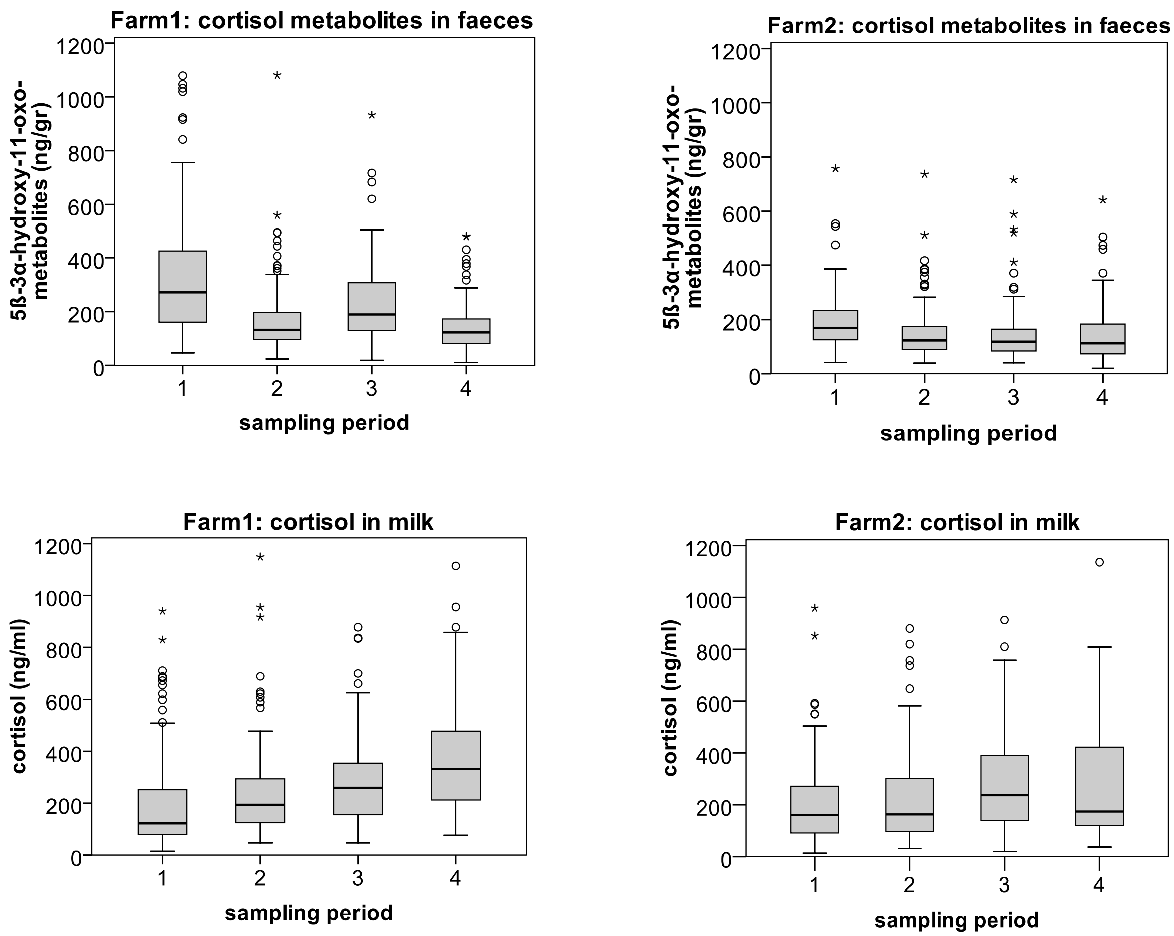

Fig. 13: Concentration of cortisol metabolites in faeces (ng/gr) and cortisol in milk (ng/ml) for farm1 and farm2 related to sampling periods (farm1: before first regrouping (1), three weeks after first regrouping (2), four weeks after first regrouping (3) and four weeks after second regrouping (4); farm2: before resting platforms (1), one week after installation (2), four weeks after installation (3) and after removal of platforms (4)), based on observed data. For each farm: N=60.

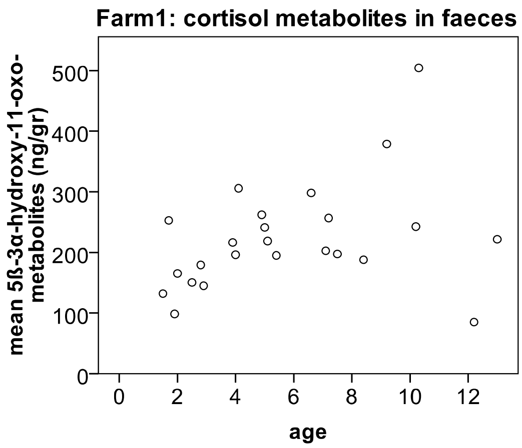

Fig. 14: Concentration of cortisol metabolites in faecal samples (ng/gr) on farm1 related to age of animals, given in years, based on observed data. N=60.

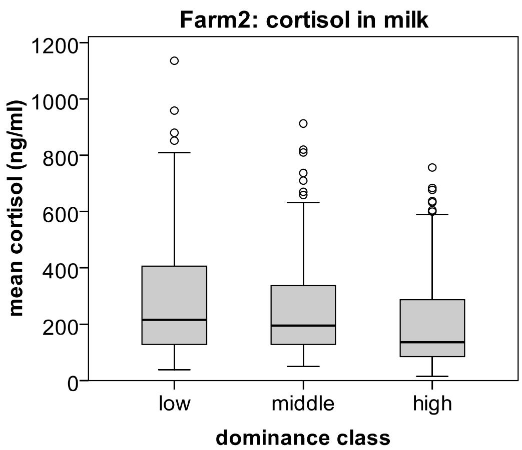

Fig. 15: Concentration of cortisol in milk samples (ng/ml) on farm2 related to dominance class (low, middle, high) based on the index of success. Figure is based on observed data, N=60.

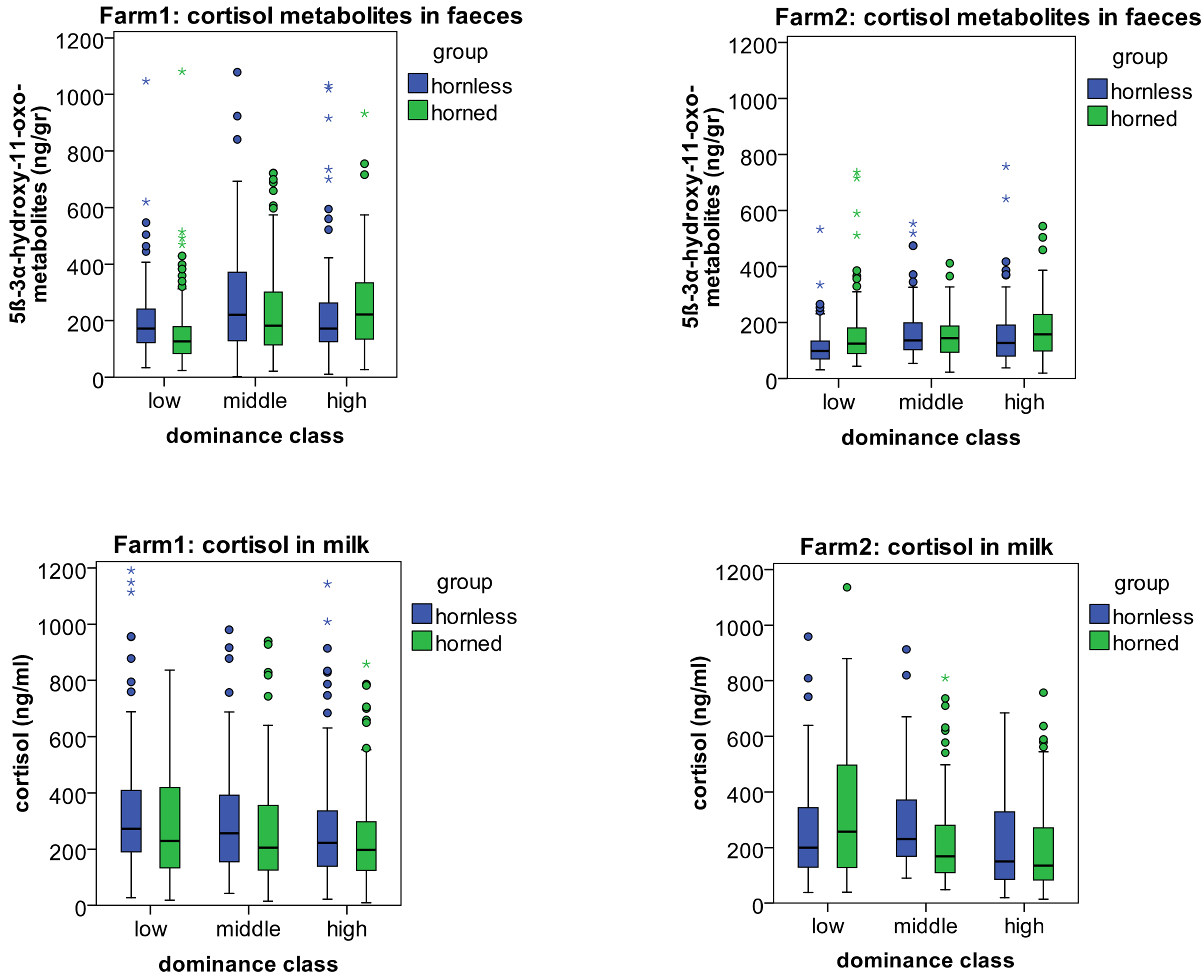

Fig. 16: Concentration of cortisol metabolites in faeces (ng/gr) and cortisol in milk (ng/ml) in groups (hornless, horned) for farm1 and farm2 related to dominance class (low, middle, high) based on the index of success. Figure is based on observed data, for each farm: N=60.

2.4 Discussion

Results support the hypothesis that presence of horns influences social behaviour in goats. Hornless goats interacted more often agonistically in general and more often with body contact, in tendency, than horned goats. Rank and group, i.e. presence of horns, affected basic activity, but the hypothesis of more pronounced differences between dominance classes within groups has to be rejected, as differences were similar or even more pronounced in the hornless than horned group. According to the interaction group*dominance class rank influenced the basic activity of hornless and horned animals differently. Hornless goats assigned to the low dominance class were feeding more often than those assigned to the high dominance class. In the horned group the opposite was observed. Regarding lying including lying with contact levels in the hornless group increased with dominance class, with lowest levels in the low dominance class and highest levels in the high dominance class. In the horned group, however, lying activity did not change across classes. Basic activities varied across the observation period, however, differences could not be assigned to the presence of resting platforms, except for lying with contact, which was not as often observed when platforms were offered. Resting platforms were accepted well and used irrespectively of rank and horns. Cortisol (metabolite) levels in milk and faeces did not differ in hornless and horned goats in relation to dominance classes, contradicting the hypothesis of higher stress levels in low ranking horned goats compared to low ranking hornless goats.

2.4.1 Experimental design

In general results of the present study have to be interpreted carefully, as they are only based on two groups of each hornless and horned goats and some of them only on one group (basic activity, feeding occupancy). On farm1 group size differed throughout the experimental period in hornless and horned goats and regroupings also took place. Data however, were collected three to four weeks after regroupings when according to earlier studies in goats (Alley and Fordham 1994, Fernandez et al 2007, Andersen et al 2008, Slavnitsch 2008) and other species (cattle: Kondo et al 1984, Hasegawa et al 1997, von Keyserlingk et al 2008; pigs: Meese and Ewbank 1973, de Groot et al 2001) dominance hierarchy was expected to be established and behaviour to have returned to base levels. Yet, the effect of group size on parameters remains unclear, as it was not possible to include this effect in statistical analysis.

But as this experiment was based on on-farm conditions, experimental design had to include terms and conditions of each farm and adapt to circumstances. In order to gain wider data basis parameters were recorded on two farms. When data was analysed some indicators pointed toward an influence of farm characteristics on recorded parameters, to what extent, however, these characteristics were affecting parameters remains unclear. Even though circumstances were determining data recording and the statistic program was limiting options of statistical analysis results of this study are supported by earlier studies in smaller groups and with individuals (e.g., Loretz et al 2004, Bøe et al 2006, Andersen and Bøe 2007, Jørgensen et al 2007, Tønnesen et al 2008, Aschwanden et al 2009a). Also studies in larger groups (Keil and Sambraus 1996, Waiblinger et al 2010) arrived at similar results additionally supporting the validity of results of the present study.

2.4.2 Social behaviour

Hornless goats interacted agonistically more often in general and also more often with body contact than horned goats which is in line with predictions and other studies (Müller 2006, Aschwanden 2008a, Nordmann et al 2011). Yet, hornless animals also interacted more often without body contact and without displacement than horned ones; the latter being in line with findings of Barroso et al (2000), the former contradicting earlier studies (Müller 2006, Aschwanden 2008a).

Dominance hierarchies in groups have the function of reducing frequent fights for limited resources by clearly regulating access to these resources (Fraser and Broom 1997, Lindberg 2001). According to the present study horned goats seemed to have a more clearly established dominance hierarchy than hornless goats, as levels of total agonistic behaviour were higher in hornless goats, being in agreement with Keil and Sambraus (1996). Differences in hierarchy could be due to the missing signalling effect of horns (Sambraus 1978) in hornless animals. This may lead to low ranking hornless goats having less respect for social distances of higher ranking individuals than horned goats (Aschwanden et al 2008a), consequently individual distances of high ranking goats are penetrated more often in hornless herds. High ranking goats are displacing intruders leading to higher frequencies of agonistic behaviour, as found in the present study in hornless groups and in other experimental studies comparing hornless and horned groups in feeding situations (Aschwanden 2008a, Nordmann et al 2011). The efficiency of aggressive behaviour is also known to be affected by presence of horns (Barroso et al 2000), possibly resulting in hornless goats retreating slower and more interactions are needed until retreat takes place, respectively, explaining higher levels of interactions without success in hornless goats.

According to previous studies in experimental settings higher levels of agonistic interactions with body contact would be expected in hornless goats (Müller 2006, Nordmann et al 2011). This may also be assigned to differences in dominance hierarchy in relation to presence of horns (Keil and Sambraus 1996) and the signalling effect of horns (Sambraus 1978) allowing horned goats to maintain social distances with agonistic behaviour of low intensity, i.e. threat and avoidance (Collis 1976). In the present study hornless goats tended to interact more often with body contact, supporting this. In cattle hornless animals also seem to interact more often with body contact (e.g. Graf 1974), being in line with the present study. Yet hornless goats also interacted more often without body contact than horned ones, contradicting Müller (2006). A higher level of total agonistic interactions in hornless goats compared to horned ones implies higher levels in other behavioural classes, i.e. agonistic interactions without body contact, possibly explaining these results. Nevertheless the social behaviour of hornless goats (higher numbers of total agonistic behaviour and interactions without success) points toward them having a less stable hierarchy than horned animals.

The only behaviour differing between farms were socio-positive interactions, with higher levels on farm1 than farm2. In sheep behaviour is affected by group size (Jørgensen et al 2009) and in goats the frequency of socio-positive behaviour was found to be negatively correlated with group size (Tønnesen et al 2008). Goats on farm1 spent part of the experimental period in smaller groups (18 to 23 individuals), while all goats on farm2 were kept in large groups (72 to 75 individuals). According to Tønnesen et al (2008) higher levels of socio-positive behaviour could be expected in smaller groups on farm1, explaining the results of this study.

2.4.3 Basic activity

Regarding **feeding** activities groups did not differ during 48h and feeding periods, coinciding with Keil and Sambraus (1996). The precision of scan sampling, the method used for observing basic activity in Keil and Sambraus (1996) and the present study, depends on the duration of the behaviour and the chosen interval, with shorter intervals being more accurate than long ones (Martin and Bateson 1993). Even though the same results were obtained in these studies, it has to be kept in mind that sampling intervals for activities were rather long ranging between 20min (present study) and 60min (Keil and Sambraus 1996).

At night feeding differed between groups and dominance classes, with more horned than hornless goats and more subordinate than dominant goats feeding. Feeding patterns at night regarding presence of horns may be related to horned goats feeding at larger distances throughout the day than hornless goats, which is probably due to differences in groups regarding dominance hierarchy, respect for social distance and efficiency of interactions (Keil and Sambraus 1996, Barroso et al 2000, Aschwanden et al 2008a). Feeding at larger distances may not allow all animals in the horned group to feed sufficiently during the day consequently feeding times are extended into night periods. Regarding dominance status of feeding animals at night, these results are in line with earlier studies in other species (Sherwin and Johnson 1987, Ekman and Askenmo 1984, Brouns and Edwards 1994) with the conclusion that dominant individuals gain prior access to limited resources, e.g. to feed. Therefore subordinate animals may have to switch to feeding at night, in order to satisfy feeding needs, when competition is low and probably no dominant animals are feeding. Even though animals were housed in large groups, which seemed to favour sufficient feed intake of all animals due to less waiting for access to the feed barrier compared to small groups (Jørgensen et al 2009), results suggest that not all animals were able to feed satisfactorily during the day. Furthermore these results indicate that subordinate horned goats are not put at a disadvantage compared to subordinate hornless goats, with regard to feeding.

With respect to feeding the interaction of group*dominance class, however, showed that groups differed according to rank (48h, feeding). Hornless goats assigned to the low dominance class were feeding more often than those assigned to the high dominance class. In the horned group the opposite was observed, with lower levels of feeding in the low dominance class and higher levels in the high dominance class. As differences between dominance classes are distinct in both groups, results are not in accordance with Loretz et al (2004) concluding that differences in classes are less pronounced in hornless than horned goats. Therefore the hypothesis of more pronounced differences between dominance classes in horned compared hornless groups has to be rejected. Results for horned goats coincide with earlier studies on dominance and access to limited resources (Sherwin and Johnson 1987, Ekman and Askenmo 1984, Brouns and Edwards 1994), as discussed earlier. Research on goats concluded that high ranking animals spent most and low ranking ones least time feeding (Loretz et al 2004, Jørgensen et al 2007), irrespective of horn status (Loretz et al 2004), being in line with feeding patterns in horned goats, but not in hornless goats.

In previous research dominant animals in goats and other species were observed to be occupied with defending their individual space and food supply, respectively, rather than feeding when fresh feed was given (goats: Barroso et al 2000; sheep: Sherwin 1990; pigs: Csermely and Wood-Gush 1990, Brouns and Edwards 1994). In this study dominant hornless goats may have also spent more time defending their space than feeding, possible explaining the results of this study. Levels of standing, however, did not differ between dominant hornless and horned goats at the feeding period. Lying though was more often seen in dominant hornless than horned animals. Therefore differences between dominant hornless and horned individuals in feeding have to be assigned to lying activity, rather than standing, i.e. feed defence. Sampling intervals being too long may bias results on standing and feeding activity, but as standing patterns are in accordance with lying patterns, this seems unlikely to have happened in this case. Therefore reasons for these feeding patterns in hornless goats remain unclear for now.

Feeding activity was also influenced by observation period (48h, feeding) and the interaction of group*observation period (night). But no consistent pattern could be seen in reference to resting platforms, therefore other circumstances like goats adapting to environmental conditions, e.g. temperature and variations in feed, may have an impact on results.

Standing was not affected by group, i.e. presence of horns, over 48h confirming Keil and Sambraus (1996) and only in tendency at night with minor differences between groups (hornless goats standing more often than horned goats). During the feeding period, rank affected standing differently depending on the presence of horns. Differences between dominance classes in hornless goats were minor, but those assigned to the low dominance class tended to stand most often. In the horned group differences were more distinct with goats allocated to the high dominance class tending to stand less than those in the middle and low classes. In both groups, however, variation was rather large. High ranking animals seemed to occupy feeding places during feeding times while low ranking ones spent more time waiting until they are able to gain access to the feeding rack (Loretz et al 2004, Jørgensen et al 2007), being in line with this study. Furthermore low ranking animals are more often displaced than dominant ones when feeding (Aschwanden et al 2009a); therefore subordinate animals spend more time standing and walking (both included in standing) in search of an empty feeding place than actually feeding.

Levels of standing tended to vary somewhat across observation periods (48h), but no clear development could be seen. At night levels increased toward the end of the observation period. During the feeding period a higher incidence of standing was seen in the horned group compared to the hornless one after platforms had been available for four weeks (period3), other periods did not differ. Standing patterns, as those in feeding, can not be related to resting platforms and may therefore be influenced by other factors, e.g. environmental conditions, as explained earlier.

Lying, i.e. including lying with contact, was not affected by group, i.e. presence of horns, at any observation period, coinciding with Keil and Sambraus (1996) and Loretz et al (2004) who also did not find any differences between hornless and horned groups of goats in lying activities. At feeding and night periods lying was affected by dominance class or group*dominance class, respectively. At night low ranking goats were seen lying less often than high ranking ones, confirming earlier studies (Bøe et al 2006, Andersen and Bøe 2007, Aschwanden et al 2009a). These results are likely to be due to dominant goats being less often disturbed when lying than subordinate ones (Aschwanden et al 2009a), resulting in shorter lying bouts for low ranking individuals (Bøe et al 2006, Andersen and Bøe 2007). Low ranking goats were also feeding more often at night than high ranking ones, being in line with results of the present study on lying activity. During the feeding period lying in horned goats did not differ between dominance classes, yet, more dominant than subordinate hornless goats were lying at this period. As already discussed in feeding activity high ranking goats are expected to gain prior access to limited feed resources (Sherwin and Johnson 1987, Ekman and Askenmo 1984, Brouns and Edwards 1994) and were therefore expected to use their chance of selective feeding after fresh feed was provided, rather than spending their time lying. Yet differences in groups regarding dominance hierarchy, respect for social distance and efficiency of interactions (Keil and Sambraus 1996, Barroso et al 2000, Aschwanden et al 2008a) may explain results. During competitive feeding situations the costs for defending feeding space and status may be too high for dominant hornless goats and therefore they choose to lie during this period. This would explain feeding and lying patterns of hornless goats during feeding situations, research confirming these predictions, however, has not been carried out yet.

Observation periods did not affect lying during 48h, but during feeding and night periods. As in standing and feeding activities, levels of lying can not be related to resting platforms. Other factors may have influenced results, as discussed in feeding activity.

Lying with contact tended to differ in groups across dominance classes (48h, night). The similarity, however, of high ranking goats lying with contact less often than low ranking ones, irrespective of group (48h, night), is in accordance with Loretz et al (2004). These results may indicate that goats in general prefer to rest at larger distances, i.e. without body contact, having a more individualistic nature than e.g. sheep (Lyons et al 1993, Bøe et al 2006, Andersen and Bøe 2007). Dominant goats are more likely to be able to fulfil their lying preferences than low ranking ones do, as was seen in other studies regarding feeding and resting behaviour (Loretz et al 2004, Bøe et al 2006, Andersen and Bøe 2007, Jørgensen et al 2007, Aschwanden et al 2009a), possibly explaining the results of the present study. Differences between dominance classes in hornless and horned goats in lying with contact were not more distinct in horned than hornless groups, but seemed more pronounced in hornless than horned goats. Therefore these results are contradicting the hypothesis of more pronounced differences in dominance classes in horned groups.

Lying with contact was also affected by observation period (48h, in tendency at night). Immediately after resting platforms were installed the incidence of lying with contact dropped by half (48h, night), four weeks after installation the incidence increased, but was still lower than before installation of platforms over 48h, but not at night, i.e. incidences before and four weeks after installation were similar. Andersen and Bøe (2007) found that lying with contact occurred not as often when lying space is organised on two versus one level, coinciding with the present study. Additional space by providing resting platforms may allow more goats, not only dominant ones, to rest at larger distances, explaining higher levels of this activity when platforms were available. Results also may indicate that goats preferred to do so, as discussed earlier.

Regarding **use of resting platforms** animals accepted them well, confirming the hypothesis on use of platforms. According to observations in this study a maximum of 14 animals, i.e. about 20% of the herd, could rest on platforms provided in the present study and up to 16% were seen. Preferences of dairy goats in relation to surface of lying areas seemed to differ according to ambient air temperature, with straw not being an attractive flooring material at cold and moderate temperatures in contrast to solid wood and rubber mattresses (Bøe et al 2007). In other studies softer floors like straw are preferred to sand or different types of slatted floors (cattle: Manninen et al 2002 (straw - rubber mat with a thin layer of straw, sand without straw); sheep: Gordon and Cockram 1995 (straw - wooden slats); goats Mayer et al 2006 (straw - solid wood)). Wooden resting platforms offered in this study, however, seemed to offer sufficient physical comfort for goats to use them, possibly offering attractive qualities like good views at the surroundings (Bürger 1966). Most goats were either standing or lying (without contact) on top of the platforms, almost none of the animals were seen lying below platforms (with or without contact), possibly due to distances between pen floor and platform being too little. Lying with contact on top was also hardly seen, which may be due insufficient width of platforms (0.6m). When rank was taken into account subordinate hornless goats were lying with contact on top more often than dominant ones. Correlations, however, were low ($r_s<0.200$, $p<0.05$ hornless group) and can therefore be disregarded. In horned goats rank did not influence basic activities related to resting platforms ($p>0.05$). Platforms in general were used irrespective of presence of horns. Rank did only influence us of platforms marginally and can be disregarded as discussed earlier, being in accordance with Andersen and Bøe (2007). Individual differences between goats regarding use of platforms were large, suggesting other factors, e.g. personal preferences of animals (Erhard and Schouten 2001) were determining the use of additional structures.

When resting platforms were available, fewer goats were lying with contact. However, differences in other parameters (standing, feeding, lying activity, feeding place occupancy, body condition, injuries and adrenocortical activity) throughout the observation period could not be assigned to the presence of platforms. The effect of resting platforms on social behaviour could not be investigated in this study due to experimental design and joint statistical analysis of social behaviour for both farms.

As other studies found positive effects of additional structures on feeding, lying and social behaviour (Simantke et al 1997, Andersen and Bøe 2007, Jørgensen and Bøe 2009, Aschwanden et al 2009a, Aschwanden et al 2009b, Ehrlenbruch et al 2010) platforms were expected to have a positive effect on more than levels of animals lying with contact, e.g.

reducing stress and therefore adrenocortical activity. Number of provided resting platforms may not have been sufficient and/or chronic stress may still be present in other areas, possibly explaining the lack of an effect of resting platforms on goat's lying or standing behaviour and adrenocortical activity. Effects of resting platforms in general may be more pronounced when larger areas are offered, allowing more goats to use them simultaneously. As activities tend to be very synchronous in farm animals, including resting patterns, if environmental conditions allow it (Rook and Penning 1991, Fraser and Broom 1997), additional platforms are likely to be used well. Mayer et al (2006) found when a platform construction with three levels was offered to goats, big enough to allow all animals to rest on, they spent up to 40% of the day on the platform construction (including stairs leading to the different levels) and 15-20% on the platform itself (lying area on respective levels), supporting the potential of additional platforms.

