M.Sc. Thesis

Effect of stocking density at the feeding rack and social rank on the behaviour of Icelandic heifers

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Yfirlýsing höfundar

Hér með lýsi ég því yfir að ritgerð þessi er byggð á mínum eigin athugunum, er samin af mér og að hún hefur hvorki að hluta né í heild verið lögð fram áður til hærri prófgráðu.

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Andrea Rüggeberg

Abstract

Overstocking of Icelandic dairy heifers with regard to the animal feeding place ratio has become more common during the last years. Rather little is known about the behavioural consequences for heifers of this management procedure, which imposes a competitive situation on the animals.

The aim of this study was to investigate the effects of stocking density at the feeding rack on both the social and maintenance behaviour of heifers. Furthermore, it was the aim to study possible interactions of stocking density with the social status of the animals.

Two groups of nine Icelandic dairy heifers each were used in a cross over design applying competition levels of four (competitive situation) and nine (control situation) feeding places for nine heifers respectively. For the evaluation of the time budgets, i.e. lying, feeding and standing, two video recording periods of three days each were performed. Agonistic behaviours for determination of the social order and feed intake related behaviours such as manipulating or smelling in the feed were observed directly.

Regarding agonistic behaviours at the feeding rack, displacements occurred on average five times more often with increased competition at the feed rack than during the control situation. With increased competition, heifers of both ranks tended to spend less time eating (3.8 hours during competition vs. 4.2 hours during control, $p = 0.061$).

When comparing high and low ranking heifers, it turned out that low ranking heifers spent significantly more time lying, both during control and competition (13.2 hours low ranking heifers vs. 10.8 hours high ranking heifers during control and 13.5 hours low ranking heifers vs. 11.0 hours high ranking heifers during competition, $p = 0.002$). There were no significant differences in the feed intake related behaviour neither between high and low ranking heifers nor between control and competitive situation

In conclusion, the time budgets of the heifers or their behaviour in the course of the day did not change substantially, but agonistic interactions increased markedly during the competition. Because of the increased agonistic interactions it would not be advisable to have a restricted feeding area and expose animals by that to competition during feeding.

Key words: competition, dominance order, behaviour, heifers

Útdráttur

Síðusta áratug hefur færst í vöxt að kvígur á Íslandi séu hýstar í stíum þar sem átpláss við fóðurgang eru færri en gripirnir. Þetta leiðir óhjákvæmilega til samkeppni um átpláss, en fáar rannsóknir hafa verið gerðar á áhrifum þessa á kvígur. Markmiðið með þessari rannsókn var að kanna hvaða áhrif fjöldi gripa á hvert átpláss hefur á samskipti kvíganna og annað atferli þeirra. Auk þess átti að skoða hvort staða gripsins í virðingarröðinni skipti máli fyrir hvernig þeim reiðir af í samkeppni um átpláss.

Tveir hópar með níu íslenskum kvígum hvor voru notaðir í cross-over-tilraun þar sem fjögur (samkeppni) eða níu (viðmiðun) átpláss voru fyrir níu kvígur. Til að skrá atferli kvíganna voru þær myndaðar tvisvar sinnum í þrjá sólarhringa. Af myndbandsupptökunum var skráð atferli s.s. hvíld, át og hvar þær stóðu. Samskipti kvíganna var skráð beint og virðingarröð innan hópsins reiknuð. Einnig var átatferli eins og að hnusa, finna lykt og éta skráð með beinni athugun þrisvar sinnum á daga.

Varðandi samskipti kvíganna við fóðurganginn kom í ljós að kvígur voru u.þ.b. fimm sinnum oftar reknar frá sínu átplássi við samkeppnisaðstæður heldur en hjá viðmiðunar hópnum. Það var tilhneyging til að við samkeppnisaðstæður ætu bæði háttsettar og lágsettar kvígurnar í u.þ.b. hálftíma skemur en við eitt átpláss á grip (3,8 klst. á móti 4,2 klst. $p = 0,061$).

Þegar atferli háttsettara og lágsettara kvíga var borið saman kom í ljós að lágsettar kvígur lágu lengur en háttsettar, bæði við samkeppnisaðstæður og viðmiðunaraðstæður (13,2 klst. hjá lágsettum kvígum á móti 10,8 klst hjá háttsettum kvígum fyrir viðmið og 13,5 klst. hjá lágsettum kvígum á móti 11,0 klst. hjá háttsettum kvígum við samkeppni, $p = 0,002$). Enginn munur fannst í áthegðun kvíganna, hvorgi milli háttsettum og lágsettum kvígum nor milli samkeppni og viðmiðun.

Niðurstöðurnar sýna að atferli kvíganna breytist ekki verulega yfir daginn, en ógnanir og slagsmál sáust í verulega auknum mæli meðan á samkeppnisaðstæðum stóð. Út frá þessum niðurstöðum má draga þá ályktun að samkeppni um átpláss hjá kvígum geti haft neikvæð áhrif á velferð gripanna.

Lykilorð: samkeppni, virðingarröð, atferli, kvígur

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Contents

1. Introduction

So far only a very few researches about the Icelandic Cattle have been carried out, especially not about their behaviour or welfare. This study was performed in order to get some information about their behaviour in situations with different stocking density. However, for the beginning some information about their origin and utilisation today ought to be given.
The arrival of cattle in Iceland is very much in connection with the colonisation of Iceland during the years 874-930. Genetic studies have shown that Icelandic cattle is very much related with the Norwegian native breeds Doela, Telemark and Blacksided Troender and Nordland cattle. The exact genetic relation between native North European cattle breeds and their divergence from commercial cattle breeds has not been found so far. But it has been found out that the separation of Icelandic cattle and Blacksided Troender and Nordland cattle took place 1105-1326 years ago and longer ago with other breeds. Since the settlement of Iceland, the cattle has been isolated on Iceland with a very few exceptions (Aðalsteinsson, 1981; Kantanen et al., 2000; Torfason and Jónmundsson, 2001). During the 19th century some Danish beef cattle and Holstein heifers were imported. Later, in 1933, a Galloway bull was imported and there were about 300 Galloway crossed cattle in Icelandic. Still later, in 1976 a project was launched leading to the importation of semen from Galloway bulls, but besides that, Icelandic cattle stayed without any breeding influence from abroad (Aðalsteinsson, 1981). Anyway, Kantanen at al. (2000) characterizes the Icelandic cattle as “scientifically, historically and culturally unique”.
Icelandic cows reach a weight of 300 to 500 kg and are about 120-130 cm high. They are used for milk - and meat production (Torfason and Jónmundsson, 2001). The average milking yield of the 24,000 cows was 5,229 kg in the year 2004 (Bændasamtök Íslands, 2005).

1.1. Individual distance

An important attribute to social group life is the fact that every animal tries to maintain its individual distance, meaning on the one hand the space each animal requires for its basic movements such as standing, lying down and getting up, grooming etc. (Fraser and Broom, 1990). However, individual space is more than the space which an animal requires for these movements. It indicates and characterises the minimum distance that an animal allows another animal to come close before it reacts, e.g. stops the other animal with a move or gesture to come closer. Individual space is “no general personal space which is the same at all times and for all individuals” (Potter and Broom, 1987, p. 130). For example high ranking cattle claim a greater individual distance than low ranking cattle. The individual space for

cattle ranges between 0.5 m (Sambraus, 1969) and 4 m to 12 m for varying space allowance (Kondo et al., 1989). Cattle defend their space with agonistic behaviours, which results in more movements of low ranking cattle in order to avoid the individual space of high ranking animals (Reinhardt, 1980; Craig, 1986; Fraser and Broom, 1990).

The correlation between space, density, group size and agonistic behaviour changes with age. Confined calves, at the age of 6 to 13 months, did not show a significant correlation between group size and agonistic behaviour. This correlation between group size and agonistic behaviour was on the other hand significant for adult cattle. Consequently, with the increase of group size agonistic behaviour increased too. Both calves and adult cattle showed a significant correlation between agonistic behaviour and space allowance. When space increased and group size decreased, agonistic interactions decreased and the distance to the nearest neighbour increased (Kondo et al., 1989). According to Kondo et al. (1989), this difference between calves and adult cattle is due to the different stages of development of a dominance order in these two age groups. In cattle, establishment of a social order starts at an age of about 3-6 months (Schein and Forman, 1955); according to Stricklin et al. (1980) cattle start to establish a dominance order soon after weaning.

Under (semi-) natural conditions or at pasture individual space is not often violated since there is enough space. It is though ignored when social interactions, such as licking and horning take place, and of course also when cattle fight (Schloeth, 1961; Reinhardt, 1980).

1.2. Social behaviour patterns with regard to the establishment of social relationships

The behaviour patterns described in the following chapters lead to the establishment of social relationships between members of a group. Dominance order is the sum of those relationships (Beilharz and Zeeb, 1982, Wierenga, 1990). The dominance value of each animal is the “ratio of the number of subordinate animals to the total number of known dominance relationships of that animal” (Wierenga, 1990, p.12).

1.2.1 Cohesive behaviours

Not only aggressive or agonistic behaviour patterns determine the relationship between two and more members of a group. For instance Schloeth (1961), Reinhardt (1980) and Reinhardt and Reinhardt (1981) noted positive interactions or cohesive bonds, which keep a group together in their (semi-)natural environment. Schloeth (1961) described several ways cows show in order to have social contact such as social licking or horning. Reinhardt (1980)

described bonds, which are built on their kin relation with each other, i.e. mothers with their calves. Cows also prefer grazing or licking partners, which are not only based on kin relation but also on attachment (Reinhardt and Reinhardt, 1981).

1.2.2 Agonistic behaviour patterns

The only agonistic behaviour where no physical contact is involved is threatening. According to Schein and Fohrman (1955) and Schloeth (1961), the involved animals have some distance between each other and the animal which is threatening lowers its head, puts it in a perpendicular position to the ground and is facing the opponent. There is no contact for it is "an intended aggressive act" (Reinhardt et al., 1986, p. 127). The threatened animal has two possibilities to react: it can respond with a threat which could lead to a fight, or walk away from the threatening animal. The last option is more common (Schein and Fohrman, 1955). An agonistic behaviour including physical contact is the so called head but. One animal directs a blow with its forehead or horns at another animal's side of the neck, shoulder, rump or upper leg. The animal receiving the but is not retaliating (Schein and Fohrman (1955), Reinhardt (1980) and Stricklin and Graves (1980)). This kind of aggressive interaction appears most often in cattle (Reinhardt, 1980).