2.4.4 Feeding place occupancy

This parameter was only recorded on farm2, with hornless goats feeding more often next to each other, irrespective of time after fresh feed had been provided. Accordingly horned goats fed more often with one empty place in between, confirming predictions of horned goats feeding at larger distances than hornless goats. Yet differences were only seen immediately after fresh feed was given, with horned animals feeding more often at this distance and levelled off in the hours after feeding. Regarding feeding at larger distances, i.e. with two and more than three empty feeding places between animals, horned goats seemed to do so more often than hornless ones, being also in line with predictions. Most goats fed with two and more than three empty feeding places between animals the hours after fresh feed was given, irrespectively of horn status, while levels immediately after fresh feed was given were lowest.

Results on distances at the feeding rack regarding groups are in line with differences in relation to presence of horns regarding dominance order, dominance classes and respect for social distances as already discussed for social behaviour (see 2.4.2). Dominance order seems to be not as strict in hornless goats (Keil and Sambraus 1996), differences between dominance classes not as pronounced in hornless goats (Loretz et al 2004) and respect for social distances higher in horned animals (Aschwanden et al 2008a). The efficiency of an interaction is affected by the presence of horns (Barroso et al 2000) and therefore larger distances in horned goats may also be due to them being able to displace others not only in the pen but also at the feeding rack more effectively. Therefore Loretz et al (2004) also expected to find the same results on distances at the feeding rack as in the present study. Hornless goats, however, kept larger average distances at the feeding rack than horned ones. Loretz et al (2004) also state that low ranking horned goats had to share feeding places quite often in order to avoid getting too close to dominant individuals and still being able to feed, possibly leading to smaller distances on average in statistical analysis. Furthermore differences in analysis, occurrence of zero, one, two or more than three empty feeding places (present study) versus average distances between animals at the feeding rack (Loretz et al 2004), may obtain different results. In the present study animals were housed in large groups (hornless group 75, horned group 72) which offered more space and feeding places in total than in small groups, e.g. ten animals (Loretz et al 2004). Consequently goats in this study had the opportunity to switch between a range of feeding places available, allowing to feed in large distance from a special, high-ranking goat, which is not possible in small groups where there are fewer feeding place options.

Distances at the feeding rack in the hornless and horned group differed also the hours after fresh feed was given, as already explained. Differences, however, were more pronounced immediately after fresh feed was given than one, four or five hours after. This may be related to number of animals feeding; with most goats feeding immediately after fresh feed was provided with higher numbers in the hornless than the horned group. In the experimental study of Nordmann et al (2011) similar results regarding presence of horns was seen, as the number of hornless goats feeding at the same time was higher than in horned goats (40 versus 25%) in small groups of 14 goats. Differences between groups in relation to time after feeding can probably be assigned to the previously discussed issues of dominance hierarchy and social distances differing between horned and hornless goats (Keil and Sambraus 1996, Aschwanden et al 2008a).

In comparison to other ruminant species, goats markedly select feeds leaving lower quality feed components behind (Morand-Fehr 2003), Selective feeding may be limited in total mixed ration (TMR) as given on farm2, yet animals seemed to try and pick the best feed according to their preferences as soon as feed was provided. This may explain why most animals were feeding immediately after fresh feed was given compared to one, four and five hours later, irrespective of horn status. As number of goats feeding declined in the hours after fresh feed was given, goats were feeding at larger distances (two and more than three empty feeding places). The fact that goats were fed only once a day on farm2, may enhance feeding patterns, i.e. distances and number of animals feeding, found in the present study in addition to goats feeding characteristics. Analysis of feeding activity revealed that those goats feeding more often were dominant horned goats, while the opposite was observed in hornless goats. The recorded feeding pattern in horned goats is in accordance with earlier research (Sherwin and Johnson 1987, Ekman and Askenmo 1984, Brouns and Edwards 1994, Loretz et al 2004, Jørgensen et al 2007), as discussed in 2.4.3 (Basic activity), while results in hornless goats remain unclear. Even though around 20 to 50% of animals were feeding up to five hours after fresh feed was given, not all horned and subordinate animals seemed to be able to feed satisfactorily during the day. This is likely to explain more horned than hornless goats and more subordinate than dominant goats feeding at night.

2.4.5 Body condition and injuries

Groups of goats differed in body condition. On farm1 more hornless goats were scored 2.0 and less hornless ones 4.0 compared to horned goats than expected (BCS sternal). On farm2 less hornless goats tended to be scored 3.5 and 4.5 than expected (BCS lumbar). Results on BCS contradict the hypothesis on horned goats having more often lower scores than hornless animals. Regarding injuries groups did not differ in injuries body (total), but occurrence of injuries of the udders was higher in horned than hornless goats. Types of injuries differed according to presence of horns on farm2, confirming the hypothesis on types of injuries being different in hornless and horned groups.

Whether individuals feed according to their needs can be seen among other parameters in the body condition of animals. Determining body condition of farm animals is a tool used worldwide, first developed for dairy cows, in order to prevent diseases and complications in fertility due to animals having too little or too much body fat (von Korn et al 2007). In goats it is more difficult to determine body condition than in cattle, because their depot fat is seldom stored as visible subcutaneous adipose tissue), but mainly in the abdominal cavity (Gall 2001, von Korn et al 2007). To define body condition in goats the lumbar spine and the sternum are scanned manually and scored between 1 (i.e. too little depot fat) and 5 (i.e. too much depot fat) (Hervieu and Mohrand-Fehr 1999). According to Gall (2001) and von Korn et al (2007) animals with scores around 2.5 to 3 are in good body condition.

In the present study more hornless goats were below score 3 and more horned ones above on farm1, while on farm2 fewer animals fitted this pattern. Differences on farm1 could be due to hornless goats spending a larger part of the experimental period in four smaller groups (18 to 23 individuals each) than in one large group (86 individuals), possibly affecting feeding behaviour differently. Jørgensen et al (2009) came to the conclusion that group size affected feeding behaviour in ewes, with more feeding and less time queuing at the feed barrier in large (36 ewes) compared to small groups (nine ewes). In small groups it may be more difficult for all animals to gain access to the feeding rack and to feed sufficiently, than in larger groups. Furthermore production levels were higher on farm1 than farm2 and consequently reduced feeding may be more critical on BCS levels on farm1. If energy needs are not covered, body fat is metabolised (Gall 2001) resulting in lower BCS levels. This may have occurred more frequently in the smaller groups, possibly explaining hornless goats being not as good in body condition as horned ones on farm1. On the other hand differences were found at the sternum (BCS sternal), where body fat is known to be mobilised later than at the lumbar spine (BCS lumbar) (Gall 2001, von Korn et al 2007) and BCS lumbar did not differ between groups on farm1. Furthermore analysis of feeding place occupancy on farm2 revealed that hornless goats were feeding more often at smaller distances than horned goats, being in line with other studies in smaller groups. Consequently hornless goats are likely to satisfy their dietary needs even in small groups. In sum, the lower BCS of hornless goats remains unclear and may be due to individual variation in herds and farm.

BCS was also affected by rank, with dominant animals having higher scores than low ranking ones, irrespective of farm and BCS parameter. When groups were analysed separately, a higher index of success also resulted in higher BCS in hornless goats on both farms. On farm2 a similar correlation was seen in horned animals. On farm1 a higher index of success, however, did not clearly result in higher BCS in horned animals. Dominant animals are gaining prior access to the feeding rack (Brouns and Edwards 1994, Barroso et al 2000), while low ranking goats spend more time waiting and less time feeding (Loretz et al 2004, Jørgensen et al 2007). The results of the present study are in accordance with previous research, except for horned goats on farm1. According to data on feeding place occupancy (only recorded on farm2), however, BCS in hornless goats was not expected to increase with dominance status, as low ranking animals were seen feeding more often than high ranking ones. Contradictory results on feeding activity and BCS may be explained by chosen sampling intervals (20min). These intervals may have been too long, not reflecting and biasing, respectively, the actual feeding situation. To my knowledge no research has been carried out that could help in clarifying the results on feeding activity and BCS, found in this study.

Furthermore results on body condition contradict the hypothesis of larger differences between lower and higher ranking animals, i.e. a more distinct positive association between the index of success and BCS, in horned compared to hornless herds. With respect to farm1 this may be due to the fact that nearly all the animals were able to fulfil their needs (as indicated by BCS ≥2.5 (Gall 2001), ten goats of 90 examined horned and hornless goats with BCS ≤2.5), probably by using different behavioural strategies (Mülleder et al 2003). Horned goats on farm1 spent more time in one large group than in four small ones compared to hornless goats, which may be more in favour of fulfilling the dietary needs of all animals regardless of social status (Jørgensen et al 2009). On farm2 where more goats (47 goats of 240 examined horned and hornless goats) had a BCS ≤2.5 the index of success had similar effects in both horned and hornless groups.

In line with Waiblinger et al (2011), injuries on the body including head, back and body sides (injuries body (total)) no differences between hornless and horned goats were found. Descriptive analysis of single parameters pooled into injuries body (total) showed that on farm1 groups hardly differed, while on farm2 more hornless goats were seen with swellings and crusts than horned ones. Descriptive analysis (data not shown) revealed that levels of agonistic behaviour with body contact were in general higher in farm2 than farm1. This suggests a farm – influence, which will be discussed in detail in the paragraph below Hornless goats tended to interact with body contact more often than horned ones, possibly explaining these results. The interactions with body contact may also be of higher intensity in hornless goats, resulting in larger numbers of animals with swellings, supporting the hypothesis of different types of injuries in hornless and horned goats, as also confirmed in earlier research (Waiblinger et al 2010). Scars accounted for most injuries on both farms irrespective of group, most of them found on ears suggesting that biting into ears is used to defend individual distances and displace other individuals. Numbers of scars hardly differed between groups on farm1, but on farm2 more hornless goats were seen with scars than horned ones, being in agreement with Tölü and Savaş (2007) investigating the social behaviour of mixed (hornless, horned) groups.

Regarding udder injuries (injuries udder (total)) more hornless than horned goats were examined without udder injuries on both farms, but differences throughout examination periods were inconsistent. Analysis of single parameters pooled into injuries udder (total) over examination periods showed that crusts were most common on udders in both groups, followed by scars. Therefore differences between groups in injuries udder (total) can mainly be assigned to the occurrence of crusts. A higher prevalence of crusts in the horned than hornless group may be due to horns being able to cause this type of injury. In hornless goats crusts could only result from biting toward the udder, but this behaviour was very rarely observed in this study. Deep lesions were only found on two horned goats during the experimental period on farm2. Regarding injuries in general, it can not be differentiated whether all observed injuries, especially crusts at the udder, were caused by other animals or originate from physiological reactions, e.g. crusts from healing pustules (pustules were not included in analysis, crusts were).

Farms differed in BCS, with the majority of animals having higher scores on farm1 than 2, and total occurrence of injuries, which was higher on farm2 than 1. These results suggest a farm - influence and also indicate the importance of feeding management. Feeding management on farm1 allowed goats to feed selectively and ad libitum throughout the day due to the provision of sufficient quantities of hay and silage twice a day. On farm2 TMR was fed once a day, reducing selective feeding and not supporting the specific feeding characteristics of goats (Gall 2001). Additionally sometimes problems with the provision of feed occurred and feeding times were delayed or cancelled (these days were excluded from analysis of parameters). Lack of predictability can cause frustration, fuel aggression (Carlstead 1986), subsequently increase competition between animals, when feed is given and also increase risk of injuries. Feeding management according to the needs of animals is an important factor to reduce conflicts and prevent injuries (Noack and Hauser 2004, Waiblinger et al 2010).

2.4.6 Adrenocortical activity

Concentrations of cortisol in milk and cortisol metabolites in faeces were not influenced by group, i.e. presence of horns, with the exception of hornless goats tending to have higher milk cortisol levels than horned ones on farm1. No interaction of presence of horns and dominance class existed, contradicting the hypothesis of more social stress in low ranking horned compared to hornless goats.

The welfare of farm animals is gaining importance and so is the determination of chronic and acute stress, which is known to increase susceptibility to diseases (e.g. de Groot et al 2001). The front-line hormones to cope with stressful situations are glucocorticoids and catecholamines. Glucocorticoids can be determined as a parameter of adrenocortical activity and thus of disturbance (Möstl and Palme 2002). In order to monitor chronic stress in farm animals analysing faecal samples is a valuable tool, using the advantages of a non-invasive and easy sampling technique (Mormède et al 2007). Furthermore diurnal variation in cortisol secretion and minor short term fluctuations are dampened (Palme et al 2003). Cortisol metabolite concentrations in goat faeces reflect adrenocortical activity 11 to 13 hours prior to sampling (Kleinsasser et al 2010), thus the sampling procedure itself (handling of goats) does not affect values. In species used for milk production e.g. dairy cows, analysis of cortisol concentration in milk can also be used to determine acute stress up to two to four hours before collection of samples (Fox et al 1981, Verkerk et al 1998). The circadian rhythm of cortisol concentration in milk is characterized by an early morning peak and a late afternoon elevation (Wenzel et al 2003, Gygax et al 2006), but this pattern was not found consistently in studies in cattle (e.g. Hagen et al 2004).

In the present study hornless and horned groups did not differ with the exception of hornless goats on farm1 tending to have slightly higher cortisol levels in milk compared to horned goats. In an experimental study hornless and horned goats did not differ in cardiac activity in feeding situations and during separation (Aschwanden et al 2008b), suggesting that physiological parameters are not affected by presence of horns per se.

Social status was not very important regarding adrenocortical activity. There was only a tendency on farm2, with low ranking goats tending to have higher cortisol levels in milk. Regarding age, older animals had higher cortisol metabolite levels than younger ones on farm1, contradicting research in cattle (Mülleder et al 2003).

As cortisol concentration in milk reflects acute stress up to two to four hours before collection (Fox et al 1981, Verkerk et al 1998), these data reflect the animals' experiences when being moved into the waiting area and the situation in the waiting area itself. In the present study this process may have led to slightly higher stress levels in low ranking goats compared to dominant ones on farm2, coinciding with research on dominance and access to limited resources (e.g. Barroso et al (2000). Dominance and age seemed to be linked, the correlation, however, is quite weak (farm1 r_s+0.373, p=0.003, farm2 age of animals not available). Older animals were observed to occupy topmost ranks (Sambraus 1978, Barroso et al 2000) consequently results on dominance hierarchy and age are expected to conspire. Yet, it has to be taken into account that goats on farm1 experience their surroundings, e.g. waiting before being milked, differently to farm2, possibly explaining differences between farms.

Contradictory to the results of this study social status in general is often suggested as a major determinant of the animals' neuroendocrine response to social stress (Zayan and Dantzer 1990), with low ranking animals showing an increased activity of the adrenocortical axis (Zayan and Dantzer 1990, Mendl et al 1992). According to Sachser et al (1998) low positions in a hierarchy do not necessarily lead to enhanced endocrine stress responses if circumstances allow all animals to satisfy their needs. For example stable social systems, i.e. no change in group composition, resulting in predictable behaviour and also sufficient space allowance is reducing stress in herds, especially for low ranking individuals (Sachser et al 1998, Mülleder et al 2003). In stable herds with low competition like in beef-suckler cows adrenocortical activity is not affected by social rank (Adeyemo and Heath 1982, Mülleder et al 2003), supporting Wiepkema and Koolhaas (1993) stating that high predictability and controllability of the environment are the basic requirements for low stress levels in animals.

The fact that adrenocortical activity was only affected in tendency by dominance class on one farm and not by the interaction of group*dominance class, indicates that stress levels were marginally determined by social status and that subordinate horned goats were not experiencing more stress than subordinate hornless ones. Even though group composition was not stable on farm1, animals seemed to have established a dominance hierarchy allowing all animals to fulfil their needs sufficiently, by the time observations took place. According to literature e.g. Keil and Sambraus (1996), Aschwanden et al (2008a), and results of the present study showing differences between hornless and horned animals in social and basic behaviour, feeding place occupancy and types of injuries, presence of horns is expected to affect stress levels also. As group, i.e. presence of horns, did not influence adrenocortical activity, characteristics of hornless and horned groups are likely to still allow all animals, irrespectively of horn status and rank, to satisfy their needs and to experience their environment as being predictable and controllable.

Sampling period also influenced adrenocortical activity. Differences in cortisol (metabolite) concentrations in milk and faeces, however, were inconsistent between sampling periods and can therefore not be related to resting platforms (farm2), contradicting the hypothesis of platforms reducing adrenocortical activity. As already discussed in 2.4.3 (Basic activity), additional structural elements positively affected behaviour in several studies, e.g. by reducing aggression levels and displacements in the lying area and at the feeding rack leading to increased feeding and lying times (Simantke et al 1997, Andersen and Bøe 2007, Jørgensen and Bøe 2009, Aschwanden et al 2009a, Aschwanden et al 2009b, Ehrlenbruch et al 2010). The positive effects of resting platforms may also reduce stress levels, i.e. adrenocortical activity. In this study, however, only the variation of lying with contact throughout the experimental period was in line with the presence of resting platforms (less goats lying with contact when platforms offered). Results of this study could be due to too little resting platforms being provided and/or chronic stress being still present in other areas. Therefore the influence of platforms may be more pronounced, if more of them are provided allowing a larger number of animals to use them simultaneously.

Steadily rising cortisol levels in milk throughout observation periods on both farms suggest physiological influences. In dairy cows stage of lactation has been found to influence concentration of milk cortisol, with highest concentrations of milk cortisol in early lactation (Fukasawa et al 2008), not supporting the results of the present study. Hagen et al (2004) did not find milk cortisol related with day of lactation, again contradicting Fukasawa et al (2008). Milk protein content seems to be correlated negatively with cortisol levels in milk (Fukasawa et al 2008), but protein levels in milk are rising after the first third of lactation in cattle and goats (Gall 2001, Bömkes 2004). Therefore they were presumably also rising in the experimental period on both farms, irrespectively of goats being in their last third of lactation (farm1) or mid lactation (farm2) when being part of the study. Consequently results on milk cortisol can not be explained by earlier studies in cattle (Bömkes 2004, Hagen et al 2004, Fukasawa et al 2008), which could be due to characteristics of cortisol in goat milk differing from that in cows milk or due to other physiological processes.

2.5 Conclusion

In hornless groups the individual distances of higher ranking animals seemed to be more often violated as compared to horned groups, leading to differences in social behaviour (higher levels of total agonistic interactions, interactions with body contact and without displacement in hornless groups) and hornless goats feeding at smaller distances than horned goats. Lower levels of agonistic interactions in horned goats, which may be interpreted as higher respect of individual distances, did, however, not seem to be associated with higher stress levels, as indicated by faecal cortisol metabolites and milk cortisol. The occurrence of injuries on top of the body was not related to the presence of horns and BCS was only marginally influenced by horn status. The risk of injuries on the udder, however, seemed to be higher in horned goats. Resting platforms were used frequently, irrespectively of horn status and rank, reducing lying with contact. According to these results large groups of dairy goats can be successfully housed without negative implications on welfare, irrespectively of presence of horns. Sufficient feeding space should be provided, especially for horned animals. Indications also point toward the importance of adequate feeding management in general in order to support body condition, reduce agonistic interactions and the risk of injuries. Further research is needed to support this thesis by investigating large hornless and horned groups without changes in group size and additional repetitions, validating these results.

Overview on hypotheses and results:

- *levels of agonistic interactions in total are expected to be lower in horned goat groups compared to hornless groups, due to a more clearly established dominance hierarchy in horned herds. →* **Yes**
- *levels of agonistic interactions with body contact are also expected to be lower in horned goat groups compared to hornless groups, due to horned low ranking goats respecting social distances of higher ranking goats more. →* **Yes**
- *horned goats are expected to feed at larger distances than hornless goats, due to horned low ranking goats respecting social distances of higher ranking goats more. →* **Yes**
- *horned goats are expected to have more often lower BCS than hornless goats, due to feeding at larger distances and therefore allowing not all horned goats to feed sufficiently. →* **No**
- *types of injuries are expected to differ between horned and hornless goats, as horns are causing different types of injuries compared to horn buds (sharp versus blunt trauma) and hornless goats are expected to interact agonistically more often with contact than horned ones. →* **Yes**
- *adrenocortical activity is expected to be higher in low ranking horned than hornless goats, due to dominance classes being more clearly established in horned herds, resulting in low ranking horned animals not gaining sufficient access to resources and therefore increasing stress levels in low ranking horned goats. →* **No**
- *differences in parameters between low and high ranking goats are expected to be more distinct in horned groups, due to a more clearly established dominance hierarchy in horned herds and horned low ranking goats respecting social distances of higher ranking goats more. →* **No**
- *resting platforms are expected to be used frequently, reduce social conflicts and therefore stress, by offering additional space and allowing especially low and middle ranking animals to retreat from dominant individuals. →* **Partially supported**

3 Introducing young dairy goats into the adult herd: effects on behaviour, adrenocortical activity, body condition and injuries

3.1 Introduction

Wild or feral goats live in relatively stable herds, based on female family groups (Sambraus 1978, O'Brien 1988 a review). That is, female offspring staying within the group of origin, with their mother and siblings, while only male goats leave their group. On dairy goat farms, however, young animals are generally reared separately from adult animals, due to economic reasons and introduced into the adult herd after several months of separation, usually when being pregnant or after first parturition. The social structure of goat herds (as in other social animal species) is characterized by an established (quite strict) dominance hierarchy (Addison and Baker 1982, Keil and Sambraus 1996, Barroso et al 2000, Coté and Festa-Bianchet 2001). Changes in group composition, be it mixing of unfamiliar animals, or introducing few unfamiliar animals into an already established larger herd, disrupts the social structure and requires the establishment of new dominance relationships.

Consequently, increased levels of agonistic behaviour after mixing are observed (e.g. review in cattle: Bøe and Færevik 2003, in goats: Addison and Baker 1982, Alley and Fordham 1994, Fernandez et al 2007, Andersen et al 2008) leading to an increased risk of injuries (Menke et al 1999, Menke et al 2000). Bøe et al (2006) and Jørgensen et al (2007) state that in general high levels of chasing, fighting and displacement from resources in a group of animals may indicate social stress, leading to reduced access to feed, water and attractive lying areas and also reduced time for rest (Andersen et al 1999, Bøe et al 2006, Andersen and Bøe 2007). The mixing of animals therefore also leads to a change in basic activity. Feeding (Schwarz and Sambraus 1997, O´Driscoll et al 2006, Slavnitsch 2008, von Keyserlingk et al 2008) and lying (Raussi et al 2005, Slavnitsch 2008) are reported to decrease, while number of standing animals increase (Raussi et al 2005, Slavnitsch 2008) after introducing unfamiliar animals. Also in relation to this mixing physiological stress reactions lead to reduction of milk yield and growth (Stookey and Gonyou 1994, Hasegawa et al 1997, Fernandez et al 2007, von Keyserlingk et al 2008) as well as suppressed immune response (Tuchscherer et al 1998, de Groot et al 2001).

The level of stress experienced during integration may depend on different animal-related and management factors. Regarding animal-related factors the early social environment and previous social experiences may influence the way animals deal with regrouping situations and encounters with unfamiliar animals. Research in cattle indicates differences between artificially reared animals and those raised by their mothers with respect to social behaviour and their position within the dominance hierarchy later in life (Le Neindre 1991). The different social environment during a period potentially important for socialisation may lead to long-term effects in reactions to social challenge also in goats, as can be expected from other species (Sachser et al 1998). Regarding management, research in cattle revealed contradictory results on single versus group introductions (Knierim 1999, Menke et al 2000). When single heifers and a group of heifers (three animals) were introduced, no differences in agonistic interactions of resident cattle toward introduced heifers were found (Knierim 1999). Feeding activity in introduced heifers, however, indicated higher stress levels for single heifers than group heifers: four out of eight single heifers did not feed on the unfamiliar type of feeding rack the first day, while all but one group heifer out of 15 succeeded. Menke et al (2000), however, recorded higher levels of aggression toward unfamiliar heifers and within resident animals when heifers were introduced in groups (three animals) compared to single animals (Menke et al 2000), contradicting Knierim (1999).

Different reproduction stages (pregnancy, lactation), may also affect responses, due to a different hormonal status in pregnancy and lactation, respectively (Gall 2001). Hormones are known to be a major mechanism ensuring coordination between individuals (Adkins-Regan 2005) influencing among other factors social behaviour (Hurnik et al 1975). Schwarz and Sambraus (1997) reported on an observation in one dairy goat herd where social agonistic interactions were more frequent when a group of young goats was introduced into a herd during pregnancy compared to a group introduced after parturition. Some dairy goat farmers, as well as dairy farmers, report reduced fights when grouping animals shortly after parturition compared to other reproductional stages.

Responses to introductions may also be influenced by the presence of mothers for those young goats reared by their mothers as long term social bonds are reported between closely related individuals, e.g. mother and offspring, in sheep and cattle (sheep: Napolitano et al 2008, Hinch et al 1990; cattle: Veissier et al 1990a, Lazo 1994, Murphy et al 2000). Therefore in case of recognition the presence of the mother may reduce experienced stress in young goats as observed in other species (Mendoza et al 1974, von Holst 1990).

The aim of this experiment was to compare social stress in differently reared young dairy goats (artificially or with their mothers) during the first week after introduction into a herd of adult goats either during the dry period of the herd (i.e. both young goats and adult goats in the herd being pregnant/DRY) or after parturition (i.e. all animals where lactating and with their kids/KIDS). Social behaviour, basic activity, injuries and adrenocortical activity indicating social stress of young dairy goats were recorded. As changes in feeding behaviour implicate effects on weight and body condition of animals, these parameters were also recorded. Furthermore neighbours of introduced goats were noted down, in order to determine whether animals disperse at random or not (Sibbald et al 2005). Cohesion within groups can vary with the degree of familiarity (Bouissou and Andrieu 1978, Boissy and Dumont 2002) and may be additionally affected by different levels of social stress.

The following hypotheses were tested:

- *when young goats are introduced in KIDS, i.e. after parturition when kids are present, lower levels of social stress for young goats are expected, due to different hormonal stages in pregnancy and lactation. This is indicated by*

  lower levels of agonistic behaviour,

  less disturbance of feeding or lying,

  less weight reduction and declining body condition,

  lower increases of cortisol metabolites in faeces (reflecting basal glucocorticoid levels) and

  greater dispersion of young goats into the herd without staying close together.