Displacements can be defined as interactions when an animal gives up its position because of a threat or head but of another animal (Reinhardt et al., 1986, Wierenga, 1990). Fights develop if the butted animal retaliates (Schein and Fohrman, 1955) and form the rarest agonistic social interaction (Reinhardt, 1980). In a fight, animals can be in several positions towards each other and change them permanently during the fight, e.g. circling around each other for different periods of time and then bounce their head in each other's bodies when the fight erupts (Schein and Fohrman, 1955). Reinhardt (1980) observed that the opponents would also bounce on each other with their foreheads front to front and try to push one another. This lasts until one animal withdraws or is too weak to fight back or one animal is able to chase the other away (Schein and Fohrmann, 1955; Reinhardt, 1980). A fight does not need to be decided after one collision or interaction, it can consist in several encounters which can be very different in numbers between different animals (Schein and Fohrman, 1955). Fights occur most often among animals which are close in the dominance order. Tension resulting in fights also take place when a high-ranking animal is weakening for some reason and the lower ranking animals try to overrule the previously stronger animal. The higher-ranking animal tries to get back its former position and has often to fight hard for that. So this

kind of incidences ending in a fight build up quite slowly over some time and could be divided in three stages: threatening, aggressive horning and chasing (Schloeth, 1961).

Another agonistic behaviour pattern is chasing: one animal is running after another in order to drive it away, and, in some cases, butting it in the end (Schloeth, 1961).

1.3. Development and benefits of social relationships and dominance order

The social hierarchy of cattle is built on social relationships which all social living animals develop in their groups. It has a great influence on the life of each individual as well as on the whole group (Grant and Albright, 2001), since it is the dominance order which determines the position of an individual in the group.

Individuals in a herd know each other, which is an important precondition for the possibility to predict the outcome of an encounter (Sambraus, 1975, Bernstein, 1981). By that cattle know their relation to each group member: either it is subdominant or dominant to the other. The social relationships are learnt by each individual from former encounters and have to be relearned from time to time. It is often the higher ranked animal, which "reminds" the subordinate animal of its position (Beilharz and Zeeb, 1982; Reinhardt, 1980; Bernstein, 1981).

Established dominance orders are complex in most cases, i.e. an animal with a low dominance value can be dominant over an animal with a higher dominance value (Sambraus, 1975; Reinhardt, 1980; Wierenga, 1990). Once established, dominance order remains rather stable for a long time (Schloeth, 1961; Sambraus and Osterkorn, 1974; Reinhardt and Reinhardt, 1975; Beilharz and Zeeb,1982; Reinhardt et al., 1986). On the other hand, the dominance order is also flexible or dynamic under certain circumstances, since it is influenced when new members join the group, old members die or members try to move up in the order (Reinhardt and Reinhardt, 1975; Reinhardt, 1980; Bernstein, 1981). Reinhardt and Reinhardt (1975) state, that flexibility is always there, because "a shift in rank position is the very ambition of every low ranking animal" (Reinhardt and Reinhardt, 1975, p. 315). Sometimes these changes of positions in the dominant order happen, i.e. a former subdominant animal dominates over a former dominant animal. This occurs only in about 5-10% in two years of the established relationships (Sambraus and Osterkorn, 1974; Reinhardt, 1980). Wierenga (1990) found a change in relationships of 6.7 % of all pairs in one year in confinement.

Dominance order has several advantages for group-living animals. For example the outcome of a contest is predictable, hence both the dominant and the subdominant animal can reduce their involvement in contests. By that the risk of injury in consequence of a fight is

reduced and thus both parts benefit from the established relationship (Bernstein, 1981, Reinhardt et al., 1986). Hence dominance order prevents the members of a group from constant fights or quarrels among each other. As a consequence, injuries related to agonistic social encounters decrease. Social order is also the keystone in social groups in the sense, that aggression in groups may be kept at its minimum (Reinhardt and Reinhardt, 1975; Beilharz and Zeeb, 1982).

The possible disadvantages for low ranking cattle to stay with the group, e.g. to wait for access to resources, cannot be of great value because they do not "seek to obtain improved grazing away from the herd" (Phillips and Rindt, 2002, p. 51) because this would be against the cohesive bonds which let the cows stay together in herds, for protection among other things (Reinhardt, 1980; Reinhardt and Reinhardt, 1981; Phillips and Rindt, 2002).

1.4. Social behaviour in semi- natural environment and in confinement

In their natural habitat, cattle live in mixed groups, i.e. female and male animals together, only for a certain time of the year. The composition of the herd changes during the seasons because the males separate from the female groups most of the time except during the mating season (Schloeth, 1961; Reinhardt et al., 1986). A major difference between free-living animals and those living in confinement consists in the greater distribution of age in the free-living animals (Schloeth, 1961). As already said, semi-wild groups cattle develop stable social relationships, which often remain for a long time (Schloeth, 1961; Sambraus and Osterkorn, 1974; Beilharz and Zeeb,1982; Reinhardt, 1980).

In commercial housing conditions, beef cattle, heifers and dairy cows are put together in groups according to their age, weight and/or calving time. Under these circumstances, however, they still develop a relatively stable dominance order (Sambraus, 1975; Leaver and Yarrow, 1980; Stricklin et al., 1980; Stricklin and Gonyou, 1981; Miller and Wood-Gush, 1991).

Animals living in their natural environment do not have many reasons to act aggressively against each other (Reinhardt and Reinhardt (1981 c.f. Rowell 1974)), but do always show a certain level of agonistic behaviour. Under (semi-) natural conditions, space or feed would usually not be the reason to fight for, when both resources are abundant. Only when feed is scarce or little space available at the drinking place, cattle get aggressive and chase each other away in order to get access (Schloeth, 1961; Metz, 1983; Craig, 1986). Cattle use their position in the dominance order for priority of access to certain sources e.g. to the best grazing spot and space at the drinking place. On these occasions the dominant

animals prevail most of the time (Reinhardt, 1980; Beilharz and Zeeb, 1982). So access to a limited resource indicates dominance (Craig, 1986) and is therefore often a privilege for dominant animals (Reinhardt, 1980).

1.5. Influence of housing and management on the behaviour of cattle

Since the animal's behaviour is its "most immediate expression of its interaction with the environment" (Metz and Wierenga, 1987, p. 14) it is possible to assess how well animals cope with their environment based on their behaviour.

Space allowance forms one of the most pronounced differences between their (semi-) natural environment and being housed inside. It also has a very big influence on both the social behaviour of cattle and the behaviour patterns of each individual (Metz and Wierenga, 1987; O'Connel et al., 1989). Since space allowance in cattle housing systems is usually rather low, animals meet more often, which increases the incidences when their individual distance cannot be maintained, resulting in more agonistic interactions (Metz and Wierenga, 1987). This puts a strain on the social relationships already established (Reinhardt, 1980). With the higher level of agonistic behaviour in confinement than at pasture, cattle show that their individual space is being violated and they defend it (O'Connel et al., 1989; Fraser and Broom, 1990). Agonistic interactions increase with decreasing space allowance (Kondo et al., 1989). Thus, aggressive behaviour is only a consequence of the cattle's unfulfilled requirement of individual space since it is not their natural habit to stay together so close to each other (Fraser and Broom, 1990; Metz and Wierenga, 1987; Potter and Broom, 1997). Further more, Metz (1983) regards aggression as a punishment for the receiving animal, with the consequence of reduced welfare for the animal receiving aggression.

Alterations of behaviour patterns, such as eating and lying time also have often been observed to be affected by competition for a resource in terms of reduced feeding space allowance (Friend et al., 1977; Keys et al., 1978; Leaver and Yarrow, 1980; Metz and Mekking, 1978; Frank and Magnusson, 1994; Olofsson, 1999). On the other hand, there are also some studies where no alteration or effect on the cattle's behaviour was found, but those are rather rare. For example, in one study, manger space was reduced from 105 cm to 15 cm per cow. Mean total feeding time decreased during the time with the reduced manger space, but not significantly. There was either not a difference between the number of cows standing, lying or feeding nor changed the amount of aggressive behaviour among the animals (Collis et al., 1980). In another study the highest competition level was at 2.5 animals per feeding place but that did not have any influence on the time low ranking cows spent at the

feeding rack or in the cubicles. Time budgets did not differ between high and low ranking cows (Stumpf et al., 2000).

1.5.1 Influence of housing on synchrony

In (semi-)natural environments or at pasture, cattle show synchrony in many behaviour patterns such as feeding, resting and drinking (O'Connel et al., 1989; Miller and Wood-Gush, 1991). Allelomimetic behaviour resulting in synchrony may be seen as another evidence for the need of a herd to remain in contact and to behave as a social unit (Metz und Wierenga, 1987; Miller and Wood-Gush, 1991). However, synchrony decreases in confinement but is kept at a certain degree though, especially when all animals can feed at the same time and it is easy for them to get a feeding place (Potter and Broom, 1987; O'Connel et al., 1989; Miller and Wood-Gush, 1991). Synchrony is reduced when there is not enough feeding space or lying places for each animal at the same time. This may end in competition and reduced animal welfare (Potter and Broom, 1987, Miller and Wood-Gush, 1991).

1.5.2 Influence of space at the feeding rack on interactions among cattle

The situation at the feeding rack is special, because although feed is abundant it is provided on a very limited area and the number of animals competing for feed is potentially high (Metz, 1983). The influence of competition depends, among others, on factors such as duration or time that feed is available, design of the feeding rack, e.g. its length, the design of the feed barriers and the feeding space for each cow. The composition of the group (e.g. age) is also an important influencing factor on the amount of interactions (Metz and Mekking, 1978; Potter and Broom, 1987, Grant and Albright, 2001). Metz and Mekking (1978) state that cows in confinement actually always compete against each other for feed.

When dairy cows were offered 1 m space at the feeding rack per animal, the distance among the cows increased compared with 0.5 m space. With higher space allowance at the feed alley the range in inter-cow distances was greater (McLean, 2003; DeVries et al., 2004).