- *young goats reared by their mothers are expected to cope easier with introductions than ones reared artificially, due to a different social environment potentially influencing reactions in novel social situations.*

- *presence of mother is also expected to influence how young goats reared by their mothers cope with introductions, with easier coping for those young goats reared with their mothers. As mothers and their offspring are known to be important bonding partners, in case of recognition mothers are expected to offer support and reduce stress for young goats.*

3.2 Methods

3.2.1 Animals, housing and management

The experiment was performed with dairy goats (German Improved Fawn breed) of the Institute of Organic Farming (Johann Heinrich von Thünen Institute, Federal Research Institute for Rural Areas, Forestry and Fisheries), Trenthorst, Germany, from November 2008 to April 2009. 75 adult dairy goats formed the lactating herd, with average milk yields of 570kg/animal/year (3.4% fat, 3.0% protein) and average age of 4.4±1.64 years (range: 2.7 - 7.7 years). Adult goats were separated into two groups of 36 animals three months (first of September 2008) before the start of the experiment. Groups of adult goats were balanced for milk yield, age and presence of horns (group1: two polled animals, group2: one polled animal; all others horned). The composition of these groups did not change until the end of the experiment. The two groups were housed in a deep litter system (5.0m²/adult goat (group1), 5.4m²/adult goat (group2)) with a wooden palisade feed barrier with 36 feeding places (1.0 feeding places/animal) in each group (width 40cm) and separations in the head zone. Each group had access to a drinking trough, mineral blocks and a brush. As soon as the kidding started an area only accessible for kids with two hayracks within the group was also provided. All goats were kidding in their group and then separated within their group with their kids by using iron bar elements. After five to seven days metal elements were removed again and goats were milked. In group1 63 kids were born, while in group2 58 kids were born. Number of goats losing their offspring ranged between five (group1) and seven (group2).

Mating took place in September and October; the adult goats were dried off at the end of November (one day before the experiment started), and the kidding period started in February and ended at the beginning of March. Goats were milked twice daily for about two hours (one hour/group) in a ten aside milking parlour. The waiting area provided 0.9m²/animal. Adult goats were fed with fresh hay at 8.00am in the dry period and at 8.30am during lactation. At 12.30 and 5.00pm remaining hay was pushed towards the feeding rack again and about three weeks before expected birth concentrate feed was added (2x250g/day and animal).

32 young goats were kept in one group before the start of the experiment (age at start: 1.8 years). Rearing of these young goats differed during the first 45 days of life, where 17 of them had been reared with their mothers (all young goats horned) and 15 were reared artificially with automatic milk feeders from day5 of birth (all young goats horned except one). After 45 days post partum all young goats did not have any contact with adult goats until the start of the experiment and were kept as one group either on pasture until the end of February or in a separate part of the barn thereafter. Animals had access to hay racks offering hay ad libitum and a drinking trough. On pasture a calf shelter was provided. To ensure constant group size and composition of the adult goat group1 and 2 during introductions, mating in young goats started after mating of adult goats was finished, and ended at the beginning of December. Kidding procedure in young goats was equivalent to adult goats and took place between middle of March and the beginning of April.

3.2.2 Experimental design

Young goats were introduced in eight groups of four animals each, half of them when all goats were pregnant and not milked (introduction period DRY, two repetitions) and the other half shortly after parturition when all goats were lactating and with their kids still present (introduction period KIDS, two repetitions). Always in parallel one group of young goats was introduced into each of the adult goat herds (Tab. 14). Overall, four groups of young goats were introduced into each of the two adult groups, two during DRY and two during KIDS. Young goats were introduced at midday (day1) and stayed in their respective adult group for seven days. After removal from the adult goat group on day7 they were not returned to the original young goats group but kept separately. Time between repetitions in DRY and KIDS was seven days (Tab. 14, Tab. 25 in Appendix). Young goats were allotted to adult groups of goats balanced for rearing (artificial, mother reared) within young goat groups (Tab. 14). Young goat twins were separated resulting in one animal having its mother present in the group of adult goats and the other one not.

According to mating periods kidding in adult goats was finished before young goats' kidding started in order to avoid changes in group composition in the experimental phase. Therefore adult goat kids were older (median 52±8.74 days, range (26-62) at the beginning of KIDS) than those of young goats (median 12±4.06 days, range (six-19) at the beginning of their respective introduction). In order to be able to introduce four young goats with their kids into each of the adult goat groups at the same time (i.e. eight young goats in total) it was inevitable to have to wait until eight of them had given birth before the introductions could begin. Consequently the age of the introduced kids of young goats ranged between six and 19 days.

Space allowances in DRY ranged between 4.5m²/animal in group1 and 4.8m²/animal in group2. In KIDS space allowance for the goat herd was smaller (due to the separated kid area where kids could rest and feed undisturbed): 4.3m²/goat (adult and young goats without kids) in group1 and 4.5m²/goat in group2. In both groups 0.90 feeding places/animal were offered.

Tab. 14: Time line of the experiment and distribution of young goats in adult goat groups (1, 2) with different rearing history over introduction periods (DRY, KIDS) and repetitions (1, 2) within introduction periods. Numbers in rearing columns refer to number of young goats being reared artificially (a) and with their mothers (m), while numbers in presence of mother columns refer to numbers of mother reared young goats being in the same group as their mothers.

		adult goat group1		adult goat group2	
time line (weeks)	introduction period – repetition	rearing	presence of mother	rearing	presence of mother
1	DRY -1	2 a, 2 m	1	2 a, 2 m	1
2					
3	DRY -2	2 a, 2 m	0	2 a, 2 m	1
4 to 16					
17	KIDS -1	2 a, 2 m	1	1 m, 3 a	1
18					
19	KIDS -2	2 a, 2 m	2	2 a, 2 m	2

3.2.3 Behavioural observations

3.2.3.1 Social behaviour

Social behaviour of introduced young goats was recorded on each of the seven days from 12.00-2.00pm, 2.30-4.00pm and 5.30-7.30pm (day1 = day of introduction), 8.30-10.30am, 1.00-3.00 and 5.30-7.00pm (day2 to 7) by direct observation (Tab. 25 in Appendix). The observer was located on a heightened seat at the feeding area in between the two groups of adult goats; observations on day1 started immediately after goats were introduced. To be able to identify all goats individually, all animals were marked on their sides and back with animal markers (young goats) or hair dye (adult goats) before introduction.

Agonistic and socio-positive interactions were observed by continuous focal sampling using a net book with the observational software The Observer 5.0, Noldus, NL. The focal animal was changed every four min in always the same order, alternating between the two groups of young goats that have been introduced in parallel from day2 to 7. On day1 both groups were observed simultaneously by an additional observer. Thus each young goat was observed for 64 min on day1 and 32 min per day on day2 to 7, respectively. Observations started each day with a different young goat (day1 to 7) and adult herd (day2 to 7). For each interaction actor (goat initiating interaction) and receiver (goat being target of interaction) were recorded. For socio-positive interactions the minimum bout length was three seconds and if the behaviour paused for more than ten seconds a new event was noted down. Goats lying with body contact is also considered a socio-positive interaction of high importance (Schino 1998, Tønnesen et al 2008) and recording of this behaviour took place with the observation of basic activity.

The following agonistic behaviours were recorded:

Butt: A goat hits any part of the body of another goat, except the head, with her forehead/horn base but without an upward swing.

Horn kick: A goat performs a quick upward swing with her head and hits another one with the end of her horns or - in hornless goats - forehead. All extremities of the other goat stay on the ground.

Lift: A goat performs a quick upward swing with her head and hits the body of another goat with the end of her horns or - in hornless goats - forehead and lifts the receiver partly or totally. At least one extremity of the receiving goat loses contact to the ground.

Stroke: When animals are feeding or standing close interactions of little intensity occur, these are sideways head movements toward the neighbouring goat. In horned animals often only the horns of the involved animals are touching. This movement is similar to a butt or kick due to the proximity of the animals but not as intense.

Bite: A goat bites another one at any part of the body, except vulva or anus.

Push: A goat pushes another one away from the feeding barrier using her shoulder or neck/head.

Threat: A goat directs her horns, displays another threatening posture, indicates biting, or moves her head or body quickly towards another goat.

Avoid: A goat retreats, if another one is approaching. In case of feeding she leaves her feeding space without any visible agonistic behaviour demonstrated by the approaching goat. The avoiding movement itself can be either slow or fast. In case of avoiding the animal walking away was recorded as receiver and the goat she avoided as actor.

Clash: Both goats face each other and strike forward, making contact either with their horns or - in hornless goats - forehead; the animals may rear onto their hind legs before clashing.

Fight: two or more goats are facing each other standing or circling each other; butts, horn kicks and levering out may occur during fighting. For fights the minimum bout length was three seconds and if pauses lasted longer than ten seconds a new event was noted down.

The following socio-positive interactions were recorded:

Lick, nibble: A goat licks or nibbles at the body of another goat, except vulva or anus, using her tongue, teeth or lips.

Rub: Slow cautious rubbing of the head at any body part of another goat, except vulva or anus. The receiving goat does not withdraw.

Lean against each other: A goat leans or rests her head/bottom jaw against any part of the body of another goat. The receiving goat does not withdraw.

For further analysis interactions were grouped into the following four classes and the number of interactions/animal/hour and day calculated:

agoPhysRec: agonistic interactions where clear physical contact was observed, i.e. sum of butt, horn kick, lift, stroke, bite, push and clash with the young goat as receiver.

agoNonPhysRec: sum of avoid and threat with the young goat as receiver.

agoPhysAct: agonistic interactions where clear physical contact was observed, i.e. sum of butt, horn kick, lift, stroke, bite, push and clash with the young goat as actor.

agoNonPhysAct: sum of avoiding and threat with the young goat as actor.

positiveTotal: sum of lick, nibble, rub and lean against each other with the young goat as either actor or receiver.

Fights were not analysed further due to little occurrence (14 fights, total number of interactions 3479) during the total experimental period. PositiveTotal was only observed 28 times (total number of interactions 3479) during the total experimental period, and was therefore only analysed descriptively.

3.2.3.2 Nearest neighbours

The observation of the two nearest neighbours was linked to the observation of social behaviour on 28 days throughout the experimental period (Tab. 25 in Appendix). The nearest and second nearest neighbours of all young goats were recorded on seven days for every introduction using scan sampling (ten min intervals, 220 scans in total, after every second focal animal observation). The head of animals was taken as point of reference. In case of young goats feeding the animal feeding closest to the right and to the left of the young goat, respectively, were noted down as neighbours.

For further analysis the proportion of young goats as nearest or second nearest neighbour in relation to scans was calculated, i.e. number of scans with young goats as nearest or second nearest neighbour / total number of scans × 100). The proportion of mothers as nearest or second nearest neighbour of mother reared young goats in relation to scans was also calculated, i.e. number of scans with mother as nearest or second nearest neighbour of mother reared young goats / total number of scans × 100)

3.2.3.3 Basic activity

Basic activity of all animals (adult and young goats) was recorded using scan sampling (ten min intervals) over 24h on the first day (day1) and the last day (day7) of each introduction

(Tab. 25 in Appendix). To be able to observe animals at night lighting in the barn was used and was switched on two days before each observation for habituation. Behaviour of goats was recorded as either standing, feeding (= head in feeding barrier), lying no contact (= lying without touching an adult or young goat except a kid) or lying with contact (= touching of the body of one or more other adult or young goats, contact to a kid was ignored). Lying no contact and lying with contact was summed up into lying for further analysis.

Basic activity was analysed for the total observation time (24h), for night periods (9.00pm-5.00am: night) and during two feeding periods (two hours just after remaining hay was pushed toward the feeding barrier again: feeding period (old); and two hours after fresh hay was fed: feeding period (fresh)). The basic activities of standing, feeding and lying were analysed for all periods, lying with contact (i.e. lying with contact only) was only calculated for 24h and night periods. Due to relevance and low occurrence lying with contact was not looked at in feeding periods, for more details see 3.3.3. Basic activity.

3.2.4 Body condition, injuries and weight

All young goats were examined and weighed the hours directly before being introduced into the adult herd (day1) and immediately after they were taken out of the adult herd (day7) again (Tab. 25 in Appendix). Body condition score was taken from young goats of the lumbar spine (BCS lumbar) and sternum (BCS sternal), ranging from 1 to 5 (Hervieu and Mohrand-Fehr 1999).

Regarding injuries, the inspection of young goats was divided into examination of the abdominal side including the udder (examination abdomen) and the rest of the body including head, back and body sides (examination body). The abdominal side and udder were visually inspected by using a hand mirror and a torch, the rest of the body was visually inspected and manually scanned (palpation).

In the case of occurrence of injuries a description of the type of injury was recorded:

- type of injury: crust, deep lesion, scar, swelling, callus
- size: >3cm, 1-3cm, <1cm
- shape: horizontal, vertical, v/l shaped, circular, punctual
- location:

  examination abdomen: thorax (ventral), abdomen (ventral), udder
  examination body: head, horn base, ears, neck, thorax (dorsal), abdomen (dorsal), pelvis, tail, front and hind limbs

Injuries were not analysed further due to low occurrence; three injuries were recorded (i.e. three animals) in total in DRY and KIDS. For analysis weight loss and changes in BCS were calculated, i.e. weight and BCS of young goats at the end of introduction (day7) minus before introduction levels (day1).

3.2.5 Adrenocortical activity

The analysis was based on faecal samples of young goats taken between 4.30-5.30pm. About 1g was taken rectally on two successive days, two days and one day before introduction (baseline, day-2 and day-1) and on the third, fifth and seventh day of introduction (day3, day5, day7) (Tab. 25 in Appendix). Samples were put on ice immediately and stored at -20℃ after samples of all goats were collected. Later they were thawed and after an extraction procedure (0.5g faeces with 5ml of 80% methanol (Palme and Möstl 1997)) the concentration of cortisol metabolites was determined using a group specific 11-oxoaetiocholanolone enzyme-immunoassay (EIA), first described by Möstl et al (2002). This EIA has been successfully validated for measuring adrenocortical activity in goats (Kleinsasser et al 2010).

3.2.6 Statistical analyses

Statistical analysis was performed using the program PASW Statistics 17.0. General linear mixed models (GLMM) were used to analyse basic activity, weight loss, social behaviour (agoPhysRec, agoNonPhysRec, agoPhysAct, agoNonPhysAct) and cortisol metabolites.

For analysis of basic activity two GLMM were calculated: a model with data of young goats only and a model with data of adult and young goats. The young goats only model was calculated to allow investigating the effect of rearing and presence of mother. The young goats only model included the fixed factors of introduction period (DRY, KIDS), rearing (artificial, with mother) and in case of rearing with the mother presence of mother (yes, no) and the random effects of identity of the mother (young goats with same identity of the mother were twins), group of adult goats (1, 2) and young goat within the young goat group (each introduced group of young goats was numbered ranging from one to eight). Weight at the start of the introduction was included as a covariate factor. For GLMM analysis of basic activities of adult and young goats age (adult, young goat), day (day1, day7), introduction period and age*introduction period were included as fixed factors and individual young goats and group of adult goats as random effects.

Weight loss was analysed using the same model as for basic activity of young goats only with introduction period, rearing and in case of rearing with the mother presence of mother as fixed factors. As random effects, identity of the mother, group of adult goats and young goat within the young goat group were chosen.

Social behaviour and cortisol metabolites were analysed with introduction period, rearing and in case of rearing with the mother, presence of mother as fixed factors. For cortisol metabolites introduction period*day of sampling (-2, -1, 3, 5, 7 days of sampling) was included as a fixed factor additionally. As random effects, identity of the mother, group of adult goats and young goat within the young goat group were chosen, weight at the start of the introduction was included as a covariate factor. For social behaviour day of introduction (day1 to 7) and for cortisol metabolite analysis day of sampling were used as repeated measures.

To check for the possible effects of repetition, all parameters were analysed separately for introduction periods (DRY, KIDS) using the same GLM-models and procedure as described above, except for replacing the fixed factor introduction period with repetition (1, 2).

Not significant fixed and random effects were step by step excluded; p-values of identity of the mother and group of adult goats were always excluded due to $p>0.05$. Yet the fixed effects of introduction period, rearing and presence of mother and the random effect of young goat within the group of young goats were retained irrespective of p-values. Residuals were checked graphically for normal distribution, homogeneity of variance and outliers. In order to fulfil essential criteria in residuum analysis data were transformed where necessary.

BCS lumbar, BCS sternal and socio-positive behaviours (positiveTotal) were analysed descriptively. Agonistic behaviours (agoPhysRec, agoNonPhysRec, agoPhysAct, agoNonPhysAct) were additionally analysed descriptively per day (day1 to 7) for DRY and KIDS, in cortisol metabolites differences between mean base levels (day of sampling -2, -1) and mean levels of following sampling days (day 3, 5 and 7) were calculated for DRY and KIDS and analysed descriptively.

For analysis of the nearest and second nearest neighbour of young goats a general linear model (GLM) was used. Number of scans when a young goat was recorded as the nearest and second nearest neighbour, as well as number of scans when the mother of a mother reared young goat was recorded as a neighbour, were analysed. Introduction period, rearing, in case of rearing with the mother, presence of mother, group of adult goats and introduction period*group of adult goats were included as variables. Furthermore it was tested for each young goat, if she had other young goats as a nearest and second nearest neighbour more often than would be expected by chance (model1). For those young goats being reared with their mothers and having their mother present in the group, it was also tested if they had their mothers as a nearest and second nearest neighbour more often than would be expected by chance (model2).

For this purpose Z and p-values were calculated:

Z-value = $(\hat{p} - p_0 / \text{sqrt}\ (p_0 \times (1-p_0)) \times \text{sqrt}\ n$

p-value = σ (Z-value)

$\hat{p}$: proportion of young goats as nearest or second nearest neighbour (model1)

proportion of mothers as nearest or second nearest neighbour (model2)

p_0: proportion of young goats within the total group (= 0.1)

proportion of mother reared young goats with mothers present within the total group (= 0.025)

σ = standard deviation

3.3 Results

3.3.1 Social behaviour

In the total of 3479 interactions recorded, adult goats were involved in 64% of them. The largest part of the observed social interactions were agonistic interactions without physical contact, i.e. threats and avoidance, mostly with young goats as receivers (agoNonPhysRec DRY 71.8%, KIDS 68.0% of total number of interactions) and hardly as actors (agoNonPhysAct DRY 11.9%, KIDS 18.5%, Tab. 15). Agonistic behaviours with physical contact (agoPhysRec DRY 10.1%, KIDS 7.7%; agoPhysAct DRY 5.4%, KIDS 4.5%) and especially socio-positive interactions (positiveTotal DRY 0.6%, KIDS 1.1%) were not observed very often (Tab. 15).

Tab. 15: Number of interactions relative to total number of interaction given in percent and number of interactions for behavioural classes in introduction period DRY (D) and KIDS (K): socio-positive interactions in total (positiveTotal), agonistic interactions with young goats as receivers (agoPhysRec, agoNonPhysRec) and actors (agoPhysAct, agoNonPhysAct).

	positive Total		agoPhysRec		agoNonPhys Rec		agoPhysAct		agoNonPhys Act		total number	
	D	K	D	K	D	K	D	K	D	K	D	K
%	0.6	1.1	10.1	7.7	71.8	68.0	5.4	4.5	11.9	18.5	100	100
number	12	16	211	109	1494	953	114	63	248	259	2079	1400

Statistical analysis for social behaviours revealed that during introduction period DRY young goats were more often target of agonistic interactions without physical contact and tended to be so for agonistic interactions with physical contact (agoNonPhysRec $p<0.05$, agoPhysRec $p=0.059$, Fig. 17, Tab. 16). They also initiated interactions with physical contact (agoPhysAct $p<0.05$) more often compared to KIDS. According to descriptive analysis of behavioural classes, higher incidences were found at almost all days in DRY compared to KIDS (Fig. 18). Rearing and presence of the mother for those animals reared with their mothers did not influence any of the agonistic behaviours (Tab. 16).

When introduction periods were analysed separately, repetitions only differed in DRY. Young goats received and also tended to initiate more agonistic interactions without physical contact in repetition1 than repetition2 (agoNonPhysRec $p<0.05$, repetition1 median 22.50 interactions/animal and hour (range 1.88-63.75), repetition2: 12.19 interactions/animal and hour (0.0-50.63); agoNonPhysAct $p=0.090$, repetition1 0.0 interactions/animal and hour (0.0-30.00), repetition2 0.0 interactions/animal and hour (0.0-9.38))

Tab. 16: Results of general linear mixed model (GLMM) analysis for agonistic behaviour with young goats as receivers (agoPhysRec, agoNonPhysRec) and actors (agoPhysAct, agoNonPhysAct). P-values and F-values are given for fixed variables introduction period (DRY, KIDS), rearing (artificial, with mother) and presence of mother (yes, no). Transformations performed with response variables for statistical analysis are indicated in brackets, N=32.

	agoPhysRec (LG10)		agoNonPhysRec		agoPhysAct (LG 10)		agoNonPhysAct (LG 10)	
	F-value	p-value	F-value	p-value	F-value	p-value	F-value	p-value
introduction period	3.873	**0.059**	5.972	**0.021**	9.146	**0.006**	0.001	0.978
rearing	0.039	0.845	1.153	0.292	1.423	0.244	0.406	0.529
presence of mother	0.005	0.945	0.003	0.960	0.143	0.708	0.465	0.501

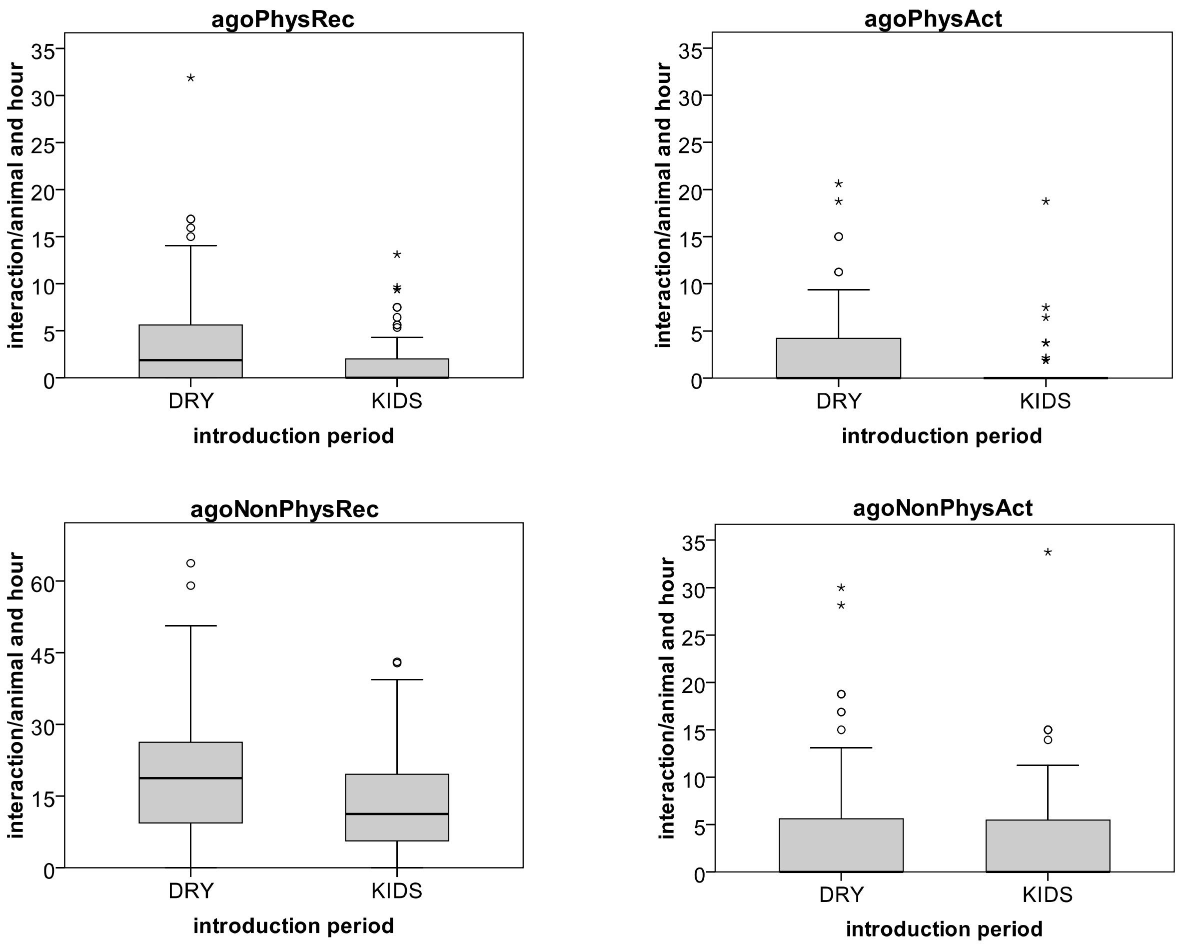

Fig. 17: Frequency of agonistic behaviour with young goats as receivers (agoPhysRec, agoNonPhysRec) and actors (agoPhysAct, agoNonPhysAct) for introduction periods DRY and KIDS given in interactions/animal and hour, based on observed data. N=32.