It has often been shown in cattle herds that the reduction of feeding space, either by reducing its length or providing fewer eating places than animals, leads to a higher aggression level in the whole group (Metz and Mekking, 1978; Metz, 1983; Frank and Magnusson, 1994; Olofsson, 1999; Stumpf et al., 2000; DeVries et al., 2004). The level of agonistic behaviour decreased when the feeding space was enlarged from 0.5 m to 1 m (DeVries et al., 2004).

A high level of aggression in the group could lead to a higher incidence of lameness, because falling and slipping on concrete or slatted floors, e.g. in pushing contests, often leads

to injuries on the feet (Potter and Broom, 1987). This is more likely to occur when displacements and chases increase in competitive situations (Metz, 1983; Grant and Albright, 2001).

1.5.3 Influence of reduced access to feed on feeding behaviour and performance of cattle

When housed cows are provided with one feeding place per animal they spend between 3.8 and 5 hours per day feeding (Friend et al., 1977; Keys et al., 1978; Olofsson, 1999). By decreasing the number of feeding places per animal and by that increasing competition at the feeding rack, feeding time of cows and heifers decreased (Keys et al., 1978; Metz and Mekking, 1978; Frank and Magnusson, 1994; Longenbach et al., 1999; Olofsson, 1999). In contrast, Collis et al. (1980) did not find a significant difference in feeding time when less feeding space per animal was available. On the other hand feed intake or consumption rate of cows and heifers did not change significantly under competitive conditions (Reynolds and Campling, 1981; Frank and Magnusson, 1994; Longenbach et al., 1999). Olofsson (1999) obtained contrary results because feed consumption increased when the number of cows per feeding station was increased from one to four. Higher feeding activity and higher daily mealtime was observed when feeding space was increased (DeVries, 2004).

When the time of access to feed was increased from 8 hours to 20 hours, dry matter intake of cows increased slightly, but had no effect on the dry matter intake expressed as percentage of body weight (Erdman et al., 1989).

Considering daily weight gain or growth under conditions with reduced number of feeding places, daily weight gain decreased in Holstein heifers and dairy cows (Keys et al., 1978; Metz and Mekking, 1978; Frank and Magnusson, 1994). Longenbach (1999) on the other hand did not find any negative effects on growth or performance of the heifers. This was also true for the effects on milk production in dairy cows (Frank and Magnusson, 1994). In fattening bulls, Gottardo et al. (2004) did not find any difference in performance, but the competition level was not high.

1.5.4 Influence of competition on resting behaviour

Under normal conditions, i.e. with no competition for any resource, cattle spend about 50% of the day lying or resting (Friend and Polan, 1974; Lamb, 1976; Friend et al. 1977; Olofsson, 1999). Friend et al. (1977) and Olofsson (1999) found that lying time decreased with increasing feed bunk density. Stumpf et al. (2000), on the other hand, did not find any alteration in the duration of lying when competition at the feed bunk increased.

However, there might also occur changes in the lying patterns throughout the day, i.e. cattle modify their lying behaviour patterns and lie down at different times of the day than without competition (Metz and Mekking, 1978).

1.6. Aim of this study

Housing systems and their management can have major impact on cattle, both on their social and maintenance behaviours. Adaptation to the environment can be facilitated by giving cattle the possibility to express their normal behaviours.

It is common practice in Icelandic dairy cattle husbandry to overstock dairy heifers with regard to the animal feeding place ratio. On the other hand rather little is known about the behavioural consequences for heifers of this management procedure, which imposes a competitive situation on the animals.

The aim of this study was to investigate the effects of stocking density at the feeding rack on both the social and maintenance behaviour of heifers. Furthermore, it was the aim to study possible interactions of stocking density with the social status of the animals.

2. Materials and methods

2.1. Animals

19 heifers and 1 first-calf cow of the Icelandic breed were used in this study. The animals were randomly assigned to two groups, Group 1 and Group 2, according to their age and expected date of calving. The age of the animals ranged from 20 to 34 months. Most of the heifers were expected to calve in November and/or December 2005, but some later. One heifer was not pregnant.

The two groups were formed in the first week of October 2005 so the animals got used to each other, although most of them had been together in a group before. The heifers were dyed a few days after the groups had been formed, with numbers from 1 to 10 (Group 1) and 11 to 20 (Group 2) on their back/small of the back and shoulders.

Initially there were ten animals in each group, but one (Nr. 14) gave birth the day videotaping started (28th Oct.), so it had to be removed. In order to have the same competition level in both groups, an hour before the second videography period started (11th Nov.), a heifer (Nr. 3) was also taken from the other group.

2.2. Feeding

Roughage, i.e. always the same kind of silage from aftermath, was given once a day at 9 o'clock in the morning. The feed was pushed up in the evening between 9 and 10 pm. During the second period in November the situation in the evenings was different, because most of the silage had been eaten at about 11 pm, i.e. heifers had no silage over the night. This fact was only discovered when the videos were analysed.

2.3. Experimental set-up

The animals were kept in pens with slatted floors and one cubicle for each animal. The size of the cubicles differed slightly between the pens, they were 1.90 m long and 1m wide in Pen 1 and 1.80 m long and 0.90 m wide in Pen 2. The head lunging space was 0.40 m space (Figure 1). The cubicles were covered with rubber mats.

The passage way between the cubicles was 1.90 m wide and 6.60 m long in Pen 1 and 6.10 m in Pen 2. The width of the passage way leading to the feeding alley was 2.60 m in Pen 1 and 2.10 m in Pen 2.

The feeding alley was 2.30 m wide in both pens and 8 m long in Pen 1 and 7.50 m in Pen 2.

The feeding racks (headlock feed barrier) differed also from pen to pen. They were 0.90 m high in Pen 1 and each feeding place 65 cm wide in Pen 1 and 0.80 m high and 53 cm wide in Pen 2.

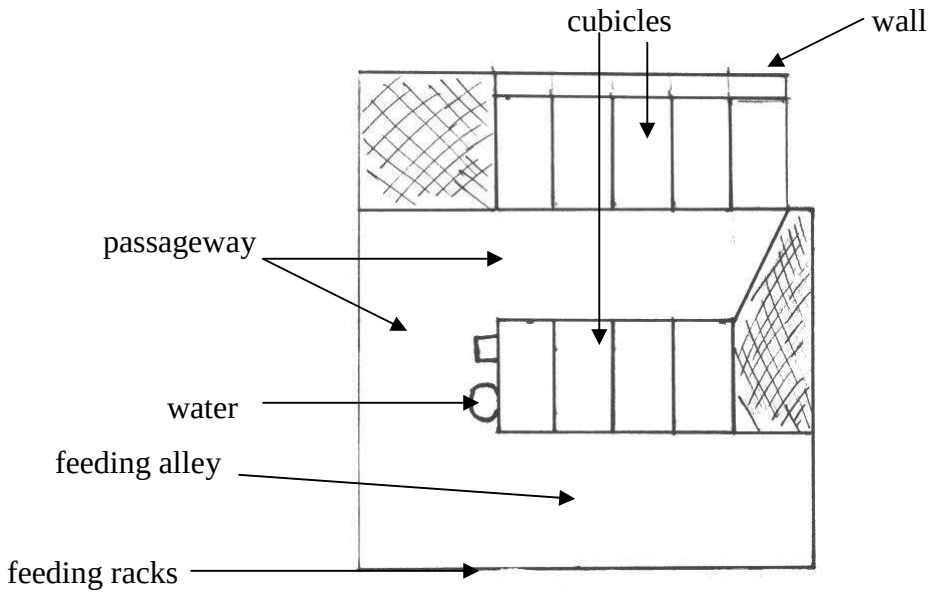

Figure 1. *Layout of the pens.*

A cross-over treatment was applied. The groups were either offered one feeding place per animal (control) or four feeding places per nine animals (competitive situation).

In mid-October (17th Oct.), Group 2 started in the competition treatment. The feeding places were reduced by blocking the five outer feeding places of the feeding rack.

The heifers got 11 days (17th-27th Oct.) to adjust to the competitive situation whereafter both groups were video-recorded for three days continuously (28th-31st Oct). Hereafter, the treatment was crossed over to Group 1. The heifers of Group 1 also had 11 days (31st Oct.-10th Nov.) to get used to the competition treatment. Then both groups were video recorded for three days again (11th-14th Nov.).

Treatments were organized as shown in Table 1.

Table 1. *Layout of the experimental set-up*

	11 days (17^{th}-27^{th} Oct.)	**3 days (28^{th} –31^{st} Oct.)**	**11 days (31^{st} Oct.-10^{th} Nov.)**	**3 days (11^{th}-14^{th} Nov.)**
Group 2	Adjustment competition: stocking density: 4 feeding places for 9 animals	Video recordings competition	Adjustment control: 9 feeding places for 9 animals	Video recordings control
Group 1	Adjustment control: 9 feeding places for 9 animals	Video recordings control	Adjustment competition: stocking density: 4 feeding places for 9 animals	Video recordings competition

2.4. Behaviour observations

2.4.1 Time budgets

Time budgets of the heifers' behaviour patterns were analysed using the video recordings. Two video cameras were used for each pen. One camera covered the feeding rack and feed alley, and one camera the lying area and passageways. The cameras that pointed at the cubicles, took one picture every minute, the cameras pointing at the feeding rack took 5 pictures every second.

Initially video recordings lasted from 27^{th}-31^{st} Oct. and from 11^{th}- 15^{th} Nov., but due to technical reasons (because it was not possible to use the first and last nights' video records), only three days out of each filming period could be used (28^{th}-31^{st} Oct and 11^{th}-14^{th} Nov.). When evaluating data only over daytime, the video records of 27^{th} Oct. were included. The remaining three day-periods lasted from 08:40 in the morning on the first day to 08:20 in the morning on the last (third) day.

Analysis from video recordings:

The video recordings were analysed using scan sampling at 5 min intervals. The behaviour was categorised into:

1) Feeding: heifer with its head through the feeding rack
2) Standing on the feeding alley: heifer standing in the area which was defined as the feeding alley, i.e. behind the feeding rack
3) Lying: heifer lying in one of the cubicles
4) Standing in a cubicle: heifer standing with two or four feet in a cubicle
5) Standing on the passageway: heifer standing in the area which was defined as passage
6) Lying on the feeding alley: heifer lying in the area defined as feeding alley.

Drinking was not recorded because it was to difficult to see whether the heifers were actually drinking or not. Neither was the heifers' licking at the mineral rock evaluated. Both

situations were therefore counted as “standing on the passageway”. A heifer lying on the feeding alley was defined as “lying” when the data were analysed.

Lying behaviour was also analysed with regard to lying periods by dividing the periods in less than an hour, one to two hours, two to three hours up to nine hours and longer. Those periods were counted per day. A lying period was defined as an interval which was not interrupted for at least 15 minutes.

2.4.2 Social behaviour

For determination of the dominance value (DV) of each heifer, the social behaviour was directly observed using continuous behaviour sampling. The observer was situated about 2-3 m in front of the feed bunk in an elevated position (3 m). The heifers were not obviously disturbed by the observer. Observations took place during both adjustment periods (17^{th}- 27^{th} Oct. and 31^{st} Oct.-10^{th} Nov.) and during both video recording periods (28^{th}-31^{st} Oct. and 11^{th}-14^{th} Nov., respectively) (Table 2).

During the adjustment periods, heifers were observed for about two hours after they had been fed or until there was obviously no more competition for feeding place, i.e. when there were fewer heifers than feeding places. During video recording periods data was collected directly for two hours after they had been fed and additionally for 1 hour around midday and 1 hour in the afternoon (Table 2).

The following behaviour patterns were directly recorded to determine the dominance order, according to the following definitions of social behaviours (Laister at al., 2006):

Head butting:

“Interaction involving physical contact where the actor is butting/hitting/thrusting/striking/ pushing the receiver with forehead or horn base with a forceful movement. The receiver does not give up its present position.”

Threat:

Interaction, which involves no physical contact. The actor lowers its head “to about halfway between the normal position and the ground, eyes directed towards the opponent, and the broad forehead on a plane perpendicular to the ground facing the opponent” (Schein and Forman, 1955, p. 47).

Chase:

“The actor makes the other animal flee by following fast behind it, sometimes also using threats like jerky head movements”, i.e. head buts.

Displacement:

"Interaction involving physical contact where the actor is butting/hitting/thrusting/striking/ pushing or penetrating (shoving itself between two other cows or between a cow and a wall or any equipment where there is obviously not enough space for both animals to be there) the receiver with forehead, horn base or any other part of the body with forceful movement. The receiver gives up its present position (walking away for at least half a cow-length or stepping aside for at least one cow-width)".

For the determination of the dominance order in the groups, the number of displacements, chases and threats performed by each heifer was summed up for each heifer. A heifer was dominant over another heifer when one heifer performed two more agonistic interactions than another heifer. When there were many interactions (eight or more), the difference of the number of agonistic interactions between two heifers had to be greater than 2 for one heifer to be clearly dominant over another heifer.

The dominance value (DV) for each heifer was calculated as follows (e.g. for cow A):

$$\frac{\text{No. of cows subdominate to cow A}}{\text{No. of known dominance relationships of cow A}}$$ (Wierenga, 1990).

The displacement index (DI) was also calculated in the following way:

$$\frac{\text{No. of active displacements}}{\text{No. of active displacements} + \text{no. of received displacements}}$$ (Galindo et al., 2000).

This coefficient was calculated in order to compare it with the dominance value, but it was not further used in this study.

Furthermore the number of displacements which took place during feeding was evaluated from the video records during the same periods, feeding behaviour was observed directly (see next chapter). The observation periods lasted twice for four days (27^{th}-30^{th} Oct. and 11^{th}- 14^{th} Nov.):

- after heifers were fed in the morning for 45 min up to one hour each group
- around midday for half an hour each group
- in the late afternoon for half an hour each group.

These data were evaluated to determine the effect of competition at the feeding rack on the agonistic behaviour. Total observation time added up to about two hours per day per group.

Table 2. *Summary over data evaluation*

	11 days (17.-28.10.)	**3 days (28.-31.10.)**	**11 days (31.-11.11.)**	**3 days (11.-14.11)**
Group 2	**<u>Adjustment Competition</u>** - ***Data from direct observations:*** -Social behaviour (head butting, threat, chase, displacement) (11 days for 2 h after feeding)	**<u>Video recordings competition</u>** ***- Data from direct observations:*** - Social behaviour (dito) (4 days: for 2 h after feeding + 1 h midday + 1 h afternoon) - feeding behaviour (feeding, manipulating, smelling, other) (4 days: for 2 h after feeding + 1h midday + 1 h afternoon), see Fig. 2 ***- Data from video:*** - behaviour scan sampling feeding, standing on the feeding alley, lying, standing in a cubicle, standing on the passageway, lying on the feeding alley) (3 days) - no. displacements (4 days: for 2 h after feeding + 1 h midday + 1 h afternoon) - changing feeding place (4 days: 2 h after feeding + 1 h midday + 1 h afternoon)	**<u>Adjustment Control</u>** - dito	**<u>Video recordings control</u>** - dito
Group 1	**<u>Adjustment Control</u>** - dito	**<u>Video recordings control</u>** - dito	**<u>Competition</u>** - dito	**<u>Video recordings competition</u>** - dito

2.4.3 Feeding behaviour

Feeding behaviour was directly observed on two 4-days observation periods (27^{th}-30^{th} Oct. and 11^{th}- 14^{th} Nov.) using scan sampling at 1 min intervals three times a day:

- after heifers were fed in the morning for about 45 min up to one hour each group
- around midday for about half an hour each group
- in the late afternoon for about half an hour each group.

Total observation time patterns varied sometimes from day to day, depending on the relative situation at the feeding rack, i.e. number of heifers feeding.

The groups were observed separately by direct observation, each for 15 minutes at the time, as shown in Figure 2.

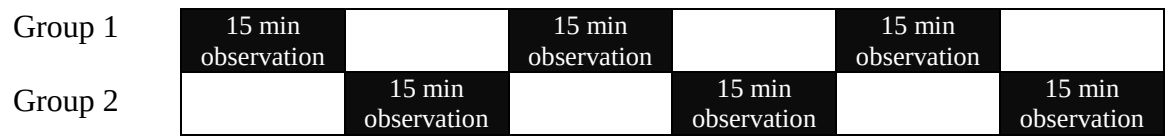

Figure 2 *Schematical setup of observation periods for feeding behaviour for each group, the black box marking the 15 minutes observation time.*

The analysis of the data revealed the percentage of the first four behaviour patterns described below.

Smelling the feed:

Heifer with its head through the feeding rack, moving the head above silage and neither feeding nor digging/manipulating silage.

Manipulating/tossing in the feed:

Heifer with its head through the feeding rack, touching the silage with the nose and also moving the silage with the nose and digging in the silage with its nose, sometimes coming up with silage in the mouth and feeding.

Feeding:

Heifer with its head through the feeding rack and chewing silage and/or taking in silage.

Doing something else/nothing:

A heifer with its head through the feeding rack and licking another heifers' head or being licked by another heifer. A heifer doing nothing is standing with its head through the feeding rack and just watching the surrounding.

Changing feeding place:

Heifer with its head through the feeding rack, taking the head back through the rack and putting it through the rack at another place. This behaviour pattern may last up to two minutes when a heifer has to find a free place at the feeding rack.

To determine how often a heifer changed its feeding place, data was collected from the video records during the same observation periods, feeding behaviour was collected directly, i.e. twice for four days for 2 hours after the heifers were fed, 1 hour around midday and 1 hour in the late afternoon. The number of feeding place changes was extrapolated as events per 15 minutes attendance at the feeding rack for each heifer.

Feeding data was also analysed with regard to the number of meals and bouts of the heifers. Meals and bouts and feed bunk attendance were counted continuously from the video records. A meal was defined as a feeding period, when it was not interrupted for more than 20 minutes. When this period however was interrupted for less than 20 minutes these periods in between were counted as bouts.

2.5. Statistics

All statistical analyses were carried out using the software package Minitab Release 14 (Minitab® Statistical Software).

To determine the correlations between the dominance value and other features Pearson's correlation coefficients were calculated (n = 18).

Frequency of agonistic behaviours at the feeding rack were analysed using ANOVA.

For further statistical analysis, General Linear Models were calculated. Time budget parameters, visits to the feeding rack and average duration of visit per day, meals, bouts and bouts per meal and lying periods were analysed taking treatment (control or competition), rank (high or low ranking) and the interaction between treatment and rank into account as fixed effects.

Feeding behaviour patterns were analysed using treatment, time of the day (morning, midday, afternoon) and interaction between treatment and time of the day as fixed effects. Regarding 'changing feeding places' behaviour, rank and time of the day was taken into account.

Differences between the two treatments or between the two rank groups during the course of the day were assessed using the T-test.

3. Results

3.1. Dominance values and dominance order

For Group 1 a total of 610 agonistic interactions (head butts, displacements, threats and chases) were observed, in Group 2, 722 agonistic interactions took place (Table 3).

Table 3. *Number and frequency of agonistic behaviour patterns over 28 days for both groups*

	Head butt		**Chase**		**Threat**		**Displacement**		**Sum**
	no.	*%*	*no.*	*%*	*no.*	*%*	*no.*	*%*	*No.*
Gr.1	255	41.8	21	3,4	46	7.5	288	47.2	610
Gr.2	311	45.8	6	0,8	40	5.5	345	47.8	722

The dominance value ranged between 0 and 0.83 in Group 1 and between 0.17 and 1.00 in Group 2. The distribution of the dominance values was slightly different in both groups (Table 4a and 4b). For the distinction between high and low ranking animals, a threshold of DV = 0.5 was chosen, i.e. heifers with a DV of 0.50 and lower were regarded as low ranking heifers (Rank 2).

In both groups the social dominance order was not linear but complex, i.e. there were some low ranking heifers dominant over a high ranking heifer, but were subdominant to many other heifers (Table 4a and 4b, Figure 3a and 3b). In Group 1 there was one heifer (no. 2) which did not dominate any heifer. In Group 2 there was one heifer (no. 19) which was dominant over all heifers with the exception of two unsettled relationships with two other heifers (no. 11 and 20). But there was no heifer which was subdominant to all other heifers in Group 2. Two heifers which had the same dominance value had an indeterminable relationship because they showed the same number of agonistic interactions (between heifer no. 6 and 8, and no. 1 and 7). Only in one case where two heifers had the same dominance value, one of the heifers was dominant over the other (heifers no. 11 and 17) (Figure 3a and 3b).