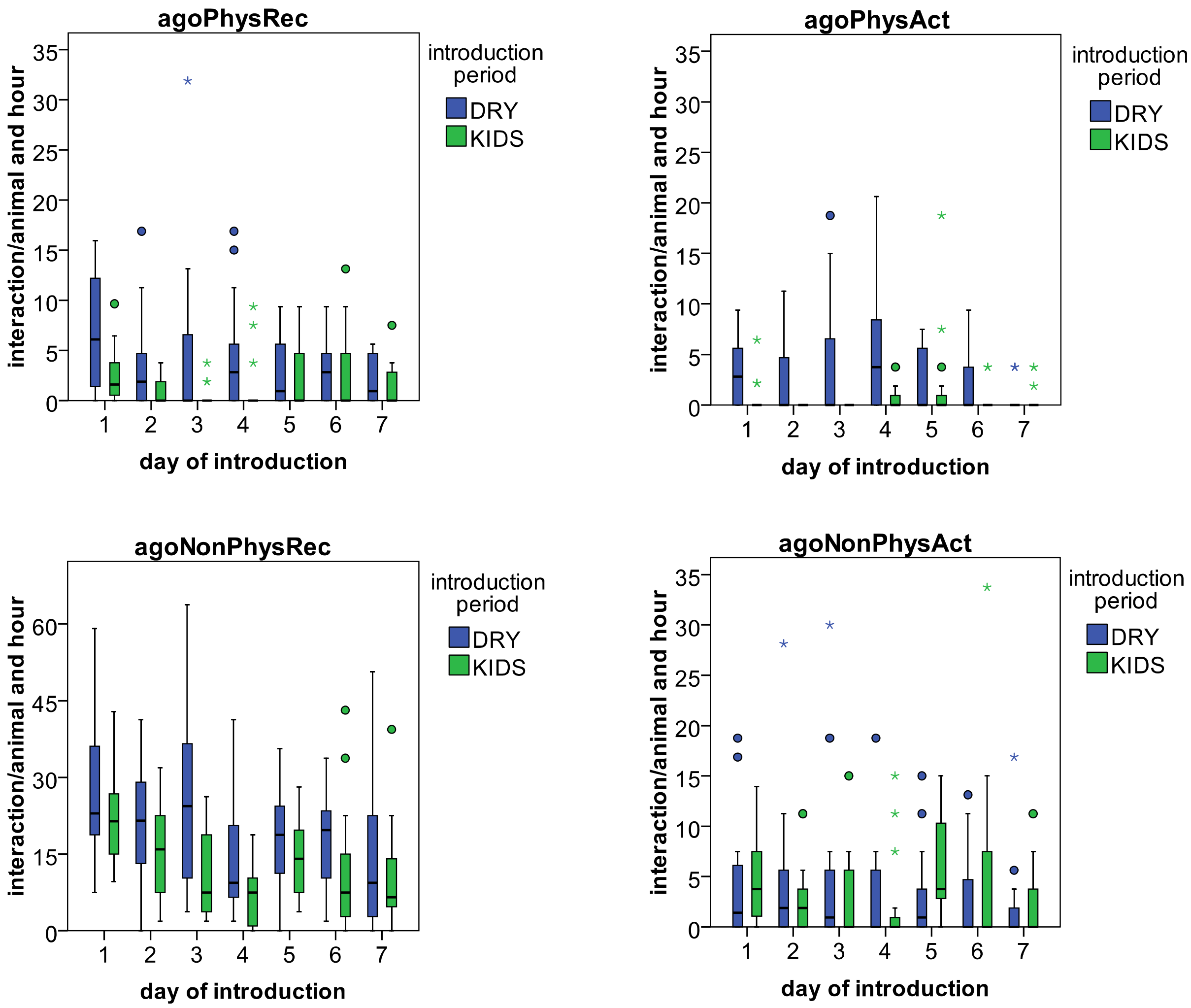

Fig. 18: Frequency of agonistic behaviour with young goats as receivers (agoPhysRec, agoNonPhysRec) and actors (agoPhysAct, agoNonPhysAct) for introduction periods DRY and KIDS in relation to days of introduction (day1 – day of introduction) given in interactions/animal and hour, based on observed data. N=32.

3.3.2 Nearest neighbours

Young goats were each others nearest neighbours on average in 68% (±0.161, range 35-90) and second nearest neighbours for 45% (±0.139, range 24-75) of the scans. In case of mother reared young goats being in the same group with their mothers, mothers were hardly seen as one of the two nearest neighbours of young goats (nearest neighbour 0.9% of scans ±0.893, range 0.0-2.0; second nearest neighbour 0.9% of scans ±0.843, range 0.0-2.7). Statistical analysis confirmed that young goats were each others nearest neighbours more often than would be expected by chance for all individuals ($p<0.001$ for 29 animals, $p<0.05$ for three animals) and second nearest neighbours in most cases ($p<0.001$ for 23 young goats; $p<0.05$ for four animals, $p>0.05$ for five animals, these five animals all were introduced in KIDS). Results of statistical analysis for mother reared young goats having their mothers in the same group did confirm that they had their mothers as nearest neighbour and second nearest neighbour at chance level ($p>0.05$ for all nine animals).

GLM analysis showed that young goats were each others neighbours more often during DRY than KIDS in both groups of adult goats (p<0.05). In KIDS, however, young goats were each others neighbours more often in adult goat group2 than 1 (p<0.05, Tab. 17), while in DRY this parameter did not differ between adult goat groups. Goats reared by their mothers had other young goats as neighbours more often than artificially reared ones (p<0.05, Tab. 17). In case of mother reared goats with their mothers being present young goats were seen as a nearest neighbour (p=0.096), in tendency, and also as second nearest neighbour less often (p<0.05).

Within introduction periods, social behaviour in repetitions did not differ consistently. In DRY young goats were seen as each others neighbours more often in repetition2 than repetition1 (nearest and second nearest neighbour p<0.05; nearest neighbour: repetition1 median 76% (range 67-90), repetition2 83% (60-90); second nearest neighbour: repetition1 52% (44-60), repetition2 66% (51-75)). Yet in KIDS ratio of young goats as neighbours was higher in repetition1 than repetition2 (nearest and second nearest neighbour p<0.05; nearest neighbour: repetition1 61% (47-74), repetition2 49% (35-66); second nearest neighbour: repetition1 43% (32-49), repetition2 33% (24-43))

Tab. 17: Results of general linear model (GLM) analysis of nearest and second nearest neighbours are given for included factors introduction period, rearing, presence of mother, group of adult goats and introduction period*group of adult goats. Estimated means ±SE are referring to proportion of scans with young goats recorded as nearest and second nearest neighbour and are given in percent, N=32.

		nearest neighbour	second nearest neighbour
introduction period	DRY	79±0.008	57±0.010
	KIDS	55±0.009	37±0.008
	p-value	**0.000**	**0.000**
rearing	Artificial	64±0.014	45±0.013
	with mother	72±0.009	50±0.009
	p-value	**0.000**	**0.006**
presence of mother	Yes	66±0.015	45±0.015
	No	70±0.008	49±0.009
	p-value	*0.096*	**0.018**
group of adult goats	group1	65±0.010	45±0.010
	group2	71±0.008	50±0.009
	p-value	**0.000**	**0.000**
introduction period*group of adult goats	DRY group1	79±0.011	58±0.014
	group2	78±0.011	57±0.013
	KIDS group1	48±0.012	32±0.011
	group2	62±0.012	43±0.012
	p-value	**0.000**	**0.000**

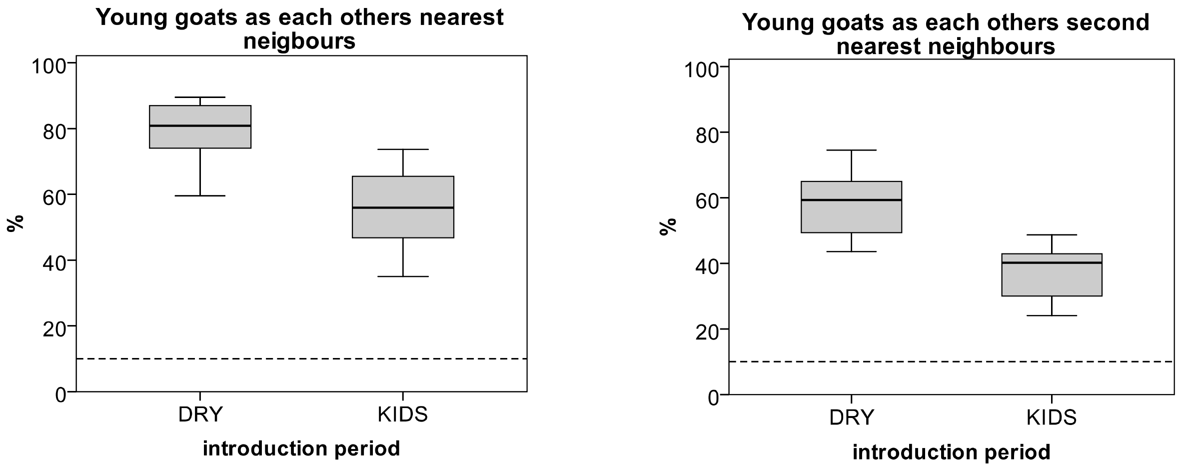

Fig. 19: Proportion of scans with young goats as nearest or second nearest neighbour in introduction periods DRY and KIDS, N=32. The dotted line refers to levels expected by chance.

3.3.3 Basic activity

Analysis of basic activities of **young goats only** showed that introduction period (DRY, KIDS) and rearing (artificial, mother reared) affected some parameters in 24h and night observations. Presence of the mother for those young goats reared by their mother, however, did not affect basic activity at any observation period (Tab. 18).

Levels of **feeding** in young goats were higher during introduction period KIDS compared to DRY at 24h and night periods ($p<0.05$), but not at feeding periods ($p>0.05$, Tab. 18). Rearing and presence of mother did not influence percent of scans were feeding was observed.

Standing in young goats was only affected, in tendency, by introduction period at 24h observations ($p=0.082$), with higher levels in DRY compared to KIDS (Tab. 18). Other factors did not influence standing levels at other observation periods ($p>0.05$).

Percent of scans with young goats **lying**, which includes lying with contact, was only affected by introduction period (night $p<0.05$), with higher levels of lying at night in DRY compared to KIDS. Percent of scans with young goats lying with contact, i.e. lying with contact only, was higher in DRY than KIDS (24h and night $p<0.05$, Tab. 18), being in line with lying activity at night.

Lying with contact was the only activity to be affected by rearing (24h and night $p<0.05$). The percentage of artificially reared young goats lying with contact was lower than in young goats reared by their mothers ($p<0.05$, Tab. 18). Lying in contact for young goats was not analysed for feeding period old and fresh due to relevance and occurrence (feeding period (old) 0.0% (0.0-23.0), feeding period (fresh) 0.0% (0.0-100).

Within introduction periods, some **repetitions** differed. Young goats were observed feeding more often (DRY) and also standing more often (DRY, KIDS) in repetition1 than repetition2 ($p<0.05$ for all; repetition1 / repetition2; DRY: feeding (24h) median 1.7% (range 0.0-7.5) / 0.0% (0.0-2.1); standing (feeding period (old)) 76.9% (31.0-100) / 34.6% (0.0-100); KIDS: standing (feeding period (fresh)) 73.1% (31.0-100) / 38% (8.0-62.0).
Lying was less often observed in repetition1 than repetition2 ($p<0.05$ for all; repetition1 / repetition2; DRY: lying (feeding period (old)) 23.0% (0.0-69.0) / 65.3% (0.0-100); KIDS: lying (feeding period (fresh)) 26.9% (0.0-69.0) / 57.9% (31.0-92.0)).
Lying with contact in young goats did not differ in repetitions irrespective of introduction period ($p>0.05$).

The calculation of the model including data of **adult and young goats** showed that adult and young goats differed in all activities (at least in one of the two introduction periods), except lying (24h) and lying (feeding period (old)), (age $p<0.05$, Tab. 19). Most basic activities were also influenced by introduction period (DRY, KIDS) and/or age*introduction period and day (day1, day7).

Regarding **feeding** activity, an interaction between age and introduction period was found for 24h and night observations ($p<0.05$, Tab. 19). Percentage of scans with adult goats feeding (24h) did not differ between DRY and KIDS, while levels in young goats were higher in KIDS compared to DRY ($p<0.05$, Fig. 20). In adults, feeding (night) was higher in DRY than KIDS, while in young goats it was higher in KIDS than DRY. Thus feeding (night) was only higher in adult compared to young goats in DRY, being in line with 24h observations, but no difference was seen in KIDS. At feeding periods (old, fresh) feeding activity was higher in adult goats than in young goats ($p<0.05$, Tab. 19). In feeding period (fresh) higher levels of feeding activity were seen when kids were present (KIDS) than during the dry period of the herd (DRY) ($p<0.05$, Tab. 19). Towards the end of the introduction (day7) levels of feeding were higher than at the beginning (day1) at all periods ($p<0.05$), with the exception of feeding period (fresh) ($p>0.05$, Tab. 19).

Percentage of scans with animals **standing** was not influenced by the interaction of age*introduction period ($p>0.05$). Adult and young goats, however, differed at all observation periods (age $p<0.05$) with higher levels in young goats compared to adult goats (Tab. 19). In introduction period DRY higher levels of standing were recorded than in KIDS during 24h and feeding period (old) ($p<0.05$, Tab. 19). At the end of the introduction (day7) percentage of scans with goats standing was lower than at the beginning of the introduction (day1) at all observation periods ($p<0.05$), with the exception of the night observation ($p>0.05$).

The activity of **lying** (night) showed a difference in young and adult goats (age*introduction period $p<0.05$, Tab. 19). Adult goats were lying at night more often in KIDS than DRY, in young goats, however, the opposite was recorded (Fig. 20). In feeding period (fresh) lying was observed more often in young goats than in adult ones ($p<0.05$). Introduction period also influenced lying activity, with higher levels in KIDS than DRY over 24h ($p<0.05$) and in tendency also in feeding period (old) ($p=0.057$), in feeding period (fresh), however, higher levels were observed in DRY than KIDS ($p<0.05$, Tab. 19). Lying (night) tended to be higher at the beginning (day1) than towards the end of introduction (day7) ($p=0.087$).

Lying with contact (24h, night) differed between introduction period dependent from the age of goats (age*introduction period $p<0.05$, Tab. 19). This activity, both over 24h and at night, was hardly seen in adult and young goats in KIDS, while in DRY levels for adult goats were also very low, but high levels for young goats were recorded (Fig. 20). Thus adult and young goats differed in KIDS. Due to relevance and low occurrence lying with contact was not looked at in feeding periods for adult and young goats (feeding period (old) 0.0% (0.0-54.0), feeding period (fresh) 0.0% (0.0-100).

Within introduction periods, **repetitions** differed mostly consistently. In introduction period DRY levels of adult and young goats feeding were higher in repetition2 than repetition1 ($p<0.05$; repetition1 / repetition2: feeding (feeding period (fresh)) median 23.0% (range 0.0-77.0) / 30.7% (0.0-100)). In KIDS, however, higher levels of feeding were observed in repetition1 than repetition2 in adult and young goats; as was standing, which was consistently observed more often in repetition1 than 2 in DRY and KIDS ($p<0.05$ for all; repetition1 / repetition2; DRY: standing (24h) 28.9% (12.0-61.0) / 25.5% (4.0-64.0); standing (feeding period (old)) 38.4% (0.0-100) / 23.0% (0.0-100); KIDS: standing (24h) 27.7% (6.0-60.0) / 25.1% (3.0-52.0); KIDS: feeding (24h) 20.8% (0.7-36.6) / 14.5% (0.0-28.2); feeding (night) 8.0% (0.0-26.0) / 6.0% (0.0-26.0); feeding period (old) 23.0% (0.0-62.0) / 15.3% (0.0-69.0); feeding period (fresh) 38.4% (0.0-92.0) / 23.0% (0.0-77.0)).

Regarding lying activity, higher levels were seen in adult and young goats in repetition2 than repetition1 in DRY and KIDS ($p<0.05$ for all; repetition1 / repetition2; DRY: lying (24h) 52.1%

(23.0-81.0) / 55.1% (23.0-96.0); lying (feeding period (old)) 38.4% (0.0-85.0) / 53.8% (0.0-100); lying (feeding period (fresh)) 38.4.1% (0.0-85) / 53.8% (0.0-100); KIDS: lying (24h) 51.7% (17.0-87.0) / 59.3% (26.0-96.0); lying (night) 74.0% (0.0-100) / 78.0% (42.0-100); lying (feeding period (old)) 46.1% (0.0-100) / 51.8% (8.0-100); lying (feeding period (fresh)) 46.1% (0.0-100) / 53.8% (8.0-100)).
Lying with contact did not differ in repetitions in adult and young goats irrespective of introduction period ($p>0.05$).

Tab.18: Results of GLMM analysis for basic activity of young goats. P-values and F-values are given for fixed variables introduction period (DRY, KIDS), rearing (artificial (a), with mother (m)) and presence of the mother (yes, no). Median and range for fixed variables are given in percent of scans in which basic activities were observed for respective periods based on observed data. Lying with contact was not analysed for feeding periods due to low occurrence. Transformations performed with response variables for statistical analysis are indicated in brackets, N=32.

	F-value	p-value	median (min-max)		F-value	p-value	median (min-max)		F-value	p-value	median (min-max)		F-value	p-value	median (min-max)	
24h			feeding (LG 10)				standing (ARSIN)				lying (LG 10)				lying with contact (SQRT)	
introduction period	16.848	**0.000**	DRY 0.7 (0.0-7.7)	KIDS 3.3 (0.0-11.9)	3.169	*0.082*	DRY 41.5 (17.0-60.0)	KIDS 40.3 (26.0-59.0)	0.017	0.898	DRY 55.8 (39.0-83.0)	KIDS 56.6 (37.0-70.0)	79.370	**0.000**	DRY 13.9 (0.0-42.0)	KIDS 0.0 (0.0-11.0)
rearing	0.011	0.917	a 2.2 (0.0-11.9)	m 1.5 (0.0-10.0)	0.203	0.655	a 39.6 (17.0-54.0)	m 42.4 (20.0-60.0)	0.055	0.816	a 57.5 (42.0-83.0)	m 54.9 (37.0-80.0)	5.461	**0.027**	a 1.4 (0.0-36.0)	m 5.5 (0.0-42.0)
presence of mother	0.009	0.925	yes 21.4 (0.0-100)	no 17.4 (0.0-11.9)	0.070	0.792	yes 42.7 (23.0-59.0)	no 39.6 (17.0-60.0)	0.172	0.681	yes 52.7 (37.0-77.0)	no 57.5 (39.0-83.0)	0.293	0.593	yes 0.4 (0.0-39.0)	no 2.8 (0.0-42.0)
night			feeding (LG 10)				standing (ARSIN)				lying				lying with contact (SQRT)	
introduction period	24.975	**0.000**	DRY 0.0 (0.0-10.0)	KIDS 8.0 (0.0-26.0)	0.007	0.934	DRY 22.0 (2.0-64.0)	KIDS 22.0 (10.0-46.0)	5.222	**0.030**	DRY 77.0 (36.0-98.0)	KIDS 68.0 (42.0-84.0)	39.037	**0.000**	DRY 19.0 (0.0-64.0)	KIDS 0.0 (0.0-14.0)
rearing	0.378	0.544	a 3.0 (0.0-26.0)	m 0.0 (0.0-22.0)	0.786	0.379	a 20.0 (4.0-38.0)	m 25.0 (2.0-64.0)	0.070	0.794	a 72.0 (42.0-96.0)	m 70.8 (36.0-98.0)	4.439	**0.044**	a 0.0 (0.0-60.0)	m 9.0 (0.0-64.0)
presence of mother	0.027	0.870	yes 5.0 (0.0-22.0)	no 10.0 (0.0-26.0)	0.350	0.556	yes 25.0 (0.0-64.0)	no 21.0 (2.0-44.0)	0.400	0.532	yes 66.0 (36.0-90.0)	no 72.0 (42.0-98.0)	0.626	0.436	yes 0.0 (0.0-64.0)	kids 0.0 (0.0-62.0)
feeding period (old)			feeding (SQRT)				standing (LG 10)				lying				lying with contact	
introduction period	0.761	0.386	DRY 0.0 (0.0-8.0)	KIDS 0.0 (0.0-23.0)	0.072	0.791	DRY 53.9 (0.0-100)	KIDS 53.9 (8.0-92.0)	0.386	0.537	DRY 46.1 (0.0-100.0)	KIDS 46.1 (8.0-85.0)	-	-	-	-
rearing	1.282	0.262	a 0.0 (0.0-8.0)	m 0.0 (0.0-23.0)	0.530	0.473	a 53.9 (0.0-92.0)	m 53.9 (8.0-100)	0.351	0.556	a 46.1 (8.0-85.0)	m 46.1 (0.0-92.0)	-	-	-	-
presence of mother	0.590	0.445	yes 0.0 (0.0-8.0)	no 0.0 (0.0-23.0)	0.008	0.929	yes 50.0 (8.0-100)	no 53.9 (0.0-100)	0.229	0.634	yes 50.0 (0.0-85.0)	no 46.1 (0.0-100)	-	-	-	-
feeding period (fresh)			feeding (SQRT)				standing (SQRT)				lying (ARSIN)				lying with contact	
introduction period	1.557	0.217	DRY 0.0 (0.0-15.0)	KIDS 0.0 (0.0-8.0)	1.125	0.293	DRY 42.3 (0.0-100)	KIDS 53.8 (8.0-100)	1.499	0.226	DRY 57.6 (0.0-100)	KIDS 46.1 (0.0-92.0)	-	-	-	-
rearing	0.942	0.336	a 0.0 (0.0-15.0)	m 0.0 (0.0-8.0)	0.160	0.691	a 46.1 (8.0-100)	m 42.3 (0.0-100)	0.022	0.883	a 53.8 (0.0-85.0)	m 53.8 (0.0-100)	-	-	-	-
presence of mother	0.248	0.621	yes 0.0 (0.0-8.0)	no 0.0 (0.0-15.0)	1.228	0.273	yes 34.6 (0.0-100)	no 46.1 (0.0-100)	1.196	0.279	yes 65.3 (0.0-100)	no 53.8 (0.0-100)	-	-	-	-

Tab. 19: Results of GLMM analysis for basic activity of adult and young goats. P-values and F-values are given for fixed variables age (adult, young), day (day1, day7), introduction period (DRY, KIDS) and age*introduction period (if p<0.1). Median and range for fixed variables are given in percent of scans in which basic activities were observed for respective periods based on observed data, for age*introduction period see Fehler! Verweisquelle konnte nicht gefunden werden.**. Lying with contact was not analysed for feeding periods due to low occurrence. Transformations performed with response variables for statistical analysis are indicated in brackets, N=104.**

	F-value	p-value	median (min-max)		F-value	p-value	median (min-max)		F-value	p-value	median (min-max)		F-value	p-value	median (min-max)	
24h			feeding				standing				lying				lying with contact	
age	282.256	**0.000**	adult 18.8 (0.0-36.6)	young 2.0 (0.0-11.9)	93.683	**0.000**	adult 25.5 (3.0-64.0)	young 40.4 (17.0-60.0)	1.124	0.291	adult 54.4 (17.0-96.0)	young 56.0 (37.0-83.0)	82.265	**0.000**	adult 0.0 (0.0-31.0)	young 1.5 (0.0-42.0)
day	4.979	**0.026**	day1 17.7 (0.0-33.8)	day7 18.3 (0.0-36.6)	7.738	**0.006**	day1 27.5 (4.0-64.0)	day7 25.6 (3.0-60.0)	1.509	0.220	day1 53.7 (23.0-96.0)	day7 56.2 (17.0-96.0)	0.124	0.725	day1 0.0 (0.0-38.0)	day7 0.0 (0.0-42.0)
introduction period	1.671	0.197	DRY 18.3 (0.0-33.3)	KIDS 17.3 (0.0-36.6)	7.682	**0.006**	DRY 26.9 (4.0-64.0)	KIDS 26.0 (3.0-60.0)	12.188	**0.001**	DRY 53.9 (23.0-96.0)	KIDS 56.5 (17.0-96.0)	103.014	**0.000**	DRY 2.0 (0.0-42.0)	KIDS 0.0 (0.0-15.0)
age* introduction period	6.277	**0.013**			-	-	-	-	-	-	-	-	135.577	**0.000**		
night			feeding (SQRT)				standing (SQRT)				lying (ARSIN)				lying with contact (SQRT)	
age	64.367	**0.000**	adult 10.0 (0.0-32.0)	young 2.0 (0.0-26.0)	13.594	**0.000**	adult 14.0 (0.0-100)	young 22.0 (2.0-64.0)	0.248	0.619	adult 74.0 (0.0-100)	young 70.8 (36.0-98.0)	79.086	**0.000**	adult 0.0 (0.0-58.0)	young 1.0 (0.0-64.0)
day	7.987	**0.005**	day1 10.0 (0.0-32.0)	day7 12.0 (0.0-30.0)	0.447	0.504	day1 14.0 (0.0-64.0)	day7 14.5 (0.0-100)	2.946	*0.087*	day1 74.0 (18.0-100)	day7 72.0 (0.0-100)	1.840	0.176	day1 0.0 (0.0-52.0)	day7 0.0 (0.0-64.0)
introduction period	7.425	**0.007**	DRY 12.5 (0.0-32.0)	KIDS 8.0 (0.0-26.0)	2.296	0.130	DRY 16.0 (0.0-74.0)	KIDS 14.0 (0.0-100)	0.286	0.593	DRY 70.8 (12.0-100)	KIDS 76.0 (0.0-100)	104.566	**0.000**	DRY 2.0 (0.0-64.0)	KIDS 0.0 (0.0-22.0)
age* introduction period	81.623	**0.000**			-	-	-	-	16.615	**0.000**			106.403	**0.000**		
feeding period (old)			feeding (SQRT)				standing (LG10)				lying				lying with contact	
age	226.891	**0.000**	adult 23.0 (0.0-85.0)	young 0.0 (0.0-23.0)	48.900	**0.000**	adult 23.0 (0.0-92.0)	young 53.8 (0.0-100)	0.844	0.359	adult 48.1 (2.0-100)	young 46.1 (5.0-98.5)	-	-	-	-
day	7.598	**0.006**	day1 15.3 (0.0-85.0)	day7 23.0 (0.0-77.0)	4.472	**0.035**	day1 30.7 (0.0-100)	day7 23.0 (0.0-100)	0.033	0.856	day1 45.7 (12.0-100)	day7 45.4 (17.0-100))	-	-	-	-
introduction period	0.0029	0.864	DRY 0.0 (0.0-54.0)	KIDS 0.0 (0.0-69.0)	2.228	0.136	DRY 30.7 (0.0-100)	KIDS 27.2 (0.0-92.0)	3.636	*0.057*	DRY 46.1 (0.0-88.0)	KIDS 49.0 (20.4-100)	-	-	-	-
age* introduction period	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-

feeding period (fresh)	feeding (SQRT)				standing (LG10)				lying				lying with contact			
age	180.510	**0.000**	adult 30.7 (0.0-100)	young 0.0 (0.0-15.0)	25.243	**0.000**	adult 30.7 (0.0-100)	young 46.1 (0.0-100)	9.713	**0.002**	adult 35.9 (0.0-100)	young 47.1 (6.0-90.5)	-	-	-	-
day	1.177	0.278	day1 30.7 (0.0-100)	day7 33.5 (0.0-92.0)	8.110	**0.005**	day1 33.5 (0.0-100)	day7 30.7 (0.0-100)	0.003	0.956	day1 46.5 (2.0-100)	day7 46.1 (0.0-100))	-	-	-	-
introduction period	14.792	**0.000**	DRY 23.0 (0.0-100)	KIDS 32.7 (0.0-92.0)	10.419	**0.001**	DRY 32.7 (0.0-100)	KIDS 30.7 (0.0-100)	27.730	**0.000**	DRY 46.1 (7.0-100)	KIDS 36.1 (0.0-100)	-	-	-	-
age* introduction period	-	**-**	-	**-**	-	**-**	-	**-**	-	**-**	-	**-**	-	**-**	-	**-**

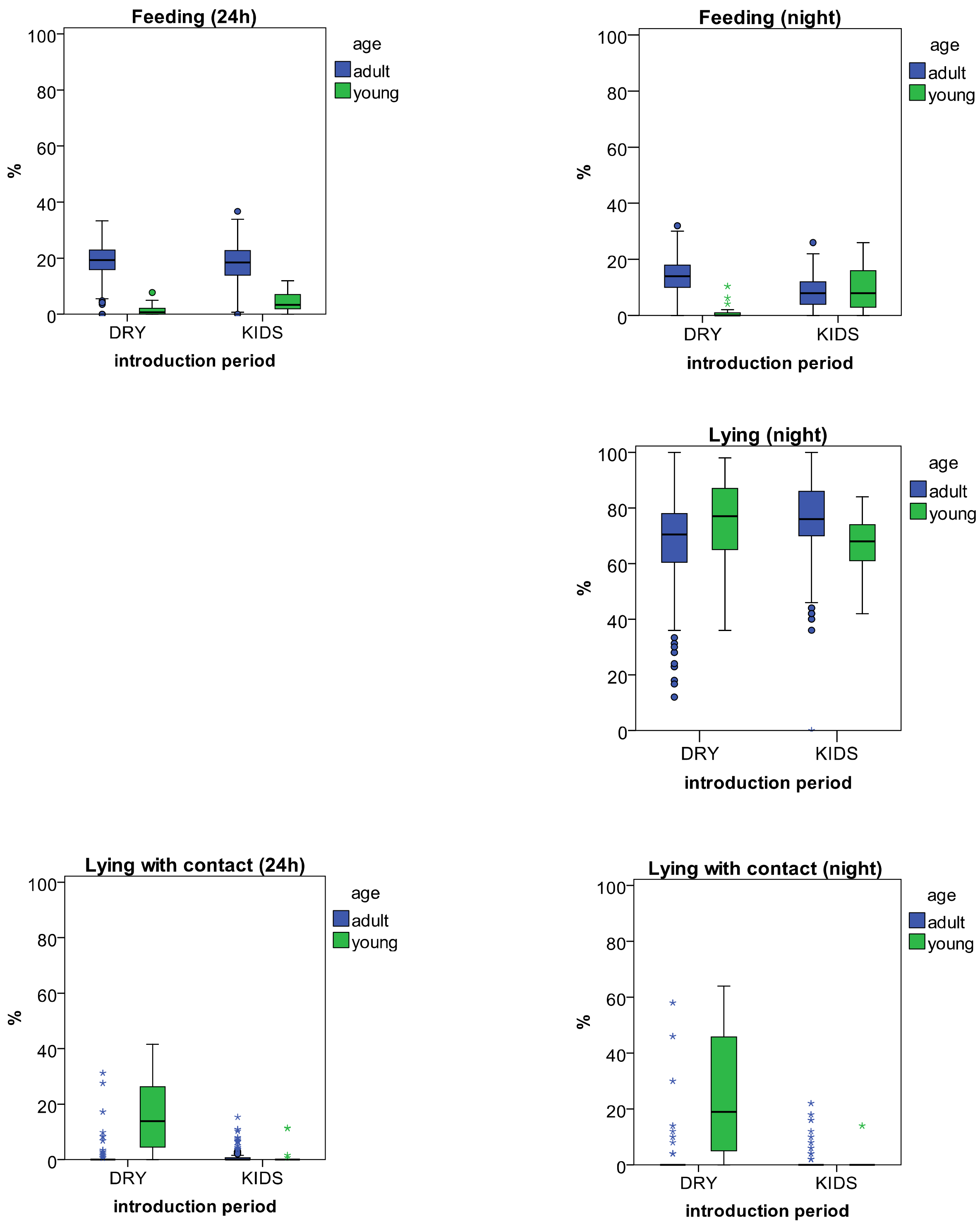

Fig. 20: Percentage of scans over 24h and night periods in which respective basic activities were observed in adult and young goats in relation to introduction periods DRY and KIDS, based on observed data. N=104.

3.3.4 Body condition, injuries and weight

Mean weight of young goats at introduction was 46.5kg (range 42-58) in DRY and 47.5kg (41-63) in KIDS. Most animals lost weight during introductions with much higher losses during KIDS than DRY (DRY 1.8±2.0% or 0.9±1.3kg, KIDS 10.3±4.8% or 5.0±2.2kg, Fig.21). Therefore body condition scores of most young goats were lower after introduction compared to scores before introduction in KIDS; in DRY scores of some young goats also declined (Tab.20, Fig. 22). Statistical analysis on reduction of weight showed that it was only affected by introduction period ($p<0.05$, F-value 33.7, Fig. 21), not rearing ($p>0.05$, F-value 0.921) or presence of mother ($p>0.05$, F-value 0.266). When introduction periods were analysed separately repetitions did not differ.

Regarding injuries, none were recorded in introduction period DRY and only three injuries (i.e. three animals) in KIDS. Two of these injuries (udder (deep lesion, size 1-3cm, shape vertical) and ear (deep lesion, size <1cm, shape vertical)) were caused in the waiting area and one in the pen (vulva (swelling, size <1cm, shape circular).

Tab. 20: Median and range (min-max) of body condition scores (BCS lumbar, BCS sternal) of young goats in introduction periods DRY and KIDS, before and after introduction.

BCS	before introduction	after introduction
	DRY	
lumbar	3.0 (2.5-4.0)	3.0 (2.5-3.0)
sternal	3.5 (3.0-4.5)	3.5 (3.0-3.5)
	KIDS	
lumbar	2.5 (2.5-3.0)	2.0 (1.5-2.5)
sternal	3.0 (2.5-3.5)	2.5 (2.0-3.0)

Fig. 21: Weight loss of young goats during introduction periods DRY and KIDS, given in percent of body weight based on observed data, N=32.

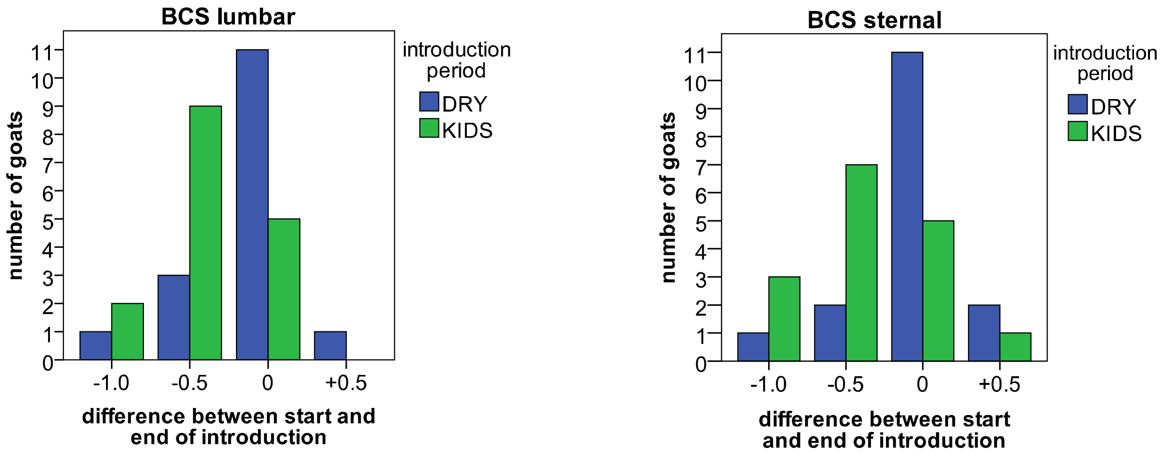

Fig. 22: Decrease in body condition scores (BCS sternal, BCS lumbar) during introduction periods DRY and KIDS given in number of goats. Figure is based on observed data, N=32.

3.3.5 Adrenocortical activity

Adrenocortical activity, i.e. concentrations of faecal cortisol metabolites, in young goats were affected by introduction period (p=0.000, F-value 56.5), with higher levels in DRY, and by the interaction of introduction period*day of sampling (p=0.001, F-value 3.95). In DRY concentrations of faecal cortisol metabolites peaked at the third day of sampling, declined thereafter, but remained higher than before introduction even on day7 (Fig. 24). In KIDS, however, few any changes in adrenocortical activity were seen throughout the days of sampling Fig.24). Thus, irrespective of higher base levels in DRY compared to KIDS (Fig. 24), differences between mean base level and mean of following sampling days was higher in DRY than KIDS (Fig. 23, no model calculated with these parameters), i.e. levels of cortisol metabolites increased more in DRY than KIDS during introductions. Rearing (p>0.05, F-value 0.03) and presence of mother (p>0.05, F-value 0.02) did not influence concentrations of cortisol metabolites. When introduction periods were analysed separately repetitions did not differ.

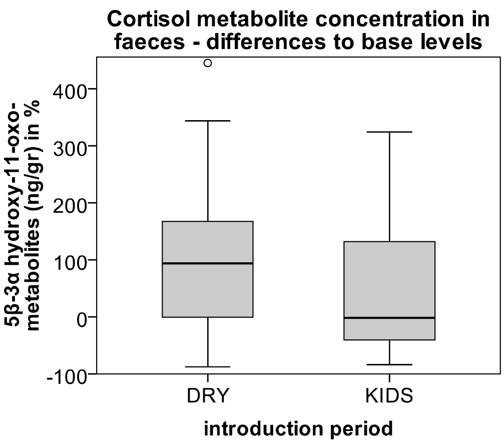

Fig. 23: Differences of concentration of cortisol metabolites in faeces (ng/gr) of young goats between mean base levels (day of sampling -2, -1) and mean levels of following sampling days (day3, 5 and 7) for introduction periods DRY and KIDS, given in percent. Figure is based on observed data, N=32.

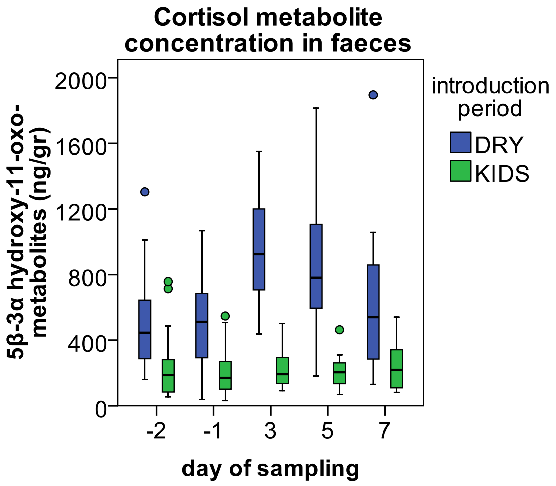

Fig. 24: Concentration of cortisol metabolites in faeces (ng/gr) of young goats related to days of sampling (one and two days before introduction (-1, -2), three, five and seven days (3, 5, 7) after introduction and introduction periods DRY and KIDS. Figure is based on observed data, N=32.

3.4 Discussion

The results of this study confirm the hypothesis of lower social stress when non-familiar young goats are introduced into a herd of adult goats after parturition when kids are still present (KIDS) compared to introduction during pregnancy (DRY). This is expressed in both behavioural and physiological parameters. Young goats in DRY were more often subjected to aggression and initiated aggression more often, dispersed less into the adult herd, spent less time feeding and – in contrast to young goats in KIDS - showed a marked physiological stress reaction (increase in cortisol metabolite concentration in faeces), being in agreement with predictions.

3.4.1 Social behaviour

The lower frequency of agonistic interactions when young goats were introduced in KIDS compared to DRY is in line with findings of Schwarz and Sambraus (1997) in one goat herd and also confirms predictions. Several factors that characterize the two introduction periods may have contributed to the reduced aggression level in KIDS.

Firstly the presence of kids may influence the social behaviour of their mothers (young and adult goats) by attracting their attention and thus distracting them from interactions with other adult goats. Secondly, the presence of kids very likely alters their mothers' social behaviour via physiological pathways. In mammals oxytocin is released during suckling. Both in humans and other species oxytocin has multiple physiological and behavioural effects, which can be summarized as a relaxing, 'antistress' and pro-social effect (Uvnäs-Moberg and Eriksson 1996, Uvnäs-Moberg 2005). Lactating rats and mice suckling their offspring are found to be less responsive to certain stressful stimuli and show reduced anxiety and fearfulness compared to non-lactating animals (Lonstein et al 1998, Toufexis et al 1999, Lonstein 2005), being in agreement with Uvnäs-Moberg and Eriksson (1996) and Uvnäs-Moberg (2005). Both in humans and other species, oxytocin increases socio-positive behaviours and social skills (recognition of social communication signals), leads to lower blood pressure and lower cortisol levels (Uvnäs-Moberg 1998, Uvnäs-Moberg and Petersson 2005). Thirdly, hormonal status differs between pregnant and non-pregnant (lactating) animals (Gall 2001) and thus may have effects that are also independent from the presence of offspring. Hormonal changes in pregnancy were shown to reduce fear reactions in pregnant compared to non-pregnant ewes (Vierin and Boussiou 2001). How this could affect reactions during grouping, however, is unclear. Because kids were present it is not possible to disentangle the effects of lactation and presence of kids for the moment.

Space allowance is another factor differing between DRY and KIDS, with lower levels in KIDS than DRY. According to literature space allowance is negatively associated with agonistic interactions (especially with body contact) both in ewes (Bøe et al 2006) and dairy cows (Metz and Wierenga 1987, Menke et al 1999, Fregonesi and Leaver 2002) and therefore not contributing to reduced aggression levels as observed in KIDS. Space allowances offered in studies with ewes and dairy cows, however, were rather low (e.g. 0.5/0.75/1.00m²/animal in Bøe et al 2006) compared to this study (4.5 and 4.8m²/animal in DRY, 4.3 and 4.5m²/animal in KIDS). Results suggest that even though space was reduced for goats in KIDS compared to DRY, due to presence of kids and a separated kid area, space allowance remained above a critical level influencing social behaviour adversely.

Agonistic interactions with introduced animals being target (AgoPhysRec, AgoNonPhysRec) were most frequent in all introductions, coinciding with Mench et al 1990. Regarding the development of these most frequent agonistic interactions, levels differed on days after introducing young goats. Especially in DRY, the frequency of agonistic interactions with physical contact with young goats being target (AgoPhysRec) was higher on the first day of introduction (day1), while agonistic interactions without physical contact (AgoNonPhysRec) were higher on the first three days (day1-3). Similar patterns are also found in other studies and species (goats: Addison and Baker 1982, Alley and Fordham 1994, Fernandez et al 2007, Andersen et al 2008; cattle: Kondo et al 1984, Hasegawa et al 1997, von Keyserlingk et al 2008; pigs: Meese and Ewbank 1973, Jensen 1994, de Groot et al 2001). The introduction of non-familiar animals disrupts the social structure and new dominance relationships have to be established. This process is finished mostly after three to five days after introduction (goats: Fernandez et al 2007, Andersen et al 2008; cattle: Kondo et al 1984, von Keyserlingk et al 2008) but periods up to two to four weeks were also reported (Hasegawa et al 1997, Slavnitsch 2008). The less pronounced increase during KIDS may point to easier integration of non-familiar animals, and maybe due to higher sociality in response to hormonal changes, as explained earlier.

3.4.2 Nearest neighbours

All young goats were each others neighbours more often than would be expected by chance, irrespective of introduction period. When kids were present, however, young goats were not observed to be each others neighbours as often, confirming predictions. Young goats being each others neighbours above chance level in all introductions can be assigned to the degree of familiarity within the group affecting group cohesion (Bouissou and Andrieu 1978, Boissy and Dumont 2002). Social cohesiveness is found to influence, among other factors, distribution patterns of cattle (Howery et al 1998) and sheep (Dudzinski and Arnold 1979) under range conditions, and is therefore likely to affect distribution and formation of subgroups within the pen in goats. Results in KIDS could be due to young goats focussing more on their kids than spending time next to their peers, i.e. other young goats, as observed in DRY. The presence of kids and their suckling, respectively, may also result in young goats being less fearful, as observed in other species (Lonstein et al 1998, Toufexis et al 1999, Lonstein 2005) and therefore needing less social support by other young goats. Lower levels of young goats being each others neighbours in KIDS could also be related to less aggressive behaviour toward introduced young goats in this period, thus making it more attractive for young goats to disperse into the herd.

3.4.3 Basic activity

Levels of feeding in young goats were higher shortly after parturition when kids were present (KIDS) than during the dry period of the herd (DRY), confirming the hypothesis. Lying activity, however, did not differ between periods. Yet levels of lying with contact were higher in DRY than KIDS.

In general, **feeding** activity was recorded very rarely among introduced young goats. This may be due to the definition of feeding (= an animal having its head through the feeding barrier), which was observed to a low extent. Yet young goats were often observed to be feeding very cautiously by not putting their head through the barrier fully. The introduced animals were also not used to feeding barriers, but as goats are known to be an inquisitive species eagerly exploring their surroundings and could also observe adult goats feeding; this is not very likely to affect results to a large degree. What is more likely to explain results is that especially in competitive situations, i.e. feeding situations, newly introduced animals are subjected to higher levels of displacement, resulting in reduced feeding times for non-familiar animals (Phillips and Rind 2001). According to Mench et al (1990) resident cows were dominant to introduced ones and as dominant animals were known to gain prior access to limited resources (Barroso et al 2000), resident animals are likely to do so too (Kjæstad 1999). Introducing animals also reduces space and decreases the amount of feeding places per animal, thus also leading to a higher level of aggressive interactions, reducing feeding times and access to feed in non-familiar animals (Jørgensen et al 2007). Analysis of feeding activity in adult and young goats supports this explanation, as much higher levels of feeding were recorded in adult goats compared to young goats, irrespective of observation period.

Feeding in adult goats also hardly differed between introduction periods DRY and KIDS (24h); suggesting undisturbed feeding activity in resident animals probably due to their high dominance status even though non-familiar animals were present. Slightly higher levels of feeding at night in adult goats in DRY compared to KIDS, however, may be assigned to other factors than ones related to introductions, as resident animals are likely to feed according to their needs (Mench et al 1990, Barroso et al 2000, Phillips and Rind 2001).

Levels of feeding in young goats, however, were higher in KIDS than DRY (24h, night), which is likely to be due to the characteristics of the two introduction periods as discussed in social behaviour, probably resulting in easier integration of young goats and less fear and stress in young goats when introduced in KIDS. These characteristics seemed to provide the sense of security for young goats resulting in young ones putting their head through the feeding barrier fully while feeding. Schwarz and Sambraus (1997) also reported on young goats feeding more often when introduced when kids were present compared to all goats being pregnant, i.e. dry. Feeding in young goats after fresh feed was given or after remaining hay was pushed toward the feeding barrier did not differ between DRY and KIDS, probably because of young goats not feeding at all at main feeding times, avoiding displacements by adult animals (Phillips and Rind 2001). As feeding levels of young goats were very similar during 24h and at night in introduction period DRY, most of the feeding must have taken place at night with less adult goats feeding than during the day, a period when displacements by adult goats are least likely. Results for introduction period KIDS suggest, that higher feeding levels of young goats during this period are not due to increasing feeding activity during the day but at night.

Toward the end of introductions levels of feeding were higher than at the beginning at most observation periods, a development Schwarz and Sambraus (1997) also found in their study in one goat herd. A decrease in feeding after introductions of non-familiar animals is found at the beginning in several studies and species (goats: Slavnitsch 2008; cattle: Hasegawa et al 1997, Phillips and Rind 2001, O´Driscoll et al 2006, von Keyerlingk et al 2008; pigs: Hyun et al 1998), being in line with results of the present study. This development is likely to be a consequence of increased agonistic behaviour in order to establish a new dominance hierarchy, which has been disrupted by the introduction of non-familiar animals (e.g. review in cattle: Bøe and Færevik 2003; goats: Addison and Baker 1982, Alley and Fordham 1994, Fernandez et al 2007, Andersen et al 2008). According to literature the process of establishing a new dominance hierarchy is mostly finished after three to five days (goats: Fernandez et al 2007, Andersen et al 2008; cattle: Kondo et al 1984, von Keyserlingk et al 2008), consequently levels of agonistic interactions decrease and feeding levels in animals increase. This development may explain lower levels of feeding at the beginning of introductions and higher levels seven days after introductions.

According to analysis of **standing** in young goats only, this activity was only affected by introduction period over 24h, with higher levels of standing in tendency in DRY compared to KIDS (24h). This development was also seen in data of adult and young goats (24h, feeding period (fresh)). Levels of standing are in line with other parameters regarding introduction periods indicating less aggression of adult goats toward young goats in KIDS than DRY, resulting in lower levels of standing in KIDS. Furthermore standing was more often observed in young than adult goats at all observation periods, probably resulting from agonistic interactions of adult toward young goats in relation to the dominance status of young goats. Standing was also more often recorded at the beginning than toward the end of introductions at all observation periods, except for the night period where no difference between start and end of introduction was recorded. Animals standing more often at the beginning than toward the end are results also seen in other studies in goats (Slavnitsch 2008) and cattle

(Hasegawa et al 1997, Raussi et al 2005). Results of standing activity in this study are in accordance with the process of dominance hierarchy establishment as described in feeding activity, and likely to explain higher levels of standing at the beginning of introductions and lower ones seven days after introductions.

Lying, i.e. lying including lying with contact, in young goats only, was minimally affected by introduction period at the night observation, with higher levels in DRY compared to KIDS. Consequently differences in lying levels at night can not be assigned to introduction periods, but to higher feeding levels at night in KIDS than DRY, reducing lying at night. As already described in social behaviour space allowances offered in this study were rather large (4.5 and 4.8m²/animal in DRY, 4.3 and 4.5m²/animal in KIDS) and therefore competition for lying space was low, basically allowing young goats to fulfil their need for rest in both introductions.

Levels of lying in adult and young goats did not differ consistently regarding introduction period; higher levels were observed in KIDS (24h), but also in DRY (feeding period (fresh)). Lying over 24h is in line with standing patterns at this period, while lying in the feeding period (fresh) is in line with feeding patterns, explaining results.

At night levels of lying in adult goats were little higher in KIDS than DRY, while in young goats the contrary was observed, resulting in higher levels of lying during night in young goats compared to adult ones in DRY and lower levels in young goats compared to adult ones in KIDS. Lying patterns in young goats were due to higher feeding levels at night in KIDS compared to DRY as explained earlier. Variation in adult goats is also in line with feeding levels at night but contrary to young goats, adult ones were feeding little more often in DRY than KIDS.

Lying activity did not differ between adult and young goats, except for feeding period (fresh) with higher levels in young than adult goats. This development is likely to be explained by the same reason as higher levels of standing during feeding periods, which are young goats not feeding at main feeding times in order to avoid displacements by adult animals (Phillips and Rind 2001). Levels of lying at night tended to be higher at the beginning compared to the end of introductions contradicting earlier studies (Hasegawa et al 1997, Raussi et al 2005, Keyserlingk et al 2008, Slavnitsch 2008). According to research on establishment of dominance hierarchies (goats: Fernandez et al 2007, Andersen et al 2008; cattle: Kondo et al 1984, von Keyserlingk et al 2008) levels of agonistic interactions are likely to decrease at the end of the introduction and consequently levels of lying to increase. But it has to be taken into account that space allowances offered in this study were higher than in others, e.g. 2m²/animal in Slavnitsch (2008), allowing all animals, i.e. resident and introduced ones, to fulfil their lying needs in general, explaining the results of this study. Furthermore slightly higher levels of lying (night) at the beginning are in line with less feeding at the beginning compared to the end of the introduction.

Lying with contact in young goats only and in adult and young goats was more often seen in DRY than KIDS (24h, night). Levels were higher in young goats than adult ones (24h, night).

Different reactions in adult and young goats toward introductions may be related to their positions within the dominance hierarchy in the herd, favouring the benefits of physical contact (Carter 1998, Unväs-Moberg 1998) in young goats rather than adult ones. On the other hand higher levels of lying with contact in young goats may not be based on deliberate choice, but result from young goats trying to increase distances to a maximum from adult goats, leading to higher levels of lying with contact in young goats than adult ones.

The lower incidence of lying with contact in young goats when kids were present compared to the dry period could be due to the definition of lying with contact (= touching of bodies of two or more young or adult goats with any body part, contact to a kid was ignored), if young goats preferred to lie with contact with their kids rather than other young goats. Yet results on lying with contact are in accordance with other results indicating less stress for introduced animals in KIDS and therefore young goats may have looked for less physical contact in KIDS than DRY, which is known to increase the release of oxytocin (Unväs-Moberg 1998), cause relaxation and increase behavioural calmness (Carter 1998).

3.4.4 Body condition, injuries and weight

Body condition and weight of young goats decreased during both introduction periods, more so in KIDS than DRY. The occurrence of (visible) injuries was very low, with no injuries in DRY and three injuries (i.e. three animals) in KIDS. These results are contradicting the hypothesis, predicting less weight loss, less decreasing body condition and fewer injuries in DRY than KIDS. Yet the hypothesis focussed only on the effects of introductions on young goats, but did not include physiological processes at the beginning of lactation (weight loss, body condition) and goats using the waiting area in lactation (injuries).

Regarding weight loss the different expectation of weight development due to different reproductional stages needs to be considered. In non-lactating pregnant goats in general weight gain would be expected at that stage of pregnancy (two months before giving birth) in an undisturbed situation, as most foetal growth takes place at that time (Zettl and Brömel 1994). In contrast weight loss at the beginning of lactation is a process commonly observed in lactating goats (Gall 2001). At this time energy needs can hardly be covered with the feed consumed (Sauvant et al 1991), therefore body fat is mobilized in order to cover the energy needs of an animal (Gall 2001, Strittmatter 2003, von Korn et al 2007). In sheep weight loss between two and twelve kg at the beginning of lactation was reported (Strittmatter 2003). Reduced feeding in DRY compared to KIDS, however, caused introduced young goats to lose weight leading to lower BCS (BCS lumbar and sternal) for most animals.

Low levels of feeding in young goats in DRY are likely to explain weight loss and decreasing BCS in this period. Research on mixing of pigs showed similar results on weight development, with increasing body weight stagnating or reversing after mixing (de Groot et al 2001). Even though slightly higher levels of feeding were recorded in KIDS, young goats lost five times as much weight in KIDS than DRY, BCS declined further and even more animals were recorded with lower BCS at the end of introduction compared to the beginning in KIDS than DRY. In this study the usual body fat mobilizing process at the start of lactation was probably potentiated by introductions associated with reduced feeding. Regarding body condition, BCS during pregnancy should range around 3.0 and not decrease by more than 0.5 at the beginning of lactation in order to sustain the animals' health (von Korn et al 2007). BCS of introduced young goats did follow these criteria and generally higher scores in BCS sternal compared to BCS lumbar can be explained by body fat being mobilized faster in the lumbar than in sternal region (von Korn et al 2007).