Table 4a and 4b. *Dominance values (DV), number of subordinate animals and unclear relationships for each heifer in Group 1(left) and Group 2 (right). A heifer dominates over the heifers listed underneath, if there is no arrow next to the heifer's number. The end of the arrow marks the heifer which is dominant over the heifer where the arrowhead ends*

Heifer No.	DV	No. of subordinate animals	unclear relationships heifer, No.
9	0.83	6	1
8	0.80	4	2, 5, 6
6	0.80	4	5, 7, 8
4	0.63	5	
1	0.50	3	7, 9
7	0.50	3	1, 6
10	0.29	2	2
5	0.17	1	6, 8
2	0.00	0	8, 10

Heifer No.	DV	No. of subordinate animals	unclear relationships heifer, No.
19	1.00	6	11, 20
16	0.83	5	12, 18
20	0.67	4	17, 19
18	0.60	3	12, 16, 17
12	0.50	3	16, 18
13	0.38	3	
15	0.29	2	11
11	0.17	1	15, 19
17	0.17	1	18, 20

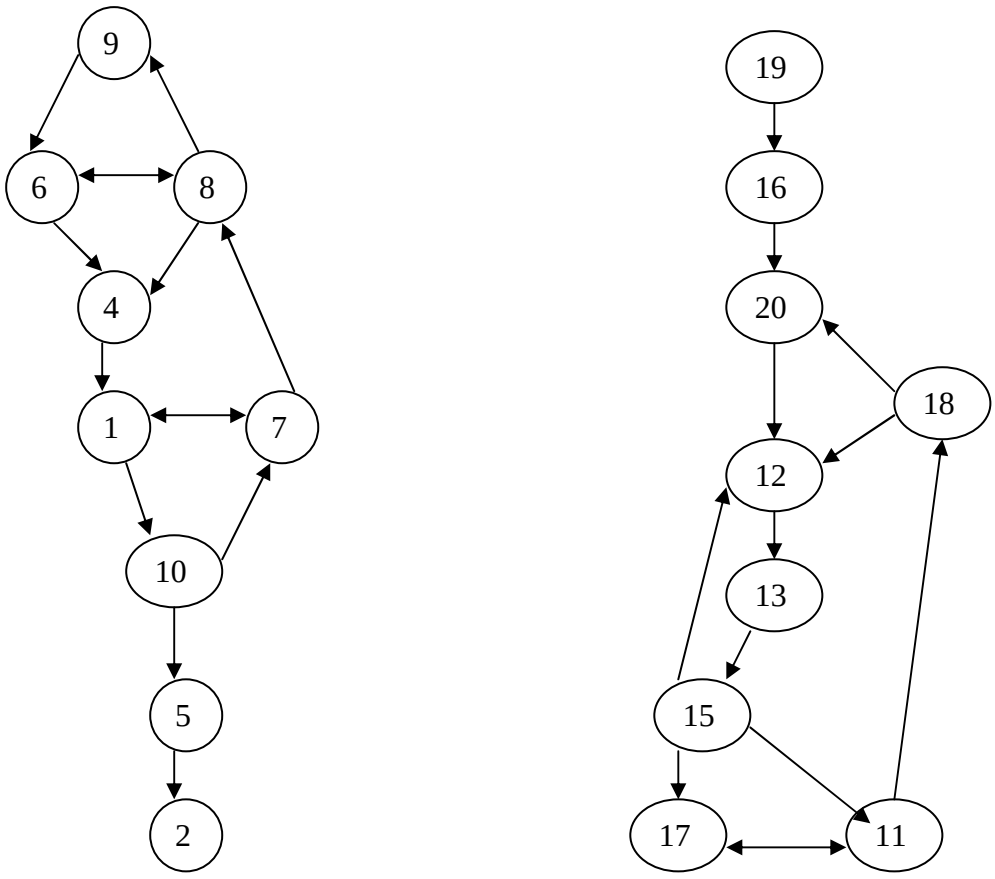

Figure 3a and 3b. *Formation of the dominance order of Group 1 (left) and Group 2 (right), respectively.*

The displacement index (DI) was also determined for each heifer by dividing the number of practised displacements by the number of received displacements. This index was calculated for comparison with the dominance (DV) value only and showed a high correlation with the DV.

Age and chest girth were also highly correlated as well as DV and chest girth, but the correlation between DV and age was lower (Table 5). These measurements and correlations were performed in order to find out whether there were correlations between physical criteria and position in the dominance order.

Table 5. *Correlations between age and chest girth, dominance value (DV) and age, DV and chest girth, DV and dominance index (DI), (n = 18)*

	r
Age – chest girth	0.81
DV[1] - age	0.77
DV – chest girth	0.81
DV – DI[2]	0.89

1) Dominance Value
2) Dominance Index

3.2. Effect of competition at the feeding rack on the interactions between heifers

The number of displacements during feeding was evaluated from the videos for the same periods when eating behaviour had been directly observed, i.e. on four days: after the heifers have been fed, around midday and in the late afternoon. This time summed up to about two hours per day per group.

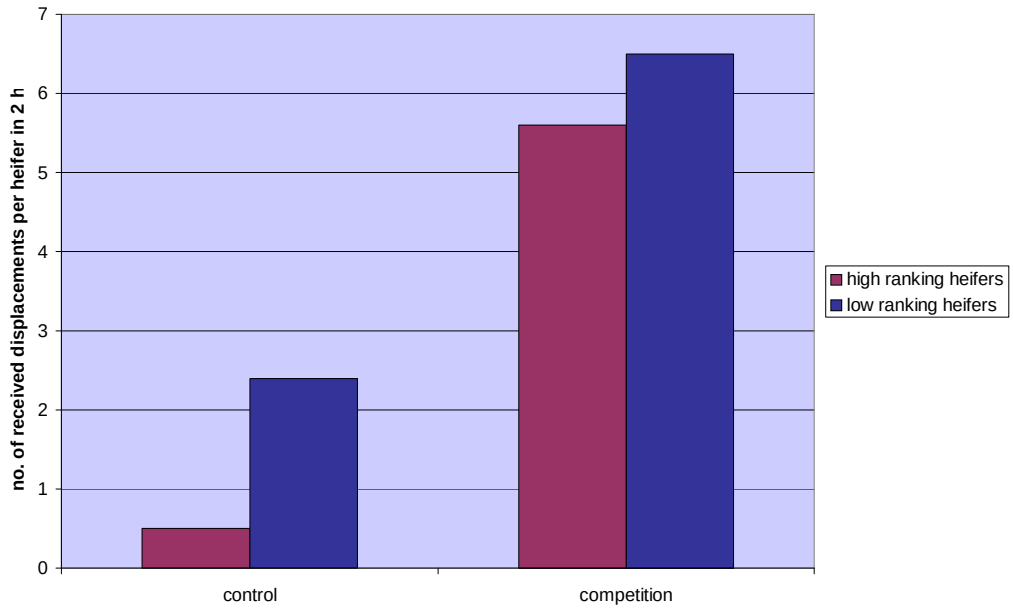

Figure 4. *Average number of received displacements per heifer in 2 hours at the feeding rack for 8 high and 10 low ranking heifers during control and competition.*

The difference between the average number of displacements per heifer during control and competition was highly significant ($n = 36$, $p < 0.001$).

During the control situation high ranking heifers were displaced 0.5 times on average, but low ranking heifers 2.4 times in two hours. The difference between high and low ranking heifers during control was significant ($n = 18$, $p = 0.014$). During the competitive situation high ranking heifers were displaced 5.6 times on average and low ranking heifers 6.5 times in two hours (Figure 2).

3.3. Behaviour patterns of high and low ranking heifers in competitive and non competitive situation

The treatment had no significant effect on the time budgets of the heifers; however, it tended to affect feeding time so that during the competition heifers fed, on average, for about half an hour less (Table 6).

Table 6. *Ls means for average time budgets (h) and Standard Deviation for heifers during control and competitive situation and results of the analysis of variance, (Total DF: 35)*

Behaviour	**Treatment**	**Average all heifers**	**StDev[1]**	**high ranking heifers**	**low ranking heifers**	**p-value**	**p-value**	**p-value**
		Hours		***Hours***	***Hours***	***Treatment***	***Rank***	***Interaction treatment-rank***
Eating	Control	4.2	0.6	4.2	4.1	0.061	NS	NS
	Competition	3.8	0.6	3.9	3.7			
Lying	Control	12.1	2.2	10.8	13.2	NS	0.002	NS
	Competition	12.4	2.5	11.0	13.5			
Standing in cubicles	Control	2.8	1.0	2.9	2.7	NS	NS	NS
	Competition	2.9	1.5	3.4	2.6			
Standing on feeding alley	Control	2.2	1.4	2.8	1.7	NS	0.029	NS
	Competition	2.1	1.0	2.5	1.9			
Standing on passageway	Control	2.7	1.7	3.2	2.3	NS	0.099	NS
	Competition	2.8	1.4	3.3	2.4			
Sum of standing on feeding alley and passageway	Control	4.9	2.7	6.1	4.1	NS	0.023	NS
	Competition	4.9	1.9	5.8	4.3			

1) Standard Deviation

Heifers in both groups were divided into high and low ranking heifers. For the results their average time budgets for the behaviour patterns were determined without considering their affiliation to their initial groups (total DF: 35) (Table 6). There was a significant difference for lying time so that low ranking heifers lay for about two hours longer than high ranking heifers, both during control and competition ($p = 0.002$). On the other hand, high ranking heifers stood significantly longer at the feeding alley ($p = 0.029$) and there was also a significant difference between the sum of standing at the feeding alley and on the passageway ($p = 0.023$) (Table 6).

3.3.1 Feeding behaviour

3.3.1.1 Attendance to the feeding rack, meals and bouts

During the competition the heifers' visits to the feed bunk was reduced by one visit, which corresponds to their reduced time spent feeding during the competition, but the difference of the feed bunk visits was not significant. The average duration of feed bunk visit was the same for the two treatments (Table 7).