Regarding the occurrence of (visible) injuries, two of these injuries (udder and ear) were caused in the waiting area and one (vulva) in the barn. The waiting area is a very critical area regarding injuries especially in horned goats as space is very limited (0.9m²/animal) compared to the barn (4.3 - 4.8m²/animal). More space allowance in the waiting area is found to be a critical factor when it comes to decreasing agonistic behaviour and consequently the occurrence of injuries (Szabó 2008). Goats were not milked during introduction period DRY and therefore animals were not using the waiting area, possibly explaining these results. We suggested lower incidence of injuries in KIDS, yet without looking at the waiting area. In this study space allowances in the pen were much higher than requested by Council Regulation (1.5m²/animal (EG) No 834/2007, 889/2008 for organic production) with 4.3 and 4.8m²/animal in DRY and 4.3 and 4.5m²/animal in KIDS. With lower space allowances incidents of injuries may have been higher (in horned dairy cattle: Menke et al. 1999, Waiblinger et al. 2001) as space allowance is negatively associated with agonistic interactions, especially with body contact (goats: Jørgensen et al 2007; ewes: Bøe et al

2006; cattle: Metz and Wierenga1987, Menke et al 1999, Fregonesi and Leaver 2002, Bøe et al 2006.

3.4.5 Adrenocortical activity

Concentrations of faecal cortisol metabolites in young goats increased in reaction to introduction in DRY but not in KIDS, confirming the hypothesis, predicting lower increases of cortisol metabolites in KIDS than DRY.

Results in DRY are in line with results in cattle where mixing of non-familiar animals affected hypothalamic-pituitary-adrenal (HPA) axis activity in the short and long term (Friend et al 1977, Mench et al 1990, Hasegawa et al 1997, Gupta et al 2005). Andersen et al (2008) did not record any differences in plasma cortisol levels between stable and unstable groups of goats on the day of regrouping and five days after. Yet Andersen et al (2008) only took one blood sample per day, so that short term fluctuations are a problem (Möstl and Palme 2002) and are likely to have covered possible effects. In faecal samples minor short term fluctuations are dampened, diurnal variation in cortisol secretion smoothed and adrenocortical responses to potential chronic stressors can be detected without the need of frequent sampling (Palme et al 2003). Additionally faecal cortisol metabolite concentrations reflect adrenocortical activity within specific time lines before sampling (eleven to 13 hours in goats: Kleinsasser et al 2010) and thus the sampling procedure itself (handling of goats) does not affect the values.

Mixing with non-familiar animals as well as separation from bonding partners may have both contributed to stress experienced by young goats. While in stable social systems established dominance hierarchies result in predictable behaviour (Sachser et al 1998). Social behaviour in a new group is less predictable and therefore causing stress, especially for newly introduced goats due to their low status in hierarchy (Mench et al 1990, Kjæstad 1999). Levels of cortisol metabolites throughout introductions, being highest on day3 and declining thereafter, are in accordance with the process of dominance hierarchy establishment as discussed earlier. Levels on day7, however, remaining higher than before introduction, may indicate that the dominance hierarchy within the group has not been fully established yet (Hasegawa et al 1997, Slavnitsch 2008).

Constant cortisol metabolite levels after introduction in KIDS are not in accordance with other studies on mixing in cattle (Friend et al 1977, Mench et al 1990, Hasegawa et al 1997, Gupta et al 2005) and establishment of dominance hierarchy after introduction of non-familiar animals (goats: Fernandez et al 2007, Andersen et al 2008, Slavnitsch 2008; cattle: Kondo et al 1984, Hasegawa et al 1997, von Keyserlingk et al 2008). Yet results may be related to the characteristics of this introduction period, leading to easier integration of young goats in KIDS. Results on adrenocortical activity in KIDS are also in agreement with behavioural parameters of less aggression toward young goats, lower cohesion between them and higher levels of feeding in this period. Furthermore the physiological effect of suckling is reported to act directly on HPA axis by decreasing cortisol levels in mothers (Uvnäs-Moberg 1998). This effect together with easier integration into the herd is likely to explain lower base levels in KIDS than DRY and may also contribute to constant levels after introduction in KIDS.

3.4.6 Repetitions

In this study adult goats could have potentially habituated to introductions and thus have decreased their level of aggression, affecting parameters observed in introduced animals. However, there were no signs of habituation, i.e. constant decrease and increase, respectively, in recorded parameters, except for standing being more often recorded in repetition1 and lying which was more often seen in repetition2.

Regarding social behaviour only levels of young goats receiving agonistic interactions without physical contact (agoNonPhysRec) were higher in repetition1 than repetition2 in DRY. Research on repeated regrouping in goats and cattle show contradictory results: aggression levels remain at almost constant high levels or even increase after repeated regroupings (goats: Fernandez et al 2007, Andersen et al 2008, cattle: Raussi et al 2005), while other studies conclude that repeated regrouping reduces aggressive interactions (cattle: Kondo et al 1984, Veissier et al 2000).

Young goats as each others neighbours were observed more often in repetition1 (KIDS), but also repetition2 (DRY), consequently not indicating habituation.

Feeding activities in young goats only and adult and young goats also did not show a pattern suggesting habituation to integrations, as it was more often recorded in repetition1 in KIDS, but also repetition2 in DRY. In both introduction periods standing activities were consistently observed more often in repetition1 than 2 in young goats only and adult and young goats. For lying activities in young goats only and adult and young goats also a consistent development was observed, yet with higher levels in repetition2 than repetition1 in DRY and KIDS. Lying with contact did not differ in repetitions, irrespective of introduction period. Results on standing and lying suggest habituation of adult goats toward the introduction procedure, contradicting Raussi et al (2005) in cattle.

Adrenocortical activity did not differ in repetitions in neither DRY or KIDS, contradicting Gupta et al (2005) investigating groups of six steers and their responses to one animal being regrouped and relocated six times. In their study steers responded to their first regrouping and relocation procedure with an increased activity of the pituitary-adrenal axis, but not the following ones. According to Gupta et al (2005) the link between the acute stress stimuli of regrouping and relocation and the chronic stress stimuli of the prolonged effects of this procedure, limited the effects of subsequent regroupings and relocations leading to habituation in steers. Differences in group size, be it of resident animals and introduced ones, in Gupta et al (2005) and this experiment may explain contradictory results. Furthermore Gupta et al (2005) carried out the six mixing procedures with two weeks in between, while in this experiment two introductions were done in DRY with one week in between followed three months later with two introductions in KIDS (Tab. 25).

3.4.7 Rearing

Early social environment of young goats (reared artificially or by their mothers) did not affect agonistic behaviour, feeding, standing and lying activity, weight loss and adrenocortical activity, contradicting predictions. Mother reared goats, however, showed more cohesion to their peers, i.e. other young goats, by having them as neighbours more often than artificially reared ones. Young goats reared with their mothers were also lying with contact more often than others. These results suggest stronger sociality in goats reared with their mothers compared to artificial rearing. Different types of rearing (group versus single, mother versus artificial) is reported to affect responses of animals in novel social situations (for review see Napolitano et al 2008). Observations of artificially and mother reared heifers at five months of age showed that artificially reared animals interacted agonistically more often with other animals than ones reared by their mothers (Le Neindre 1991). This may indicate easier integration of mother reared animals in groups and also higher sociality toward other animals. These differences may be related to mother reared animals experiencing close and also physical contact with their mothers and the beneficial effects of it (Carter 1998, Unväs-Moberg 1998) over a longer period than artificially reared ones. Therefore mother reared goats may look for physical contact more than others even later in life and may do so especially under stressful situations (e.g. introduction into adult goat groups), supporting the hypothesis of higher sociality of mother reared animals.

3.4.8 Presence of mother

The presence of the mother for those goats reared with their mother did not affect recorded parameters, with the exception of nearest neighbours, not confirming predictions. Among mother reared young goats mothers were not observed as neighbours above chance level, yet young goats were seen as neighbours less often when their mothers were present.

Closely related individuals in sheep and cattle (e.g. mother and offspring, twin animals) are reported to form long term social bonds (sheep: Napolitano et al 2008, Hinch et al 1990; cattle: Veissier et al 1990a, Lazo 1994, Murphy et al 2000). In most mammalian species, mothers are important bonding partners for their infants (Sachser et al 1998), therefore in case of recognition the presence of the mother may reduce stress experienced in young goats as observed in other species (Mendoza et al 1974, von Holst 1990). In this study, however, mothers and young goats did not have any contact for about 1.5 years and consequently other bonding partners may have become more important than their mothers (Veissier et al 1990b). These 1.5 years are also likely to affect the strength of bonds between mothers and their offspring. In ewes bonds were not observed to be strong after natural weaning after about two to three months post partum (Lawrence 1990, Lawrence 1991). Other studies, however, reported on long-term social bonds exceeding natural weaning between ewes and lambs (Hinch et al 1990, Rowell 1991). Yet young goats raised by their mothers but separated for 1.5 years, may be associated to their mother in a more distant but as yet undescribed way. Nevertheless young goats seemed to be experiencing social support by this presence to an extent allowing them to disperse more easily into the adult herd.

3.4.9 Kids versus reproductional state

Whether results of introducing young goats into a herd of adult goats after parturition with kids still present are due to kids or the reproductional state itself remains unclear, as it could not be investigated in this study. The effects of physical contact (Uvnäs-Moberg and Eriksson 1996, Uvnäs-Moberg 2005) and the description of suckling as a critical stimulus priming behaviour once kids are born (Adkins-Regan 2005) suggest that effects may largely be influenced by the presence of kids. Yet oxytocin is also released during milking, even though levels are lower than during suckling (Tancin et al 2001). Therefore responses to introducing non-familiar animals may be similar without kids being present. However, further research is needed to disentangle the effects of presence of kids and reproductional stage, i.e. lactation.

3.5 Conclusion

Introducing non-familiar young goats into a herd of adult goats is less stressful for introduced animals when done shortly after parturition when kids are still present as compared to the period when goats are pregnant and the lactating herd dried off. Therefore introductions should preferably take place shortly after parturition with kids present. Early social environment had no effect on coping with introduction but on sociality. In order to prevent above-average weight loss at the start of lactation, feeding activities of introduced animals should be closely monitored.

Overview on hypotheses and results

- *introducing young goats after parturition when kids are present are expected to result in lower levels of social stress for young goats, due to a different hormonal status during pregnancy and at the beginning of lactation. Indicated by*

  lower levels of agonistic behaviour, →**Yes**

  greater dispersion of young goats into the herd without staying close together, →**Yes**

  less disturbance of feeding or lying, → **Partially supported**

  less weight reduction, declining body condition and fewer injuries, → **No**

  lower increases of adrenocortical activity. → **Yes**

- *rearing is expected to affect how young goats cope with introduction, with easier coping for goats having been reared with their mothers. This may be due to a different social environment potentially influencing reactions in novel social situations.* → **No**
- *presence of mother is also expected to influence how young goats reared by their mothers cope with introductions, with easier coping for those young goats reared with their mothers and having them present. As mothers and their offspring are known to be important bonding partners, in the case of recognition, mothers are expected to offer support and reduce stress for young goats.* → **No**

4 General discussion

As demonstrated in many studies social stress and its implications are affecting welfare, health and performance of animals adversely (Stookey and Gonyou 1994, Hasegawa et al 1997, Schwarz and Sambraus 1997, Tuchscherer et al 1998, Andersen et al 1999, de Groot et al 2001, Raussi et al 2005, Bøe et al 2006, O´Driscoll et al 2006, Andersen and Bøe 2007, Fernandez et al 2007, von Keyserlingk et al 2008). The aim of this doctoral thesis was to determine social stress levels in dairy goats in relation to procedures linked with intensive dairy goat farming, i.e. the housing of hornless versus horned goats and introducing unfamiliar animals into an already existing herd. Furthermore results may provide information how social stress in dairy goats can be reduced, e.g. by considering time of introduction and providing additional spatial structures in pens.

In general results of the first part of this study investigating the housing of hornless and horned goats study have to be interpreted carefully, as they are only based on two groups of each hornless and horned goats and some of them only on one. Changes in group size in the hornless and horned herd on farm1 throughout the experimental period were accounted for by recording data three to four weeks after regroupings. After this period dominance hierarchy was expected to be established and behaviour to have returned to base levels (e.g. Andersen et al 2008). Yet, the effect of group size on parameters remains unclear, as it was not possible to include this effect in statistical analysis

But as this experiment was based on on-farm conditions, experimental design had to include terms and conditions of each farm and adapt to circumstances. In order to gain wider data basis parameters were recorded on two farms. When data was analysed some indicators pointed toward an influence of farm characteristics on recorded parameters, to what extent, however, these characteristics were affecting parameters remains unclear. Even though circumstances were determining data recording and the statistic program was limiting options of statistical analysis results of this study are supported by earlier studies in smaller groups and with individuals (e.g., Loretz et al 2004, Bøe et al 2006, Andersen and Bøe 2007, Jørgensen et al 2007, Tønnesen et al 2008, Aschwanden et al 2009a). Also studies in larger groups (Keil and Sambraus 1996, Waiblinger et al 2010) arrived at similar results additionally supporting the validity of results of the present study.

The first part of this thesis revealed some differences in behavioural indicators of social stress between horned and hornless groups and/or rank within group. Regarding social behaviour, hornless goats interacted agonistically more often than horned goats, being in line with predictions. The social structure of goat herds is characterized by an established dominance hierarchy (Addison and Baker 1982, Keil and Sambraus 1996, Barroso et al 2000, Coté and Festa-Bianchet 2001), having the function of reducing frequent fights for limited resources by clearly regulating access to these resources (Fraser and Broom 1997, Lindberg 2001). Consequently higher levels of total agonistic behaviour in hornless goats suggest a more clearly established dominance hierarchy in horned than hornless goats, being in agreement with Keil and Sambraus (1996). Differences in hierarchy could be due to the missing signalling effect of horns in hornless animals (Sambraus 1978). This is also in accordance with Barroso et al (2000) who stated that the efficiency of an interaction is positively affected by the presence of horns. This may lead to low ranking hornless goats respecting social distances of higher ranking individuals less than horned goats (Aschwanden et al 2008a). Consequently, individual distances of high ranking goats are penetrated more often in hornless herds. High ranking goats are displacing intruders leading to higher frequencies of agonistic behaviour, as found in the present study in hornless groups and in other experimental studies (Aschwanden 2008a, Nordmann et al 2011). In this study hornless groups also tended to interact agonistically with body contact more often than horned groups. According to previous research in experimental settings (Müller 2006, Nordmann et al 2011) these results were expected and are therefore confirming predictions. This outcome may be assigned to characteristics in dominance hierarchy in relation to presence of horns (Keil and Sambraus 1996), the signalling effect of horns (Sambraus 1978) in relation to the efficiency of interactions (Barroso et al 2000) as described above. These characteristics may allow horned goats to maintain social distances with agonistic behaviour of low intensity, i.e. threat and avoidance (Collis 1976), explaining results of the present study.

As horned low ranking goats seemed to respect social distances of higher ranking ones more (Aschwanden et al 2008a), horned animals were expected to feed at larger distances than hornless ones. Results confirm this hypothesis and are also in line with results of the present study on social behaviour, indicating that horned goats may not only displace others in the pen but also at the feeding rack more efficiently than hornless ones (Barroso et al 2000).

Results on feeding behaviour show that horned goats are feeding at night more often than hornless ones. This may be related to horned animals feeding at larger distances during the day, not allowing all animals to feed sufficiently and consequently feeding times have to be extended into the night period. Rank influenced the feeding behaviour of hornless and horned animals differently. When fresh feed was given and over 48h periods hornless goats assigned to the low dominance class were feeding more often than those assigned to the high dominance class. In the horned group the opposite was observed, with lower levels of feeding in the low dominance class and higher levels in the high dominance class. As differences between dominance classes were distinct in hornless and horned groups, results are not in accordance with predictions as well as Loretz et al (2004) leading to the conclusion that differences in classes are less pronounced in hornless than horned goats. Lying was also affected differently by presence of horns, i.e. groups according to rank. Horned goats did not differ between dominance classes, yet, lying was more often observed in dominant than subordinate hornless goats after fresh feed was given. Lying with contact tended to differ in hornless and horned groups between dominance classes at night and over 48h. The trend of high ranking goats lying with contact less often than low ranking ones, irrespective of presence of horns, i.e. group, coincides with Loretz et al (2004). Differences between dominance classes in hornless and horned goats in lying and lying with contact were more pronounced in hornless than horned goats. Results on basic activity reveal that differences between dominance classes in hornless and horned herds are differently but equally pronounced in feeding behaviour, while in lying and lying with contact differences seemed to be more distinct in hornless compared to horned herds across dominance classes. Therefore these results are contradicting the hypothesis of more pronounced differences in dominance classes in horned groups.

Regarding the body condition scores (BCS) of animals, differences were minor between according to presence of horns and not consistent. Larger distances at the feeding rack in the horned compared to the hornless group was expected to lead more often to lower BCS in horned than hornless goats, as not all horned animals may be able to feed sufficiently. Results point toward horned goats obtaining higher scores than hornless goats, not confirming predictions, but indicating that horned goats are able to feed according to their needs. BCS was also related to rank, with more dominant animals obtaining higher scores irrespective of presence of horns. This is in line with feeding activity in horned goats (dominant animals feeding more often than subordinate ones) but not in hornless goats (subordinate animals feeding more often than dominant ones). Contrary results on feeding activity and BCS in hornless goats suggest that recorded data is not reflecting the actual feeding situation, which may be due to chosen sampling intervals. Results furthermore contradict the prediction of a more distinct positive association between the index of success and BCS in horned compared to hornless herds.

Pertaining injuries, hornless and horned groups did not differ in total occurrence of injuries on the body including head, back and body sides but excluding the udder, confirming Waiblinger et al (2011). According to descriptive analysis, types of injuries on the body hardly differed between hornless and horned groups on farm1. On farm2, however, hornless goats were more often seen with swellings and crusts than horned ones, supporting the hypothesis of this study and earlier research (Waiblinger et al 2010) on different types of injuries related to presence of horns. A higher number of swellings in hornless goats than horned ones on farm2 may be related to higher levels of interactions with body contact. These interactions may also be of higher intensity in hornless goats, resulting in larger numbers of animals with swellings. The total occurrence of udder injuries differed on both farms, with higher numbers in horned than hornless goats, but differences throughout examination periods were inconsistent. Descriptive analysis revealed that crusts were most common on udders, irrespective of presence of horns, followed by scars. Therefore differences between hornless and horned groups can be assigned to the occurrence of crusts. A higher level of crusts in the horned than hornless group may be due to horns being able to cause this type of injury. In hornless goats crusts could only result from biting toward the udder, but this behaviour was very rarely observed in this study. Deep lesions were only found on two horned goats on farm2.

Adrenocortical activity, indicating chronic stress, was investigated and compared for the first time in scientific research between hornless and horned goats. As horned and hornless goats differed in the present study in social behaviour, with higher levels of total agonistic behaviour and interactions with body contact in hornless groups, adrenocortical activity would be expected to differ according to presence of horns. Cortisol levels in milk and cortisol metabolite levels in faeces, however, did not differ in relation to presence of horns, with the exception of hornless goats tending to have a higher milk cortisol level than horned ones on farm1. No interaction of presence of horns and dominance class was found, contradicting the prediction of higher levels of social stress in low ranking horned than hornless goats. These contradictory results on social behaviour and adrenocortical activity may be due to housing conditions allowing all animals to fulfil their needs, irrespective of rank and experience their environment as being predictable and controllable, a prerequisite to reduce stress levels in animals (Wiepkema and Koolhaas 1993). Yet reasons for hornless goats also not experiencing their situation as stressful remain unclear. Animals seem to have different behavioural coping strategies in order to deal with their environment (Mülleder et al 2003). In the present study hornless goats may have adapted to agonistic interaction levels, a strategy that may possibly result in higher thresholds for experiencing chronic stress. Further research is needed to clarify chronic stress levels in relation to social behaviour and presence of horns.

According to literature the installation of resting platforms was expected to have positive effects on behavioural parameters (Simantke et al 1997, Andersen and Bøe 2007, Jørgensen and Bøe 2009, Aschwanden et al 2009a, Aschwanden et al 2009b, Ehrlenbruch et al 2010) and in consequence on social stress as measured by reducing adrenocortical activity. In this study, however, only lying with contact was reduced when platforms were available, variations in other parameters throughout the observation period could not be assigned to the presence of resting platforms. These results could be due to too little resting platforms being provided (a maximum of 14 animals/ 20% of the herd could rest on the platforms) and/or chronic stress being still present in other areas. Therefore the influence of platforms may be more pronounced, if more of them are provided allowing a larger number of animals to use them simultaneously. Nevertheless resting platforms were used frequently, irrespectively of horn status and rank, confirming the hypothesis on use of platforms and supporting the potential benefits of platforms.

Results of the second part of this doctoral thesis indicate, that reactions toward introduced animals differ in relation to introduction period (all animals pregnant (DRY), all animals with their kids (KIDS)), i.e. social stress levels in introduced young goats differed. Young goats were less often subjected to aggression and initiated aggression less often in KIDS compared to introductions during DRY, confirming predictions and being in accordance with Schwarz and Sambraus (1997). Several factors are characterizing these two introduction periods and may have contributed to the reduced aggression level in KIDS. The presence of kids may influence the social behaviour of their mothers (young and adult goats) by attracting their attention and thus distracting them from interactions with other mothers. Furthermore the hormone oxytocin is released during suckling when kids were present and its relaxing and pro-social effects (Uvnäs-Moberg and Eriksson 1996, Uvnäs-Moberg 2005) may explain results. The hormonal status in general differs between pregnant and non-pregnant (lactating) animals (Gall 2001) and thus may have effects that are also independent from the presence of offspring. Because kids were present it is not possible to disentangle the effects of lactation and presence of kids for the moment.

The dispersion of young goats into the herd was analysed by recording their nearest neighbours, revealing that all young goats were each others neighbours more often than would be expected by chance, irrespective of introduction period. In KIDS, however, young goats were not each others neighbours as often, confirming the hypothesis of greater dispersion in KIDS. These results may also be due to the presence of kids and their suckling resulting in young goats being less fearful, as observed in other species (Lonstein et al 1998, Toufexis et al 1999, Lonstein 2005) and therefore needing less social support by other young goats. Lower levels of young goats being each others neighbours in KIDS could also be related to less aggressive behaviour toward introduced young goats in this period, thus making it more attractive for young goats to disperse into the herd.

Regarding basic activity, levels of feeding in young goats were higher in KIDS than DRY, confirming predictions. This is likely to be due to the characteristics of the two introduction periods as discussed above with respect to social behaviour, probably resulting in easier integration of young goats and less fear and stress in young goats when introduced in KIDS. Lying was also expected to be observed more often in KIDS, yet it did not differ between introduction periods, contradicting predictions. Space allowances offered in this experiment were rather large (4.3 – 4.8m^2/animal) and therefore competition for lying space was low, likely to allow young goats to fulfil their need for rest in both introduction periods.

Even though feeding was more often observed in KIDS than DRY levels in general were very low, resulting in a lower body condition and weight reduction of young goats during both introduction periods. Young goats loosing even more weight and having lower BCS, respectively, in KIDS than DRY, is likely to be due to this specific reproductional period (Gall 2001). At the beginning of lactation energy needs can hardly be covered with the feed consumed (Sauvant et al 1991) and therefore body fat is mobilized in order to cover the energy needs of the animal (Gall 2001, Strittmayer 2003, von Korn et al 2007). Consequently reduced levels of feeding in introduced young goats in KIDS in combination with the fat mobilizing process resulted in lower BCS and more weight reduction in KIDS than DRY. Regarding injuries, number of recorded injuries was very low, with no injuries in DRY and three injuries, i.e. three animals, in KIDS. Two of these injuries were caused in the waiting area (udder deep lesion, size 1-3cm; ear deep lesion, size <1cm) and one in the barn (vulva swelling <1cm). We expected less weight reduction and fewer injuries in KIDS, due to lower stress levels at that period. Yet the hypothesis focussed only on the effects of introductions on young goats, but did not include physiological processes at the beginning of lactation (weight loss, BCS) and goats using the waiting area in lactation (injuries).

Results on adrenocortical activity, i.e. marked increases in cortisol metabolite concentration in faeces in DRY compared to KIDS, are also in agreement with behavioural parameters. This confirms the hypothesis on introductions causing less stress for young goats when being introduced in KIDS compared to DRY. Cortisol metabolite levels in KIDS did not differ before and after introduction, which is not in accordance with other studies on mixing in cattle (Mench et al 1990, Hasegawa et al 1997, Gupta et al 2005). Yet results may be related to the characteristics of this introduction period, leading to easier integration of young goats in KIDS.

The early social environment of young goats (reared artificially or by their mothers) was expected to influence how animals cope with introductions. Rearing, however, did barely affect recorded parameters. Mother reared goats showed more cohesion to their peers, i.e. other young goats, by having them as neighbours more often than artificially reared ones. Young goats reared with their mothers were also lying with contact more often than others. According to research rearing affects how animals respond to novel situations (Le Neindre 1991, Napolitano et al 2008), which may indicate easier integration of mother reared animals in groups and also higher sociality toward other animals. These differences may be related to mother reared animals experiencing close and also physical contact with their mothers and the beneficial effects of it (Carter 1998, Unväs-Moberg 1998) over a longer period than artificially reared ones. Therefore mother reared goats may look for physical contact and peers within the herd more than others even later in life and may do so especially under stressful situations (e.g. introduction into adult goat groups), supporting the hypothesis of higher sociality of mother reared animals.

Young goats which had been reared by their mothers did also have the opportunity to form long term social bonds to their mothers, as also observed in closely related individuals in other species (sheep: Napolitano et al 2008, Hinch et al 1990; cattle: Veissier et al 1990a, Lazo 1994, Murphy et al 2000). In case of recognition the presence of the mother was expected to reduce stress experienced in young goats by offering support (Mendoza et al 1974, von Holst 1990). The presence of the mother for those goats reared with their mother did not affect recorded parameters, with the exception of nearest neighbours, not confirming predictions. Among mother reared young goats mothers were not observed as neighbours above chance level, yet young goats were seen as neighbours less often when their mothers were present. Lack of influence of the presence of mother on observed parameters may be related to mothers and young goats not having any contact for about 1.5 years and consequently other bonding partners may have become more important than their mothers (Veissier et al 1990b). Young goats, however, may be associated to their mothers in a more distant but as yet undescribed way, possibly explaining results.