Table 7. *LS means, Standard Deviation of visits to the feeding rack and average duration of visit per day for 8 high and 10 low ranking heifers during control and competition, (total DF: 35)*

Treatment	Rank	Average no. of visits to feed bunk	StDev[1]	Average min per feed bunk visit	StDev[1]
	1	15.8	2.9	16.7	3.9
Control	2	15.4	2.3	16.4	1.7
	1	14.4	3.0	16.9	5.6
Competition	2	14.9	3.1	15.4	2.3

1) Standard Deviation

Table 8. *LS means and Standard Deviation of meals, bouts and bouts per meal for 3 days, (total DF: 35)*

Treatment	Rank	Meals	StDev[1]	Bouts	StDev[1]	Bouts per meal	StDev[1]
	1	28.0	4.5	47.4	8.7	1.7	0.2
Control	2	26.4	4.5	46.2	7.0	1.8	0.4
	1	27.9	6.2	43.3	9.1	1.6	0.3
Competition	2	25.3	3.3	44.7	9.2	1.8	0.3

1) Standard Deviation

In Table 8 the meals and bouts for 3 days are listed. There was no significant effect of either treatment or rank .

3.3.1.2 Feeding behaviour patterns

When feeding behaviour of the heifers was observed directly, 4284 recordings were collected. The four categories of the feeding behaviour which were observed at three different times of the day were similar for both control and competition (Table 9). The type of treatment and time of the day did not have an influence on the feeding behaviour of the heifers.

Table 9. *LS means of the frequency of four feeding behaviour patterns per day at three different times of the day, (total DF: 106)*

Treatment	Time of the day	% Eating	% Tossing	% Smelling	% Other
Control	Morning	60.0	12.3	23.2	4.5
	Midday	63.5	10.0	19.5	6.9
	Afternoon	64.9	7.7	21.9	5.5
	Total	62.8	10.0	21.5	5.7
Competition	Morning	67.3	13.1	17.4	2.2
	Midday	67.1	11.4	17.1	4.4
	Afternoon	59.9	11.5	22.4	6.2
	Total	64.8	12.0	19.0	4.3

3.3.1.3 Change of feeding places

Changes of feeding places were determined per day for a 15 minutes' interval. There was a highly significant difference between the competitive situation and control, as during control heifers changed places on average twice per 15 minutes but during competition only once (Table 10).

The time of the day also had a significant influence on the frequency of changing feeding places, as heifers changed places once per 15 minutes in the morning, but twice at midday and in the afternoon (Table 10). Rank did not have any influence on this frequency.

Table10. *LS means of the number of changing feeding places per day for the different daytimes and for 8 high and 10 low ranking heifers during control and competition, (total DF: 106)*

Treatment	Rank	Morning	Midday	Afternoon	p-value
	1	2.8	2.6	1.9	Treatment: p = 0.007
Control	2	1.4	2.2	3.2	Time of the day: p = 0.041
	1	1.0	1.8	2.1	Rank: NS
Experiment	2	0.4	1.1	2.2	

3.3.1.4 Feeding behaviour in the course of the day

As shown in Figure 5, the heifers did not change their feeding behaviour substantially in the course of the day when feeding places were restricted, nor was there a significant difference between high and low ranking heifers. After silage had been given, a varying number of heifers began to feed in the morning, but over the day, the frequency of feeding heifers stayed between 20 and 25% until it declined in the night.

There was no period during the day when there was a significant difference between high and low ranking heifers in the competitive situation. The only significant differences between high ranking and low ranking heifers occurred during control, at 6-8 pm (n = 18, p = 0.013) and 4-6 am (n = 18, p = 0.044).

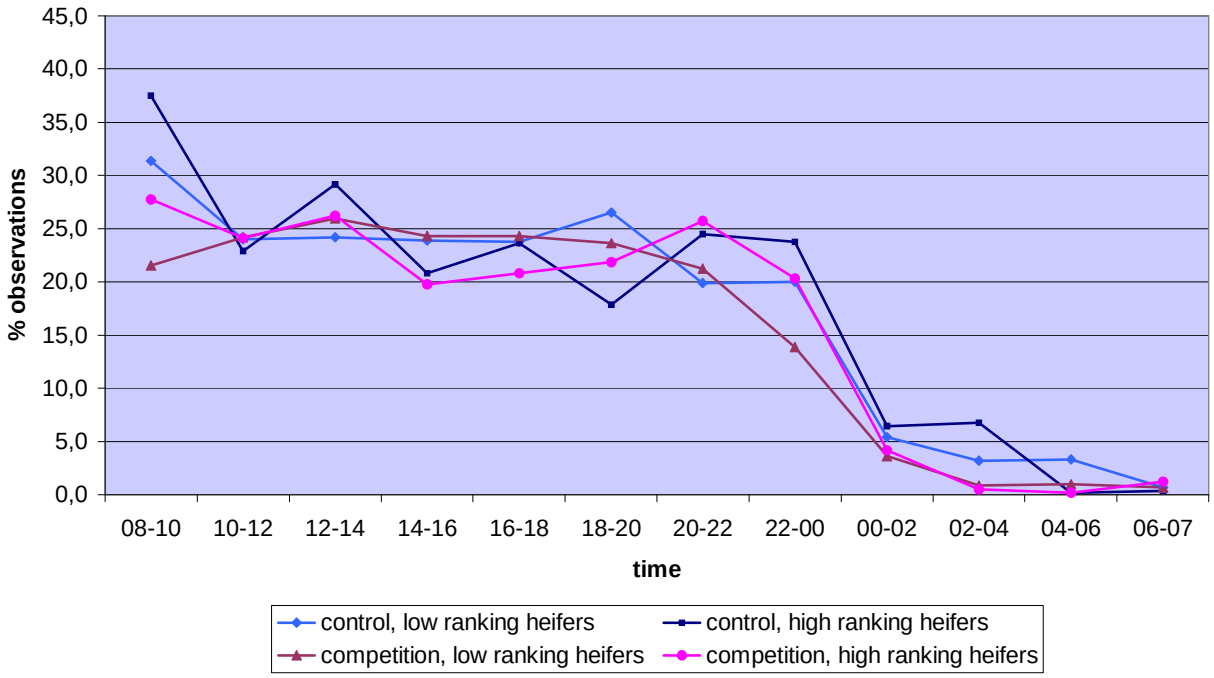

Figure 5. *Percentages of 8 high and 10 low ranking feeding heifers at the feeding rack during a 24 hours period, data for both control and competition situation.*

To find out which heifers were the first ones to feed after silage was given, the percentage of high and low ranking heifers present at the feeding rack was determined every five minutes for the first two and a half hours after feeding. In Figures 6 and 7 the points of time when silage was given were fixed to one point at 9 am.

After feeding, the high ranking heifers occupied the feeding rack for the first quarter (09:05-09:15) during competition (Figure 6). For the next quarter, more low ranking heifers were present at the feeding rack. After that the proportion of high and low ranking heifers was balanced for a short time. One hour after feeding (10:05-10:45), more low ranking heifers occupied the feeding rack for about three quarters of an hour. For the rest of the 2.5 hours there was no difference between the frequency of high and low ranking heifers at the feeding rack.

Considering the average number of heifers at the feeding rack during competition, all four feeding places were occupied for about the first hour, i.e. there was a 100% utilisation. After that there were 2-3 heifers at the feeding rack (50-75% utilisation) for the rest of the 2.5 hours.

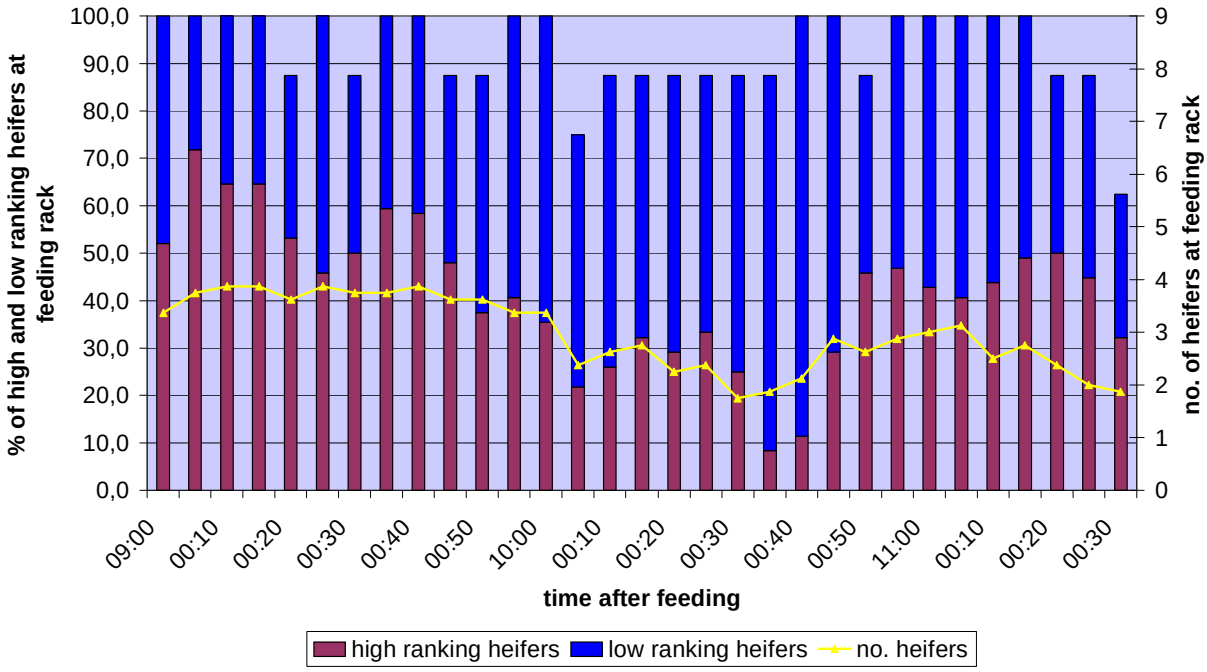

Figure 6. *Percentage of 8 high and 10 low ranking heifers at the feeding rack during the first 2.5 hours after feeding silage during the competition.*

During the control situation the proportions were more balanced, since all heifers had access to a feeding place (Figure 7).

Regarding the number of animals at the feeding rack, on average 7 heifers were feeding for the first 20 minutes during the control situation (77.8% utilisation). Thereafter the number of heifers declined rapidly to two to three heifers (22-33% utilisation) by the time of one hour after feeding and stayed stable for the rest of the time of the 2.5 hours (Figure 7).