The outcome of this doctoral thesis indicates a stricter dominance hierarchy in horned herds compared to hornless ones. More respect in horned goats, however, does not seem to be associated with higher stress levels in general neither in horned herds nor in subordinate horned individuals, as indicated by faecal cortisol metabolites and milk cortisol. Subordinate horned goats were also not put at a disadvantage regarding other behavioural parameters, i.e. differences between dominance classes (low, middle, high) were not more pronounced in horned than hornless groups. Under the housing conditions investigated a more clearly established dominance hierarchy, as seen in horned goats, still allowed all animals within the herd to satisfy their needs sufficiently. Results also indicate that less respect for social distances and a less clearly established dominance hierarchy, respectively, implies unfavourable consequences for the herd, e.g. higher levels of total agonistic interactions and a trend toward lower BCS. In order to reduce social stress and improve welfare, health and performance in animal herds, the timing of introducing unfamiliar animals into already existing herds should be considered. Young goats experience less social stress when being introduced into a herd of adult dairy goats shortly after parturition with kids still present as compared to the dry period of the herd. Changing housing conditions for indoor housed goats toward their natural habitat, e.g. by adding additional spatial structure, has according to literature the potential to improve the welfare of animals (Simantke et al 1997, Andersen and Bøe 2007, Jørgensen and Bøe 2009, Aschwanden et al 2009a, Aschwanden et al 2009b, Ehrlenbruch et al 2010). In this study, however the installation of resting platforms in the horned and hornless group did affect parameters only marginally and did not result in reduction of adrenocortical activity as expected. The number of provided resting platforms may not have been sufficient and/or chronic stress may still be present in other areas, explaining results of this study. Effects of platforms may be more pronounced when larger areas are offered, allowing more goats to use them simultaneously. Earlier research and the frequent use of platforms, irrespective of horn status and rank in this study, indicate the importance of structured pens in goat husbandry. Therefore we suggest to provide larger numbers of platforms allowing all animals to rest on, as farm animals show synchronous resting patterns, when conditions allow it (Rook and Penning 1991, Fraser and Broom 1997). Structured pens are also reflecting the natural environment of goats and therefore likely to influence animals positively.

Another factor which was not in particular investigated in this study, but seemed to have a rather large effect on the animals, was the feeding management. The welfare, health and performance of animals, i.e. body condition and number of injuries, are influenced by feeding management (Carlstead 1986, Noack and Hauser 2004, Waiblinger et al 2010). When BCS and number of injuries were looked at on these two farms, used for investigating horned and hornless herds, on farm1 the majority of animals was scored higher in BCS than on farm2, yet on farm2 the total occurrence of injuries was higher than on farm1. On farm1 the feeding management was supporting the specific feeding characteristics of goats (Gall 2001), while this was limited on farm2, i.e. ad libitum hay and silage fed two times a day (farm1) versus TMR fed once a day linked to unreliable feeding times (farm2). As lack of predictability can cause frustration, fuel aggression (Carlstead 1986) and subsequently increase competition between animals when feed is given, the risk of injuries also increases. Therefore feeding management according to the need of animals is an important factor to reduce conflicts and prevent injuries, irrespective of presence of horns (Noack and Hauser 2004, Waiblinger et al 2010). As data was partly analysed together for both farms the influence of farm characteristics, e.g. feeding management, remains unclear. There are, however, indices that individual farm effects may have a rather larger influence on recorded parameters. To completely clarify the influence of farm characteristics and e.g. the influence of presence of horns on certain parameters, further research is needed.

5 General conclusion

Results of this doctoral thesis are pointing toward the importance of housing conditions and feeding management, rather than presence of horns regarding social stress in farm animals. Large groups of dairy goats can be successfully housed without negative implications on welfare, irrespective of presence of horns, as it has already been seen in earlier studies on farming of horned dairy cattle. Therefore the risks of disbudding goat kids and the consequences of less respect for social distances as observed in hornless goat herds should be taken into account when the decision on farming hornless and horned goats, respectively, is made. Furthermore the timing of introducing unfamiliar animals into already existing herds should be considered in order to reduce social stress. Consequences of introductions are much less pronounced when animals are introduced shortly after parturition with kids still present compared to the dry period of the herd.

6 Appendix

Tab. 21: Experimental period and events on farm1; recorded parameters are given for respective days (X) and observation periods (before first regrouping (1), three weeks after first regrouping (2), four weeks after first regrouping (3) and four weeks after second regrouping (4)).

Date	social behaviour, basic activity	injuries	milk and faecal samples	observation period, events
24.2.08	X			1
25.2.08	X			1
26.2.08	X		X	1
27.2.08	X		X	1
28.2.08	X	X		1
01.3.08				first regrouping
19.3.08	X			2
20.3.08	X		X	2
21.3.08	X		X	2
23.3.08	X			3
24.3.08	X			3
25.3.08	X		X	3
26.3.08	X		X	3
27.3.08	X	X		3
02.4.08				second regrouping
24.4.08	X			4
25.4.08	X			4
26.4.08	X		X	4
27.4.08	X		X	4
28.4.08	X	X		4

Tab. 22: Farm1: the index of success and dominance class (low, middle, high) for focal goats in hornless and horned groups, N=30 per group.

number of focal animals/group	group	index of success	dominance class
1	hornless	0.05	low
2	hornless	0.13	low
3	hornless	0.14	low
4	hornless	0.15	low
5	hornless	0.18	low
6	hornless	0.18	low
7	hornless	0.20	low
8	hornless	0.28	low
9	hornless	0.30	low
10	hornless	0.34	low
11	hornless	0.38	middle
12	hornless	0.38	middle
13	hornless	0.41	middle
14	hornless	0.44	middle
15	hornless	0.46	middle
16	hornless	0.49	middle
17	hornless	0.53	middle
18	hornless	0.58	middle
19	hornless	0.59	middle
20	hornless	0.67	middle
21	hornless	0.70	high
22	hornless	0.75	high
23	hornless	0.76	high
24	hornless	0.76	high
25	hornless	0.80	high
26	hornless	0.80	high
27	hornless	0.81	high
28	hornless	0.83	high
29	hornless	0.90	high
30	hornless	0.92	high
1	horned	0.09	low
2	horned	0.09	low
3	horned	0.12	low
4	horned	0.17	low
5	horned	0.20	low
6	horned	0.20	low
7	horned	0.21	low

8	horned	0.31	low
9	horned	0.33	low
10	horned	0.36	low
11	horned	0.39	middle
12	horned	0.41	middle
13	horned	0.43	middle
14	horned	0.47	middle
15	horned	0.50	middle
16	horned	0.58	middle
17	horned	0.60	middle
18	horned	0.62	middle
19	horned	0.63	middle
20	horned	0.64	middle
21	horned	0.70	high
22	horned	0.73	high
23	horned	0.73	high
24	horned	0.79	high
25	horned	0.84	high
26	horned	0.87	high
27	horned	0.88	high
28	horned	0.90	high
29	horned	0.92	high
30	horned	0.94	high

Tab. 23: Experimental period on farm2 and recorded parameters for respective days (X) and observation periods (before resting platforms (1), one week after installation (2), four weeks after installation (3) and after removal of platforms (4)). Events and focal animal determination (fad) are also shown for farm2.

Date	social behaviour	feeding place occupancy	basic activity	injuries	milk and faecal samples	observation period, events, fad
07.04.08	X					fad
08.04.08	X					fad
09.04.08	X					fad
10.04.08	X					fad
13.04.08	X					fad
14.04.08	X					fad
15.04.08	X					fad
16.04.08	X					fad
19.04.08	X					fad
20.04.08	X					fad
21.4.08	X					fad
22.4.08	X					fad
13.5.08	X	X	X			1
14.5.08	X	X	X			1
15.5.08	X	X				1
16.5.08	X	X				1
18.5.08	X	X				1
19.5.08	X	X			X	1
20.5.08	X	X			X	1
21.5.08	X	X		X		1
26.5.08	X	X				installation of resting platforms
28.5.08	X	X	X			2
29.5.08	X	X	X			2
30.5.08	X	X				2
31.5.08	X	X				2
02.6.08	X	X				2
03.6.08	X	X			X	2
04.6.08	X	X			X	2
05.6.08	X	X		X		2
25.6.08	X	X	X			3
26.6.08	X	X	X			3
27.6.08	X	X				3
28.6.08	X	X				3
30.6.08	X	X				3

01.7.08	X	X			X	3
02.7.08	X	X			X	3
03.7.08	X	X		X		3
04.7.08		X				removal of resting platforms
07.7.08	X	X	X			4
08.7.08	X	X	X			4
09.7.08	X	X				4
10.7.08	X	X				4
12.7.08	X	X				4
13.7.08	X	X			X	4
14.7.08	X	X			X	4
15.7.08	X	X		X		4

Tab. 24: Farm2: the index of success and dominance index for all goats in hornless (N=75) and horned (N=72) groups being part of the experiment. Lame animals and those whose dominance index/index of success was based on only two or less interactions are indicated (X). For chosen focal animals (bold numbers) the dominance class (low, middle, high) is additionally shown (N=60). During the experimental period three horned goats died, therefore they are not shown in the table.

number of animals/group	group	dominance index	index of success	dominance class	two or less interactions	lameness
1	**hornless**	0.000	0.000	**low**		
2	hornless	0.000	0.000		X	
3	**hornless**	0.000	0.000	**low**		
4	**hornless**	0.000	0.000	**low**		
5	**hornless**	0.000	0.000	**low**		
6	**hornless**	0.000	0.000	**low**		
7	hornless	0.000	0.000		X	
8	**hornless**	0.000	0.000	**low**		
9	hornless	0.000	0.000		X	
10	hornless	0.000	0.000		X	
11	**hornless**	0.091	0.059	**low**		
12	**hornless**	0.091	0.059	**low**		
13	**hornless**	0.091	0.091	**low**		
14	**hornless**	0.154	0.125	**low**		
15	hornless	0.222	0.167			
16	hornless	0.231	0.318			
17	hornless	0.250	0.300			
18	hornless	0.250	0.222			
19	hornless	0.250	0.304			
20	**hornless**	**0.333**	**0.286**	**middle**		
21	**hornless**	**0.333**	**0.429**	**middle**		
22	**hornless**	**0.333**	**0.286**	**middle**		
23	**hornless**	**0.375**	**0.455**	**middle**		
24	**hornless**	**0.400**	**0.400**	**middle**		
25	**hornless**	**0.429**	**0.400**	**middle**		
26	**hornless**	**0.500**	**0.600**	**middle**		
27	hornless	0.500	0.500		X	
28	hornless	0.500	0.500		X	
29	**hornless**	**0.500**	**0.429**	**middle**		
30	**hornless**	**0.500**	**0.444**	**middle**		
31	**hornless**	**0.556**	**0.600**	**middle**		
32	hornless	0.600	0.500			
33	hornless	0.600	0.600			
34	hornless	0.600	0.643			

35	hornless	0.625	0.571			
36	hornless	0.625	0.636			
37	hornless	0.667	0.667			
38	hornless	0.714	0.714			
39	hornless	0.750	0.780			
40	hornless	0.750	0.667			
41	hornless	0.750	0.800			
42	**hornless**	**0.800**	**0.800**	**high**		
43	hornless	0.800	0.800		X	
44	**hornless**	**0.833**	**0.889**	**high**		
45	**hornless**	**0.857**	**0.889**	**high**		
46	**hornless**	**0.889**	**0.767**	**high**		
47	**hornless**	**0.900**	**0.909**	**high**		
48	**hornless**	**0.923**	**0.927**	**high**		
49	**hornless**	**0.947**	**0.962**	**high**		
50	**hornless**	**1.000**	**1.000**	**high**		
51	**hornless**	**1.000**	**1.000**	**high**		
52	**hornless**	**1.000**	**0.944**	**high**		
53	hornless	0.000	0.000			X
54	hornless	0.000	0.000			X
55	hornless	0.000	0.000			X
56	hornless	0.000	0.000			X
57	hornless	0.000	0.000			X
58	hornless	0.000	0.000			X
59	hornless	0.143	0.143			X
60	hornless	0.250	0.500			X
61	hornless	0.273	0.214			X
62	hornless	0.286	0.250			X
63	hornless	0.333	0.333			X
64	hornless	0.333	0.429			X
65	hornless	0.500	0.333			X
66	hornless	0.500	0.500			X
67	hornless	0.625	0.625			X
68	hornless	0.667	0.533			X
69	hornless	0.667	0.571			X
70	hornless	0.700	0.533			X
71	hornless	0.714	0.714			X
72	hornless	0.714	0.750			X
73	hornless	0.900	0.833			X
74	hornless	1.000	1.000			X

75	hornless	1.000	1.000		X
1	**horned**	**0.000**	**0.071**	**low**	
2	**horned**	**0.037**	**0.048**	**low**	
3	**horned**	**0.067**	**0.087**	**low**	
4	**horned**	**0.077**	**0.077**	**low**	
5	**horned**	**0.087**	**0.125**	**low**	
6	**horned**	**0.111**	**0.100**	**low**	
7	**horned**	**0.111**	**0.091**	**low**	
8	**horned**	**0.111**	**0.087**	**low**	
9	**horned**	**0.125**	**0.080**	**low**	
10	**horned**	**0.125**	**0.111**	**low**	
11	horned	0.154	0.133		
12	horned	0.167	0.154		
13	horned	0.167	0.235		
14	horned	0.167	0.133		
15	horned	0.200	0.133		
16	horned	0.200	0.214		
17	horned	0.200	0.115		
18	horned	0.200	0.143		
19	horned	0.214	0.176		
20	horned	0.222	0.267		
21	horned	0.250	0.269		
22	horned	0.267	0.292		
23	horned	0.267	0.235		
24	horned	0.267	0.208		
25	horned	0.286	0.154		
26	**horned**	**0.308**	**0.316**	**middle**	
27	**horned**	**0.316**	**0.333**	**middle**	
28	**horned**	**0.333**	**0.333**	**middle**	
29	**horned**	**0.333**	**0.250**	**middle**	
30	**horned**	**0.333**	**0.400**	**middle**	
31	**horned**	**0.333**	**0.250**	**middle**	
32	**horned**	**0.350**	**0.364**	**middle**	
33	**horned**	**0.350**	**0.333**	**middle**	
34	**horned**	**0.357**	**0.316**	**middle**	
35	**horned**	**0.364**	**0.280**	**middle**	
36	horned	0.364	0.364		
37	horned	0.400	0.444		
38	horned	0.400	0.429		
39	horned	0.429	0.273		

40	horned	0.440	0.351		
41	horned	0.440	0.318		
42	horned	0.444	0.429		
43	horned	0.455	0.417		
44	horned	0.500	0.563		
45	horned	0.500	0.419		
46	horned	0.533	0.524		
47	horned	0.538	0.529		
48	**horned**	**0.545**	**0.571**	**high**	
49	**horned**	**0.556**	**0.526**	**high**	
50	**horned**	**0.556**	**0.414**	**high**	
51	**horned**	**0.556**	**0.545**	**high**	
52	**horned**	**0.600**	**0.600**	**high**	
53	**horned**	**0.636**	**0.667**	**high**	
54	**horned**	**0.647**	**0.579**	**high**	
55	**horned**	**0.750**	**0.750**	**high**	
56	**horned**	**0.760**	**0.758**	**high**	
57	**horned**	**0.813**	**0.783**	**high**	
58	horned	0.050	0.028		X
59	horned	0.067	0.056		X
60	horned	0.100	0.083		X
61	horned	0.125	0.091		X
62	horned	0.143	0.111		X
63	horned	0.222	0.143		X
64	horned	0.250	0.250		X
65	horned	0.286	0.300		X
66	horned	0.333	0.333		X
67	horned	0.375	0.304		X
68	horned	0.556	0.304		X
69	horned	0.571	0.500		X
70	horned	0.625	0.667		X
71	horned	0.727	0.667		X
72	horned	1.000	1.000		X

Tab. 25: Experimental period for introductions of young goats into the adult herd; recorded parameters are given for respective days (X), introduction periods (DRY, KIDS) and repetitions (1, 2).

date	social behaviour, nearest neighbours	basic activity	faecal samples	body condition, injuries, weight	introduction period - repetition
26.11.08			X		DRY - 1
27.11.08			X		DRY - 1
28.11.08	X	X		X	DRY - 1
29.11.08	X				DRY - 1
30.11.08	X				DRY - 1
1.12.08	X		X		DRY - 1
2.12.08	X				DRY - 1
3.12.08	X		X		DRY - 1
4.12.08	X				DRY - 1
5.12.08	X	X	X	X	DRY - 1
6.12.08					
7.12.08					
8.12.08					
9.12.08					
10.12.08					
11.12.08			X		DRY - 2
12.12.08			X		DRY - 2
13.12.08					DRY - 2
14.12.08					DRY - 2
15.12.08	X	X		X	DRY - 2
16.12.08	X				DRY - 2
17.12.08	X				DRY - 2
18.12.08	X		X		DRY - 2
19.12.08	X				DRY - 2
20.12.08	X		X		DRY - 2
21.12.08	X				DRY - 2
22.12.08	X	X	X	X	DRY - 2
26.3.09			X		KIDS - 1
27.3.09			X		KIDS - 1
28.3.09					KIDS - 1
29.3.09					KIDS – 1
30.3.09					KIDS – 1
31.3.09	X	X		X	KIDS – 1
1.4.09	X				KIDS – 1
2.4.09	X				KIDS – 1
3.4.09	X		X		KIDS – 1

4.4.09	X				KIDS – 1
5.4.09	X		X		KIDS – 1
6.4.09	X				KIDS – 1
7.4.09	X	X	X	X	KIDS - 1
8.4.09					
9.4.09					
10.4.09					
11.4.09					
12.4.09					
13.4.09					
14.4.09					
15.4.09	X	X		X	KIDS - 2
16.4.09	X				KIDS – 2
17.4.09	X				KIDS – 2
18.4.09	X		X		KIDS – 2
19.4.09	X				KIDS – 2
20.4.09	X		X		KIDS – 2
21.4.09	X				KIDS – 2
22.4.09	X	X	X	X	KIDS – 2

7 References

Addison, W.E. and Baker, E., 1982. Agonistic behavior and social organization in a herd of goats as affected by the introduction of non-members. Applied Animal Ethology, 8: 527-535.

Adeyemo, O. and Heath, E., 1982. Social behaviour and adrenal cortical activity in heifers. Applied Animal Ethology, 8. 99-108.

Adkins-Regan, E., 2005. Why does social behaviour need hormonal regulation? In: Adkins-Regan, E, Krebs, J.R. and Clutton-Brock, T. (Eds.), Hormones and Animal Social Behaviour, Monographs in Behaviour and Ecology, Princeton University Press, 3-4.

Alley, J.C. and Fordham, R.A., 1994. Social events following the introduction of unfamiliar does to a captive feral goat (Capra hircus L.) herd. Small Ruminant Research, 13: 103-107.

Al-Sobayil, F.A., 2007. A new simple device for dehorning in small ruminants. Small Ruminant Research, 67: 232-234.

Andersen, I.L. and Bøe, K.E., 2007. Resting pattern and social interactions in goats-The impact of size and organisation of lying space. Applied Animal Behavior Science, 108: 89-103.

Andersen, I.L., Bøe, K.E., and Kristiansen, A.L., 1999. The influence of different feeding arrangements and food type on competition at feeding in pregnant sows. Applied Animal Behavior Science 65: 91-104.

Andersen, I.L., Roussel, S., Ropstad, E., Braastad, B.O., Steinheim, G., Janczak, A.M., Jørgensen, G.H.M., and Bøe, K.E., 2008. Social instability increases aggression in groups of dairy goats, but with minor consequences for the goats' growth, kid production and development. Applied Animal Behavior Science, 114: 132-148.

Anthony DC, Frosch MP, De Girolami U. Peripheral nerve and skeletal muscle. In: Robbins and Cotran Pathologic Basis of Disease. 7th ed. Philadelphia: Elsevier, 2005; 1325-1347.

Aschwanden, J., Gygax, L., Wechsler, B., and Keil, N.M., 2008a. Social distances of goats at the feeding rack: Influence of the quality of social bonds, rank differences, grouping age and presence of horns. Applied Animal Behavior Science, 114: 116-131.

Aschwanden, J., Gygax, L., Wechsler, B., and Keil, N.M., 2008b. Cardiac activity in dairy goats whilst feeding side-by-side at two different distances and during social separation. Physiology & Behavior, 95: 641-648.

Aschwanden, J., Gygax, L., Wechsler, B., and Keil, N.M., 2009a. Loose housing of small goat groups: Influence of visual cover and elevated levels on feeding, resting and agonistic behaviour. Applied Animal Behavior Science, 119: 171-179.

Aschwanden, J., Gygax, L., Wechsler, B., and Keil, N.M., 2009b. Structural modifications at the feeding place: Effects of partitions and platforms on feeding and social behaviour of goats. Applied Animal Behavior Science, 119: 180-192.

AVMA 2010. Dehorning and Disbudding of cattle, published by the American Veterinary Medical Association. http://www.avma.org/reference/backgrounders/dehorning_cattle_bgnd.asp. Accessed on February 2011.

Barnett, J.L., Coleman, G.J., and Hemsworth, P.H.,. 1999. Tail docking and beliefs about the practice in the Victorian dairy industry. Australian Veterinary Journal 77: 742-747.

Barroso, F.G., Alados, C.L., and Boza, J., 2000. Social hierarchy in the domestic goat: effect on food habits and production. Applied Animal Behavior Science, 69: 35-53.

Bengtsson, B., Menzel, A., and Holtenius, P., 1996. Cryosurgical dehorning of calves: a preliminary study. Vet Rec, 138: 234-237.

Bøe, K.E. and Færevik, G., 2003. Grouping and social preferences in calves, heifers and cows. Applied Animal Behavior Science, 80: 175-190.

Bøe, K.E., Andersen, I.L., Buisson, L., Simensen, E., and Jeksrud, W.K., 2007. Flooring preferences in dairy goats at moderate and low ambient temperature . Applied Animal Behavior Science, 108, 45-57.

Bøe, K.E., Berg, S., and Andersen, I.L., 2006. Resting behaviour and displacements in ewes-effects of reduced lying space and pen shape. Applied Animal Behavior Science, 98: 249-259.

Bogner, H. and Grauvogl, A., 1984. Verhalten landwirtschaftlicher Nutztiere. Eugen Ulmer Verlag, Stuttgart, Deutschland.

Boissy, A. and Dumont, B., 2002. Interactions between social and feeding motivations on the grazing behaviour of herbivores: sheep more easily split into subgroups with familiar peers. Applied Animal Behavior Science, 79: 233-245.

Bömkes, D., Hamann, H., and Distl, O,. 2004. Einfluss systematischer Umwelteffekte auf die Milchleistungsmerkmal bei Bunten Deutschen Edelziegen. Archiv für Tierzucht, 3: 275-285.

Bouissou, M. F. and Andrieu S. 1978. Etablissement des relations préférentielles chez les bovins domestiques. Behaviour, 64:148-157.

Breward, J., and Gentle, M.J., 1985. Neuroma formation and abnormal afferent nerve discharges after partial beak amputation (beak trimming) in poultry. Experientia; 41: 1132-1134.

Brouns, F. and Edwards, S.A., 1994. Social rank and feeding behaviour of group-housed sows fed competitively or ad libitum. Applied Animal Behavior Science, 39: 225-235.

Bürger, M., 1966. Das Wiederkäuen, eine vergleichende ethologische Untersuchung an Haus- und Wildtieren in zoologischen Gärten. Archiv Tierernährung 16, 472-505. In: Krehl, A., 1998. Ethologische Bewertung der Getrennt- und Gemischtbeweidung von Magerrasen mit Schafen und Ziegen, Internationale Nutztierzucht und –haltung, Mitteilungsblatt Nr. 20, Universität Kassel, Deutschland.

Carlstead, K., 1986. Predictability of feeding: its effect on agonistic behaviour and growth in grower pigs. Applied Animal Behavior Science. 16: 25-38.

Carter, S., 1998. Neuroendocrine perspectives on social attachment and love. Psychoneuroendocrinology, 23: 779-818.

Coté, S. and Festa-Bianchet, M., 2001. Reproductive success in female mountain goats: the influence of age and social rank. Animal Behaviour, 62: 173-181.

Csermely, D., and Wood-Gush, D.G.M., 1990 Agonistic behaviour in grouped sows II. How social rank affects feeding and drinking behaviour. Bolletino di zoologia, 57: 55-58.

de Groot, J., Ruis, M.A.W., Scholten, J.W., Koolhaas, J.M., and Boersma, W.J.A., 2001. Long-term effects of social stress on antiviral immunity in pigs. Physiology & Behavior, 73: 145-158.

Dubeuf, J.-P., Morand-Fehr, P., and Rubino, R., 2004. Situation, changes and future of goat industry around the world. Small Ruminant Research, 51: 165-173.

Dudzinski, M.L. and Arnold, G.W., 1979. Factors influencing the grazing behaviour of sheep in a Mediterranean climate. Applied Animal Ethology, 5: 125-144.

Ehrlenbruch, R., Jørgensen, G.H.M., Andersen, I.L., and Bøe, K.E., 2010. Provision of additional walls in the resting area-The effects on resting behaviour and social interactions in goats. Applied Animal Behavior Science, 122: 35-40.

Eicher, S.D., Cheng, H.W., Sorrells, A.D. and Schutz, M.M., 2006. Behavioral and physiological indicators of sensitivity or chronic pain following tail-docking. Journal of Dairy Science*,* 89, 3047-3051.

Ekman, J.B. and Askenmo, C.E.H., 1984. Social rank and habitat use in willow tit groups. Animal Behavior, 32: 508-514.

Erhard, H.W., and Schouten, J.M., 2001. Individual differences and personality. In: L.J. Keeling and H.W. Gonyou (Eds.), social behaviour in farm animals, CAB International Wallingford, 333–352.

EUROSTAT 2010 European statistics http://appsso.eurostat.ec.europa.eu/nui/setupModifyTableLayout.do. Accessed on February 2011.

EUROSTAT 2010, European statistics. http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do?switchdimensions=true. Accessed on February 2011.

Fernández, M.A., Alvarez, L., and Zarco, L., 2007. Regrouping in lactating goats increases aggression and decreases milk production. Small Ruminant Research, 70: 228-232.

Fox, L., Butler, W.R., Everett, R.W., and Natzke, R.P., 1981. Effect of Adrenocorticotropin on Milk and Plasma Cortisol and Prolactin Concentrations. Journal of Dairy Science, 64: 1794-1803.

Fraser, A.F., and Broom, D.M., 1997. Farm Animals Behaviour and Welfare. 3rd Edition, CAB International Wallingford.

Fregonesi, J.A., and Leaver, D., 2002. Influence of space allowance and milk yield level on behaviour, performance and health of dairy cows housed in strawyard and cubicle systems. Livestock Production Science, 78: 245-257.

Friend, T.H., Polan, C.E., Gwazdauskas, F.C., and Heald, C.W., 1977. Adrenal Glucocorticoid Response to Exogenous Adrenocorticotropin Mediated by Density and Social Disruption in Lactating Cows. Journal of Dairy Science, 60, 1958-1963

Fukasawa, M., Tsukada, H., Kosako, T., and Yamada, A., 2008. Effect of lactation stage, season and parity on milk cortisol concentration in Holstein cows. Livestock Science, 113: 280-284.

Gall, C., 2001. Ziegenzucht. Stuttgart (Hohenheim), Verlag Eugen Ulmer GmbH&Co.

Gloning, S., in press. Auswirkung der Enthornung von Ziegenkitzen auf ihre Gesundheit. Master thesis, University of Veterinary Medicine, Vienna, Austria.

Gordon, G.D.H. and Cockram, M.S., 1995. A comparison of wooden slats and straw bedding on behaviour of sheep. Animal Welfare, 4: 131-134.

Graf, B., 1974. Aktivitäten von enthornten und nicht enthornten Milchkühen auf der Weide. Diplomarbeit, Institut für Tierproduktion, ETH; Zürich.

Gräser-Hermann, C., 2001. Sozialverhalten Ostfriesischer Milchschafe in größeren Gruppen, Dissertation, Tierärztliche Fakultät der Ludwig-Maximilians-Universität München, Deutschland.

Gupta, S., Earley, B., Ting, S.T.L., Crowe, M.A., 2005. Effect of repeated regrouping and relocation on the physiological, immunological, and hematological variables and performance of steers. Journal of Animal Science 83.

Gygax, L., Neuffer, I., Kaufmann, C., Hauser, R., and Wechsler, B., 2006. Milk Cortisol Concentration in Automatic Milking Systems Compared with Auto-Tandem Milking Parlors. Journal of Dairy Science, 89: 3447-3454.

Habermehl, K.H., 2005. Haut und Hautorgane. In: Habermehl, K.H., Vollmerhaus, B., Wilkens, H., and Waibl, H., (Eds.), Lehrbuch der Anatomie der Haustiere. Band III Kreislaufsystem, Haut und Hautorgane, Parey Verlag Stuttgart, 492-494.

Hagen, K., Lexer, D., Palme, R., Troxler, J., and Waiblinger, S., 2004. Milking of Brown Swiss and Austrian Simmental cows in a herringbone parlour or an automatic milking unit. Applied Animal Behavior Science, 88: 209-225.

Hasegawa, N., Nishiwaki, A., Sugawara, K., and Ito, I., 1997. The effects of social exchange between two groups of lactating primiparous heifers on milk production, dominance order, behavior and adrenocortical response. Applied Animal Behavior Science., 51: 15-27.

Hervieu and Mohrand-Fehr 1999, Apprecier L´état corporel des chievres-interêt et méthode. Réussir la chévre 231, 22-33. In: von Korn S., Trautwein H., Jaudas U., Landwirtschaftliche Ziegenhaltung, Ulmer Verlag.

Hinch, G. N., Lynch, J. J., Elwin, R.L., and Green, G. C., 1990. Long-term associations between Merino ewes and their offspring. Applied Animal Behavior Science, 27: 93-103.

Hoffsis, G., 1995. Surgical (cosmetic) dehorning in cattle. Vet Clin Food Anim, 11: 159-169.

Howery, L.D., Provenza, F.D., Banner, R.E., and Scott, C.B., 1998. Social and environmental factors influence cattle distribution on rangeland. Applied Animal Behavior Science, 55: 231-244.

Hurnik, J.F., King, G.J. and Robertson, H.A., 1975. Estrous and related behaviour in postpartum Holstein cows. Applied Animal Ethology, 2: 55–68.

Hyun, Y., Ellis, M., Riskowski, G., and Johnson, R.W., 1998. Growth performance of pigs subjected to multiple concurrent environmental stressors. Journal of Animal Science, 76: 721-727.

Jensen, P., 1994. Fighting between unacquainted pigs -- effects of age and of individual reaction pattern. Applied Animal Behavior Science, 41: 37-52.

Jørgensen, G.H.M. and Bøe, K.E., 2009. The effect of shape, width and slope of a resting platform on the resting behaviour of and floor cleanliness for housed sheep. Small Ruminant Research, 87, 57-63.

Jørgensen, G.H.M., Andersen, I.L., and Bøe, K.E., 2007. Feed intake and social interactions in dairy goats--The effects of feeding space and type of roughage. Applied Animal Behavior Science, 107: 239-251.

Jørgensen, G.H.M., Andersen, I.L., Berg, S., and Bøe, K.E., 2009. Feeding, resting and social behaviour in ewes housed in two different group sizes. Applied Animal Behavior Science, 116: 198-203.

Kasai, M., Maki, H., Nosaka, N., Ayama, T., Ooyama, K., Uto, H., Okazaki, M., M.Igarashi, O., and Kondo, K., 2003. Effect of medium-chain triglycerides on the postprandial triglyceride concentration in healthy men. Biosc Biotechnol Biochem, 67: 46-53.

Keil, N.M. and Sambraus, H.H., 1996. On social behaviour of milk goats in large groups. Archiv für Tierzucht, 39: 465-473.

Kjæstad, H.P., 1999. Cubicle sheds for dairy cows. A field study of the use of cubicles, of the use of the concentrate feed dispenser and of the management of calving. The Norwegian School of Veterinary Science, Doctoral Thesis.

Kleinsasser, C., Graml, C., Klobetz-Rassam, E., Barth, K., Waiblinger, S., and Palme, R., 2010. Physiological validation of a non-invasive method for measuring adrenocortical activity in goats. Wien Tierärztliche Monatsschrift, 97: 259-262.

Knierim, U., 1999. Das Verhalten von Färsen bei der Einzel- oder Gruppeneinführung in die Milchviehherde (The behavior of heifers after single or group introduction to the dairy herd). Kuratorium für Technik und Bauwesen in der Landwirtschaft, 382: 115-120.

Koller, U., 2000. Enthornung von Gizi, Forum für Kleinwiederkäuer, 2: 10-13.

Kondo, S., Kawakami, N., Kohama, H., and Nishino, S., 1984. Changes in activity, spatial pattern and social behavior in calves after grouping. Applied Animal Ethology, 11: 217-228.

Lawrence, A. B., 1990. Mother-daughter and peer relationships of Scottish hill sheep. Animal Behavior, 39: 481-486.

Lawrence, A. B., 1991. Mother-daughter bonds in sheep. Animal Behavior, 42: 683-685.

Lazo, A., 1994. Social segregation and the maintenance of social stability in a feral cattle population. Animal Behavior, 48: 1133-1141.

Le Neindre, P., 1991. Effects of breed and early social environment on calf behaviour. In: Metz, J.H.M., Groenestein, C.M. (Eds.), Proceedings of the International Symposium on Veal Calf Production. Wageningen, The Netherlands, EAAP-Publication No. 52, New trends in veal calf production, 1991, 32-35.

Lindberg, A.C., 2001. Group Life. In: L.J. Keeling and H.W. Gonyou (Eds.), social behaviour in farm animals, CAB International, Oxon, 37-58.

Long, C. R., and Gregory, K. E., 1978. Inheritance of the horned, scurred and polled condition in cattle. Journal of Heriditability, 69: 395-400.

Lonstein, J.S., 2005. Reduced anxiety in postpartum rats requires recent physical interactions with pups, but is independent of suckling and peripheral sources of hormones. Hormones and Behavior, 47: 241-255.

Lonstein, J.S., Simmons, D.A., and Stern, J.M., 1998. Functions of the Caudal Periaqueductal Gray in Lactating Rats: Kyphosis, Lordosis, Maternal Aggression, and Fearfulness. Behavioral Neuroscience, 112: 1502-1518.

Loretz, C., Wechsler, B., Hauser, R., and Rüsch, P., 2004. A comparison of space requirements of horned and hornless goats at the feed barrier and in the lying area. Applied Animal Behavior Science, 87: 275-283.

Lyons, D.M., Price, E.O., and Moberg, G.P., 1993. Social grouping tendencies and separation - induced distress in juvenile sheep and goats. Developmental Psychology, 26: 251-259.

Malher, X., Seegers, H., and Beaudeau F., 2001. Culling and mortality in large dairy goat herds managed under intensive conditions in western France. Livestock Production Science, 71, 75-86

Manninen, E., de Passill, □□A.M., Rushen, J., Norring, M., and Saloniemi, H., 2002. Preferences of dairy cows kept in unheated buildings for different kind of cubicle flooring. Applied Animal Behavior Science, 75: 281-292.

Martin, P. and Bateson, P., 1993. Measuring Behaviour: An Introductory Guide. Cambridge University Press, United Kingdom, 2nd edition:

Mayer, C., Barth, K. and Knierim, U. 2006. Quality of the lying area in resting platforms for goats: straw bedding or wood. I Kuratorium für Technik und Bauwesen in der Landwirtschaft 448: 241-245.

Meese, G.B. and Ewbank, R., 1973. The establishment and nature of the dominance hierarchy in the domesticated pig. Animal Behavior, 21: 326-334.

Mench, J.A., Swanson, J.C. and Stricklin, W.R., 1990. Social stress and dominance among group members after mixing beef cows. Canadian Journal of Animal Science, 70: 345–354.

Mendl, M., Zanella, A.J., and Broom, D.M., 1992. Physiological and reproductive correlates of behavioural strategies in female domestic pigs. Animal Behavior, 44: 1107-1121.

Mendoza, S.P., Lyons, D.M. and Saltzman, W., 1974. Sociophysiology of squirrel monkeys. American journal of Primatology, 23: 37-54.

Menke, C., Waiblinger, S., and Fölsch, D.W., 2000. Die Bedeutung von Managementmaßnahmen im Laufstall für das Sozialverhalten von Milchkühen. Deutsche tierärztliche Wochenschrift, 107: 262-268.

Menke, C., Waiblinger, S., Fölsch, D.W., and Wiebkema, P.R., 1999. Social behaviour and injuries of horned dairy cows in loose housing systems. Animal Welfare, 8: 243-258.

Metz, J. H. M., and Wierenga, H. K. ,1987. Behavioral criteria for the design of housing systems for cattle. pp 14-15 In: Wierenga, H.K., and Peterse, D.J., (Eds.) Cattle housing systems, lameness and behaviour. Martinus Niihoff Publishers, Amsterdam, The Netherlands.

Miranda-de la Lama, G.C., Rivero, L., Chacón, G., Garcia-Belenguer, S., Villarroel, M., and Maria, G.A., 2010. Effect of the pre-slaughter logistic chain on some indicators of welfare in lambs. Livestock Science, 128: 52-59.

Mobini, S., 1991. Cosmetic dehorning of adult goats. Small Ruminant Research, 5: 187-191.

Morand-Fehr, P., 2003. Dietary choices of goats at the trough. Small Ruminant Research, 49: 231-239.

Mormède, P., Andanson, S., Auprin, B., Beerda, B., Gumen, D., Malmkvist, J., Manteca, X., Manteuffel, G., Prunet, P., van Reenen, C.G., Richard, S., and Veissier, I., 2007. Exploration of the hypothalamic-pituitary-adrenal function as a tool to evaluate animal welfare. Physiology & Behavior, 92: 317-339.

Möstl, E., and Palme, R., 2002. Hormones as indicators of stress. Domestic Animal Endocrinology. 23, 67-74.

Möstl, E., Maggs, J.L., Schroetter, G., Besenfelder, U., and Palme, R., 2002. Measurement of cortisol metabolites in faeces of ruminants. Veterinary Research Communications, 26: 127-139.

Mowlem, A., 1988. Goat Farming. Farming Press Books, United Kingdom, 1st Edition.

Mülleder, C., Palme, R., Menke, C., and Waiblinger, S., 2003. Individual differences in behaviour and in adrenocortical activity in beef-suckler cows. Applied Animal Behavior Science, 84: 167-183.

Müller, S., 2006. Einflußfaktoren auf den Ablauf von sozialen Interaktionen bei Milchziegen. Master Thesis, ETH Zürich, Switzerland.

Murphy, R.M., Paranhos Da Costa, M.J.R., Silva, R.G., 2000. Crèche composition in a group of Angus calves. In: Ramos, A., Pinheiro Machado Filho, L.C., Hötzel, M.J. (Eds.) Proceedings of the 34th International Congress of the ISAE, Florianapòlis, Brazil, 60.

Napolitano, F., de Rosa, G., and Sevi, A., 2008. Welfare implications of artificial rearing and early weaning in sheep. Applied Animal Behaviour Science, 110: 58-72.

Noack, E. and Hauser, R., 2004. Der ziegengerechte Fressplatz im Laufstall. FAT Bericht 622.

Nordmann, E., Keil, N. M., Schmied-Wagner, C., Graml, C., Langbein, J., Aschwanden, J., von Hof, Jessica., Maschat, K., Palme, R., and Waiblinger, S., 2011. Feed barier design affects behaviour and physiology in goats. Applied Animal Behavior Science. 133: 40-53.

O‘Brien, P. H., 1988. Feral goat social organization: A review and comparative analysis. Applied Animal Behavior Science, 21: 209-221.

O'Driscoll, K., von Keyserlingk, M.A.G., and Weary, D.M., 2006. Effects of Mixing on Drinking and Competitive Behavior of Dairy Calves. Journal of Dairy Science, 89: 229-233.

Pailhoux, E., Vigier, B., Chaffaux, S., Servel, N., Taourit, S., Furet, J.P., Grosclaude, F., Cribiu, E.P., Cotinot, C., 2001. A 11.7-kb deletion triggers intersexuality and polledness in goats. Nature Genetics, 29: 453-458.

Palme, R. and Möstl, E., 1997. Measurement of cortisol metabolites in faeces of sheep as a parameter of cortisol concentration in blood. International Journal of Mammalian Biology, 62: 192-197.

Palme, R., Wetscher, F., and Winckler, C., 2003. Measuring faecal cortisol metabolites: a non-invasive tool to assess animal welfare in cattle? Lovran, Croatia,.Buiatric Congress: 145-150.

Park, Y.W., 1994. Hypo-allergenic and therapeutic significance of goat milk. Small Ruminant Research, 14: 151-159.

Park, Y.W., Juarez, M., Ramos, M., and Haenlein, G.F.W., 2007. Physico-chemical characteristics of goat and sheep milk. Small Ruminant Research, 68: 88-113.

Park, Y.W., Mahoney, A.W., and Hendricks, D.G., 1986. Bioavailability of Iron in Goat Milk Compared with Cow Milk Fed to Anaemic Rats and. Journal of Dairy Science, 69: 2608-2615.

PASW Statistics 17.0. Statistical software IBM® SPSS® Statistics. SPSS Inc., Chicago, IL, USA.

Phillips, C.J.C. and Rind, M.I., 2001. The Effects on Production and Behavior of Mixing Uniparous and Multiparous Cows. Journal of Dairy Science, 84: 2424-2429.

Pirisi, A., Lauret, A., and Dubeuf, J.P., 2007. Basic and incentive payments for goat and sheep milk in relation to quality. Small Ruminant Research, 68: 167-178.

Raussi, S., Boissy, A., Delval, E., Pradel, P., Kaihilahti, J., and Veissier, I., 2005. Does repeated regrouping alter the social behaviour of heifers? Applied Animal Behavior Science, 93: 1-12.

Raynal-Ljutovac, K., Lagriffoul, G., Paccard, P., Guillet, I., and Chilliard, Y., 2008. Composition of goat and sheep milk products: An update. Small Ruminant Research, 79: 57-72.

Rook, A.J. and Penning, P.D., 1991. Synchronisation of eating, ruminating and idling activity by grazing sheep. Applied Animal Behavior Science, 32: 157-166.

Rowell, T. E., 1991. Till death us do part: long lasting bonds between ewes and their daughters. Animal Behavior, 42: 681-682.

Sachser, N., Dürschlag, M., and Hirzel, D., 1998. Social relationships and the management of stress. Psychoneuroendocrinology, 23: 891-904.

Sambraus, H.H., 1971. Zum Liegeverhalten der Wiederkäuer. Züchtungskunde, 43: 187-198.

Sambraus, H.H., 1978. Spezielle Nutztierethologie-Ziege. In: Sambraus, H.H., Nutztierethologie. Paul Parey Verlag, Berlin, Hamburg, 152-167.

Sauvant, D., Morand-Fehr, P., Giger-Rever-Din, S., 1991. Dry Matter Intake of Adult Goats. In: Goat Nutrition, Morand-Fehr, P., (Eds.), Pudoc Wageningen, 73-81.

Schino, G., 1998. Reconciliation in domestic goats. Behaviour, 135: 343-356.

Schneeberger, M. and Stranzinger, G., 2003. Genetische Ursachen für Hornlosigkeit und Intersexualität bei Ziegen, Forum Kleinwiederkäuer, 11: 6-8.

Schwarz, E. and Sambraus, H.H., 1997. Integration of young goats into a herd of adult conspecies. Berliner Münchener Tierärztliche Wochenschrift, 110: 214-219.

Seaton, T.B., Warenko, M.K., and Campell, R.G., 1986. Thermic effect of medium chain and long chain triglycerides in man. American Journal of Clinincal Nutrition, 44: 630-634.

Sherwin, C.M. and Johnson, K.G., 1987. The influence of social factors on the use of shade by sheep. Applied Animal Behavior Science, 18: 143-155.

Sherwin, C.M., 1990. Priority of access to limited feed, butting hierarchy and movement order in a large group of sheep. Applied Animal Behavior Science, 25: 9-24.

Sibbald, A.M., Elston, D.A., Smith, D.J.F., and Erhard, H.W., 2005. A method for assessing the relative sociability of individuals within groups: an example with grazing sheep. Applied Animal Behavior Science, 91: 57-73.

Simantke, C., Hörning, B., Fölsch, D. W., 1997. Modellvorhaben Artgerechte Tierhaltung, Milchziegen in Hessen, Fachgebiet Nutztierethologie und artgemässe Nutztierhaltung, Universität Kassel, Deutschland.

Simonsen, H.B., Klinken, L., and Bindseil, E., 1991. Histopathology of intact and docked pigtails. British Veterinary Journal, 147: 407-412.

Slavnitsch, K., 2008. Einfluss einer Umgruppierung auf das Sozialverhalten von Milchziegen. Master thesis, University of Veterinary Medicine, Vienna, Austria.

Smith, M.C. and Sherman, D.M., 1994. Dehorning and descenting. In: Goat Medicine, Smith, M.C. and Sherman, D.M. (Eds.), Lea&Febiger (Eds.), Philadelphia, 519-525.

Stafford, K.J., and Mellor, D.J., 2005. Dehorning and disbudding distress and its alleviation in calves. The Veterinary Journal, 169: 337-349.

STATISTIK AUSTRIA 2010 http://www.statistik.at/web_de/statistiken/land_und_forstwirtschaft/viehbestand_tierische_erzeugung/tierbestand/index.html#index3. Accessed on February 2011.

STATISTIK AUSTRIA 2010 personal communication. Goat population in Austria 2010, based on data of Agrarmarkt Austria (AMA) and Veterinärinformationssystem (VIS).

Stookey, J.M. and Gonyou, H.W., 1994. The effects of regrouping on behavioral and production parameters in finishing swine. Journal of Animal Science, 72: 2804-2811.

Strittmatter, K., 2003. Schafzucht. Ulmer Verlag, 270-271.

Süss, M., and Andreae, U., 1984. Rind. In: Bogner, H. and Grauvogl, A. (Eds.): Verhalten landwirtschaftlicher Nutztiere, Eugen Ulmer Verlag, Stuttgart, 196-197.

Szabó, S., Waiblinger, S., Barth, K. and Winckler, C.,2008. Behaviour of dairy goats in the collecting area – influence of space allowance and shape. Kuratorium für Technik und Bauwesen in der Landwirtschaft, 471: 239-240.

Tancin, V., Kratzl, W.D., Schams, D., and Bruckmaier, R.M., 2001. The effects of conditioning to suckling, milking and of calf presence on the release of oxytocin in dairy cows. Applied Animal Behaviour Science, 72: 235-246

Tölü, C. and Savas, T., 2007. A brief report on intra-species aggressive biting in a goat herd. Applied Animal Behavior Science, 102: 124-129.

Tønnesen, H.G., Bøe, K.E., and Andersen, I.L., 2008. Group size and social interactions in goats. Oscarsborg, Norway.

Toufexis, D.J., Rochford, J., and Walker, C.D., 1999. Lactation-Induced Reduction in Rats' Acoustic Startle Is Associated With Changes in Noradrenergic Neurotransmission. Behavioral Neuroscience, 113: 176-184.

Trautwein, H., 1994. ADZ-Informationen, Deutsche Schafzucht 86, 362. In: Gall, C., 2001. Ziegenzucht. Stuttgart (Hohenheim), Verlag Eugen Ulmer GmbH&Co, 275.

Tuchscherer, M., Puppe, B., Tuchscherer, A., and Kanitz, E., 1998. Effects of social status after mixing on immune, metabolic and endocrine responses in pigs. Physiology & Behavior, 64: 353-360.

Uvnäs-Moberg, K. and Petersson, M., 2005. Oxytocin, ein Vermittler von Antistress, Wohlbefinden, sozialer Interaktion, Wachstum und Heilung. [Oxytocin, a mediator of anti-stress, well-being, social interaction, growth and healing]. Z.Psychosom.Med.Psychother., 51: 57-80.

Uvnäs-Moberg, K., 1998. Oxytocin may mediate the benefits of positive social interaction and emotions. Psychoneuroendocrinology, 23: 819-835.

Uvnäs-Moberg, K., 2005. Neuroendocrinology of the mother-child interaction. Trends in Endocrinology and Metabolism, 7: 126-131.

Uvnäs-Moberg, K., and Eriksson, M., 1996. Breastfeeding: physiological, endocrine and behavioural adaptations caused by oxytocin and local neurogenic activity in the nipple and the mammary gland. Acta Paediatrica (Oslo), 85: 525-530.

Veissier, I., Boissy, A., Roussel, S., De Passille, A. M., Rushen, J., and Van Reenen, K., 2000. Calves' responses to repeated social regrouping and relocation. In: Ramos, A., Pinheiro Macho Filho, L. C., Hötzel, M. J. (Eds.), Proceedings of the 34th International Congress of the ISAE, Florianapólis, Brazil, 72pp.

Veissier, I., Lamy, D., and Le Neindre, P., 1990a. Social behaviour in domestic beef cattle when yearling calves are left with the cows for the next calving. Applied Animal Behavior Science, 27: 193-200.

Veissier, I., Le Neindre, P., and Garel, J. P., 1990b. Decrease in cow-calf attachment after weaning. Behavioural Processes, 21: 95-105.

Verkerk, G.A., Phipps, A.M., Carragher, J.F., Matthews, L.R., and Stelwagen, K., 1998. Characterization of milk cortisol concentrations as a measure of short-term stress responses in lactating diary cows. Animal Welfare, 7: 77-86.

Vierin, M. and Bouissou, M.F., 2001. Pregnancy is associated with low fear reactions in ewes. Physiology & Behavior, 72: 579-587.

von Holst, D., 1990. Stress-ein Problem sozialer Gesellschaften. Berliner Münchener Tierärztliche Wochenschrift, 132: 811-819.

von Keyserlingk, M.A.G., Olenick, D., and Weary, D.M., 2008. Acute Behavioral Effects of Regrouping Dairy Cows. Journal of Dairy Science, 91: 1011-1016.

von Korn, S., Jaudas, U., Trautwein, H., 2007. Landwirtschaftliche Ziegenhaltung. Ulmer Verlag, 99-102.

Waiblinger, S., Nordmann, E., Mersmann, D., and Schmied, C. (2011): Haltung von behornten und unbehornten Milchziegen in Großgruppen: Situation und Einflussfaktoren. In: 16. Internationale Fachtagung zum Thema Tierschutz, Tagung der DVG-Fachgruppe „Tierschutz", 23. - 25. 02. 2011 in Nürtingen, Verlag der DVG Service GmbH, Gießen, 167–181

Waiblinger, S., Schmied-Wagner, C., Nordmann, E., Mersmann, D., Szabo, S., Graml, C., von Hof, J., Maschat, K., Grubmülller, T., and Winckler, C., 2010. Haltung von behornten und unbehornten Milchziegen in Großgruppen. Endbericht zum Forschungsprojekt 100191 Eigenverlag, Wien, 170 Seiten.

Waiblinger, S., T. Baars and C. Menke (2001): Understanding the cows: The central role of human-animal relationship in keeping horned dairy cows in loose housing. In: M. Hovi, M. Bouilhol (Eds.): Human-animal relationship: Stockmanship and housing in organic livestock systems. Proceedings of the 3rd. workshop of the International Network on Animal Health and Welfare in Organic Agriculture (NAHWOA). 21.-24. October, Clermont-Ferrand, 64-78.

Wenzel, C., Schönreiter-Fischer, S., and Unshelm, J., 2003. Studies on step-kick behavior and stress of cows during milking in an automatic milking system. Livestock Production Science, 83: 237-246.

White, E. C., 2004. Caprine dehorning. In: Fubini, S. L., Ducharme, N. G. (Eds.), Farm Animal Surgery, St. Louis, 511-515.

Wiepkema, P.R. and Koolhaas, J.M., 1993. Stress and animal welfare. Animal Welfare, 2: 195-218.

Williams, C. S. F., 1990. Routine sheep and goat procedures. Vet. Clin. N. Am. Food Anim. Pract., 6: 737.

Zayan, R., and Dantzer, R., 1990. Social stress in domestic animals. Kluwer Academy Publishers, Dordrecht.

Zettl, K., and Brömel, J., 1994. Handbuch Schafkrankrheiten. Verlagsunion Agrar, Münster, pp 348.

8 Laws and Regulations

Verordnung der Bundesministerin für Gesundheit und Frauen über die Mindestanforderungen für die Haltung von Pferden und Pferdeartigen, Schweinen. Rindern, Schafen, Ziegen, Schalenwild, Lamas, Kaninchen, Hausgeflügel, Straußen und Nutzfischen - 1. Tierhaltungsverordnung (in der Fassung von 01.01.2005), BGBl. II Nr. 485/2004.

Verordnung der Bundesministerin für Gesundheit und Frauen über die Mindestanforderungen für die Haltung von Pferden und Pferdeartigen, Schweinen. Rindern, Schafen, Ziegen, Schalenwild, Lamas, Kaninchen, Hausgeflügel, Straußen und Nutzfischen - Änderung der 1. Tierhaltungsverordnung, BGBl. II Nr. 530/2006.

Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft über die Quoten im Milchsektor (Milchquoten-Verordnung 2007 - MQuV 2007), BGBl. II Nr. 209/2007.

Council Regulation (EC) No 889/2008. Implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control.

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