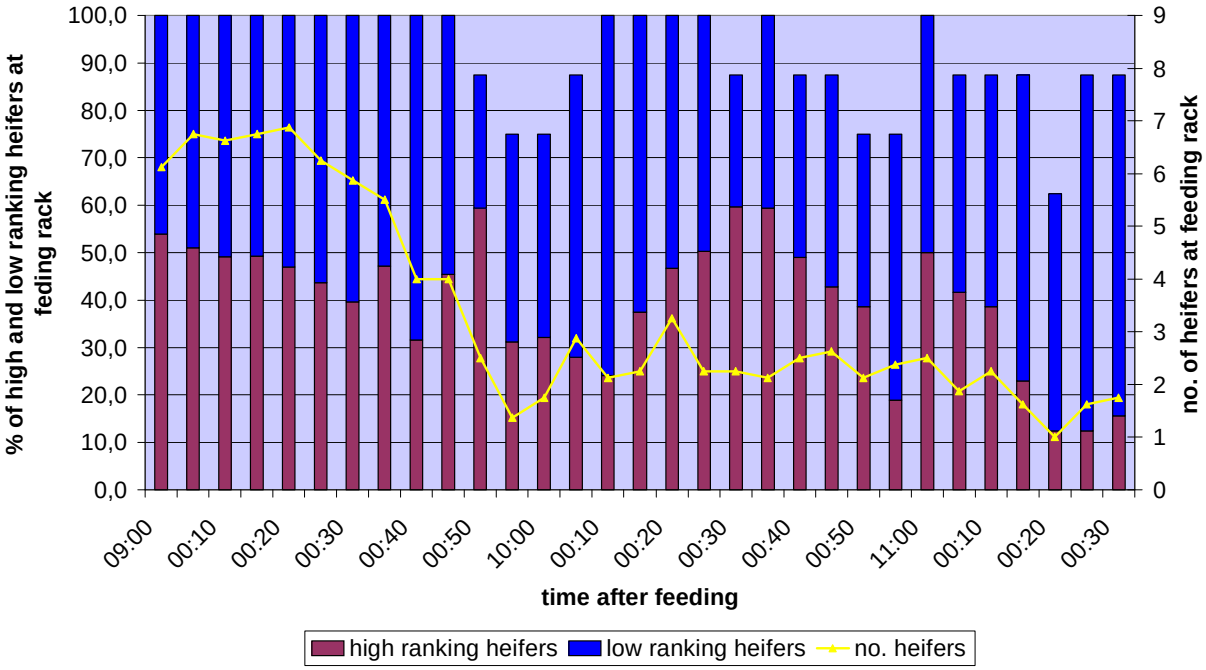

Figure 7. *Percentage of 8 high and 10 low ranking heifers at the feeding rack during the first 2.5 hours after feeding silage during control.*

3.3.2 Lying behaviour

3.3.2.1 Lying periods

The significant difference between high and low ranking heifers for total lying time (Table 6) was accompanied by the significant difference of the number of lying periods for high and low ranking heifers (p = 0.032) (Table 11).

Table 11. *LS means and Standard Deviation of lying periods for 8 high and 10 low ranking heifers per day during control and competition,(total DF: 35)*

Treatment	Rank	Average no. of lying periods per day	StDev[1]	p-value
Control	1	7.1	2.1	Rank: 0.032
	2	8.1	1.1	Treatment: NS
Competition	1	6.1	1.4	
	2	7.3	1.5	

1) Standard Deviation

When classifying the lying time periods in bouts of less than an hour, one to two hours', two to three hours' duration and so on, it appeared that most of the lying periods lasted between one and two hours, followed by less than one hour. Heifers seldom lied down for more than three hours continuously (Figure 8). There was no difference between high and low ranking

heifers, with two exceptions during control. Low ranking heifers had significantly more lying periods between two and three hours and between three and four hours ($p = 0.005$ and $p = 0.019$, respectively).

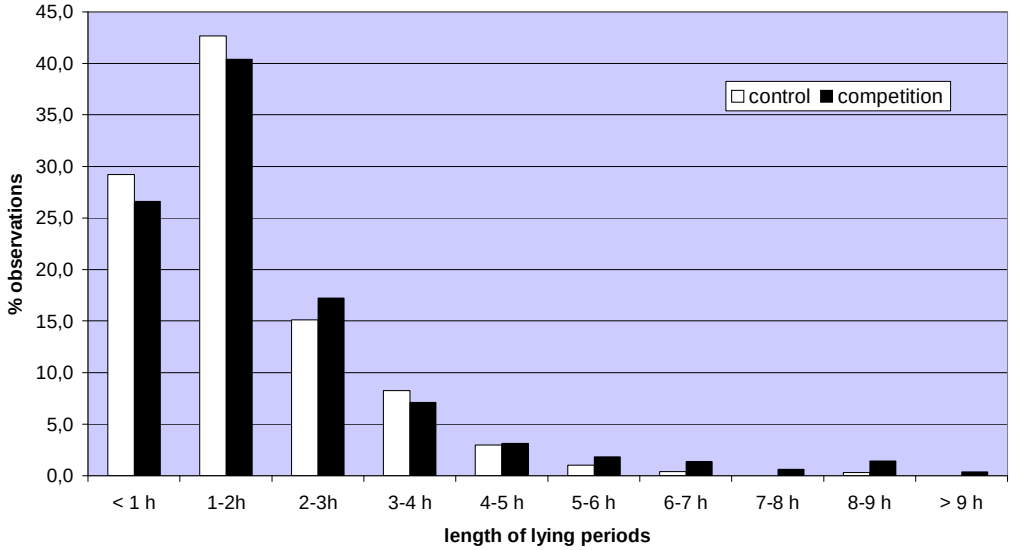

Figure 8. *Frequency of different durations of lying periods per day during control and competition.*

3.3.2.2 Lying behaviour in the course of the day

With regard to the lying behaviour of the heifers there was no difference between control and competitive situation, i.e. high and low ranking heifers did not change their behaviour in the course of the day (Figure 9). The difference of about 10% which existed between high and low ranking heifers from 8 am to 18 pm was not significant, with one exception at 12:00 to 14:00 pm for the control situation ($n = 18$, $p = 0.012$). Another significant difference came up later between 22 and 24 pm ($n = 18$, $p = 0.001$). At the same time, or between 20 and 22 pm and 22 and 24 pm differences tended to be significant during the competitive situation ($n = 18$, $p = 0.057$ and $p = 0.029$, respectively).

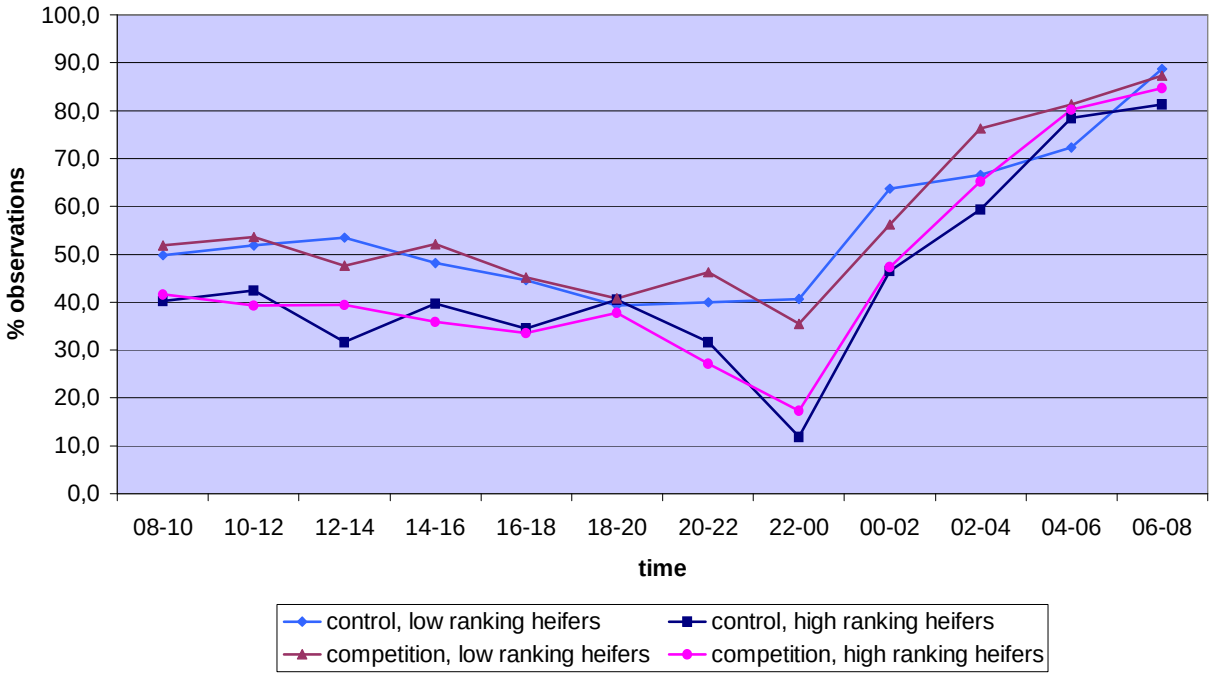

Figure 9. *Percentage of 8 high and 10 low ranking lying heifers during a 24 hours period, data for control and competition situation.*

3.3.3 Standing on the passageway and the feeding alley

High and low ranking heifers did not change their behaviour of standing on the passageway and the feeding alley during competition when comparing with the control situation (Figure 10). During control there were three periods which tended to differ regarding the percentage of high and low ranking heifers standing on the passageway and the feeding alley. These periods were between 12-14 pm (n = 18, p = 0.063), between 16-18 pm (n = 18, p = 0.096) and between 22-24 pm (n = 18, p = 0.007). For the competitive situation the significant differences between high and low ranking heifers were at similar times, or between 14-16 pm (n = 18, p = 0.035), 20-22 pm (n = 18, p = 0.026) and between 22-24 pm (n = 18, p = 0.041).

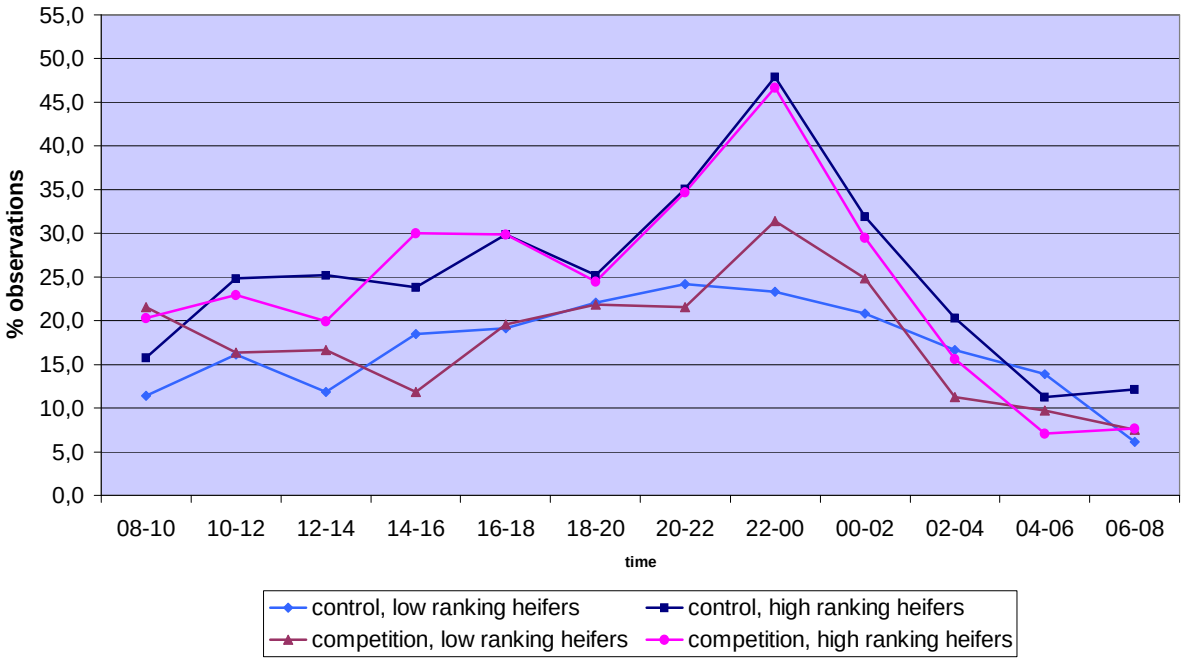

Figure 10. *Percentage of 8 high and 10 low ranking heifers standing on the passageway and the feeding alley during a 24 hours period, data for control and competitive situation.*

3.3.4 Standing in cubicles

The percentage of heifers standing in the cubicles varied between 5 and 20% over the day for all heifers both during control and competition. This behaviour was not influenced by the treatment, nor did the rank of the heifers play a role.

4. Discussion

4.1. Social dominance order

The distribution of dominance values was balanced for both groups, i.e. there were the same numbers of animals that can be regarded as low and high ranking animals. Due to the low numbers of individuals in each group, the heifers were only divided in high (DV > 0.5) and low (DV ≤ 0.5) ranking animals in the present study. The dominance structures of the groups in this study were different to some extent, since there was one heifer in Group 1 which was completely subdominant, but there was no heifer which was dominant over all other animals. However, in Group 2 there was no heifer which was subdominant to all others but one heifer that was dominant over all other members of the group with the exception that it had unsettled relationship with two heifer. These different social structures, i.e. the occurrence or absence of a cow or heifer which is dominant over all herd members has been found in some herds, for example by Beilharz and Mylrea (1963), Wagnon, (1965), Sambraus (1970) and Beilharz and Zeeb (1982). Wierenga (1990) described a so-called alpha-animal in one of his herds as well as an omega-animal in another herd, i.e. a cow which was subordinate to all other group members.

In both groups the order appeared complex just as in many other investigated herds (Beilharz and Mylrea, 1963; Reinhardt, 1973; Sambraus, 1975; Collis, 1976; Beilharz and Zeeb, 1982; Reinhardt, 1980; Oberosler et al., 1982; Wierenga, 1990). However, Reinhardt et al. (1986) studied a herd of semi-wild Scottish Highland cattle and found that this herd had developed a linear hierarchy with two exceptions. A complex dominance order implies that low ranking animals are dominant over single animals which have a higher DV. This occurred several times in both groups as well as in earlier studied groups (Collis, 1976; Metz and Mekking, 1978; Reinhardt, 1980; Wierenga, 1990).

For the correlations between dominance value (DV) and age contrary results are presented in the relevant literature. In this study, DV and age were correlated as found in some other studies (Schein and Fohrman, 1955; Guhl and Atkeson, 1959; Sambraus, 1970; Beilharz and Zeeb, 1982; Reinhardt et al, 1986). However, other authors did not find any correlation (Schloeth, 1961; Collis, 1976). The same applies to the correlation between DV and chest girth, which served as a measure of weight in this study. In the present study, this correlation was even higher than between DV and age. A correlation between DV and chest girth has also been reported by Beilharz and Mylrea (1963).

4.2. Agonistic interactions between the heifers

Compared to other studies of social behaviour in cattle, in the present study the repertoire of agonistic behaviour patterns was qualitatively similar but differed quantitatively. A reason for this difference might be found in the fact that the present study was performed in confinement and additionally under competitive circumstances. In contrast, earlier researches, which described and measured the repertoire of agonistic behaviour patterns, were often carried out under semi-natural conditions (Schloeth, 1961; Reinhardt, 1980; Reinhardt et al., 1986).

The agonistic behaviour pattern most often observed consisted in displacements with 47.5% of all agonistic interactions for both groups. This was often preceded by head buts, in most of the cases, towards the heifer which was displaced later. In the studies of Reinhardt (1980) and Reinhardt et al. (1986) butting was the most common agonistic behaviour pattern under semi-natural conditions, though with different rates, 56.6% and 22% respectively. In both studies threatening was the second common agonistic behaviour pattern (30.2% and 14%, respectively), unlike in the present study, where threats occurred only for 7.5% and 5.5% in Group 1 and 2, respectively. Chasing occurred at different rates during the present study for Group 1 and 2, or in 3.4% and 0.8% of the cases, respectively, also compared to 1.8% (Reinhardt, 1980) and 9% (Reinhardt et al., 1986).

4.3. Effect of competition at the feeding rack on the interactions between heifers

In the present study, the number of displacements on the feeding rack was significantly about five times higher during competition than during control time. This supports the results of Metz and Mekking (1978), Wierenga (1990), Frank and Magnusson (1994); Olofsson (1999), Stumpf et al. (2000), DeVries et al.(2004) and Huzzey et al. (2006). According to Metz (1983), an increase of aggression in a herd is a direct consequence of restricted food supply, because competition for feed leads to aggressive interactions. Stricklin and Gonyou (1981) and Wierenga (1990) even observed, that subdominant animals displaced dominant animals more often in the competitive situation than under non-competitive conditions. This could partly be an explanation for the increased agonistic behaviour, both in the present study and in the study of Wierenga (1990).

Additionally overcrowding has an influence on all animals but some are more affected than others (Potter and Broom, 1987). Though “displacements” were one of the measurements used to distinguish between low and high ranking heifers, the results show that the influence of competition is more on some than on other animals. In the present study, weaker heifers

were more often displaced at the feeding rack than stronger heifers (Figure 4) like in other studies where lower ranking animals were more often displaced than higher ranking animals (Potter and Broom, 1987; Metz and Wierenga, 1987; Huzzey, 2006). This difference was only significant for the control time but not for the competition time in the present study. A reason for the non-significant difference during competition could be that now, low ranking animals displaced high ranking animals nearly as often as they were displaced in order to get access to feed. This behaviour was also observed by Stricklin and Gonyou (1981) and Wierenga (1990).

4.4. Feeding behaviour

4.4.1 Feeding behaviour patterns and feeding behaviour in the course of the day

The only significant difference of feeding behaviour between control and competition situation was found for the length of feeding time. During competition, the heifers, on average, spent about half an hour less on feeding than during control time. Keys et al. (1978) obtained similar results with yearling Holstein heifers when feeding space was reduced from 0.81m/head to 0.20 m/head and feeding time decreased from 4.8 to 3.6 h/day. Experiments with dairy cows under conditions similar to the present study also revealed a reduction in feeding time from 5.6h/day during the control situation to 4.8h/day during the competitive situation (Frank and Magnusson, 1994). On the other hand, Stumpf et al. (2000) and Collis et al. (1980) did not find any difference for the time cows spent at the feeding rack under competitive conditions.

In the present study, heifers visited the feeding rack one time less per day during competition than during control, but this difference was not significant. The average duration of an attendance was the same with around 16 minutes. These results are comparable to those of Collis et al. (1980) and the ones of Frank and Magnusson (1994). The animals had access to feed ad libitum in those studies. However, in many cases no clear definitions of feeding periods have been provided and there for differences in results between studies might also be due to different definitions used.

There was no significant difference between higher and lower ranking heifers regarding feeding time, the number of feed bunk visits nor the number of meals and bouts neither during control nor during the competition. This is in contrast to the results of Leavers and Yarrows (1980) where subdominant heifers had a slightly longer feeding time but a lower number of visits to the feed bunk and a significantly lower rate of feeding than dominant

heifers, which resulted in reduced silage intake during competition. Stricklin and Gonyou (1981) found middle and low ranking beef cattle having more meals than higher ranking animals, but the total time spent feeding did not differ. In the studies of Campling and Morgan (1981) and Potter and Broom (1987) dominant cows tended to spend more time feeding than subdominant cows. Also Olofsson (1999) demonstrated that the feeding time decreased significantly for cows with low DV during the competitive period.

In the present study no change of the diurnal feeding behaviour during competition could be stated compared with the control situation. This is in contrast to the findings of Metz (1983) and Olofsson (1999) who found a shift in feeding times of cows when the feeding space was reduced so that feeding increased during the night.

4.4.2 The first 2.5 hours after feeding and synchrony in feeding behaviour

The competition level was highest for the first 2.5 hours after feeding. After that, each heifer had its first meal. For the rest of the day they distributed their meals equally over the day and avoided getting in a high competition level again, thus confirming earlier studies (Friends and Polan, 1974; Keys et al.,1978; Longenbach et al., 1999).

At this point of time, the effect of the dominance order appeared most clearly, because high ranking heifers dominated at the feeding rack for the first 20 minutes in the present study. Friend and Polan (1974) observed priority of dominant cows as well. In a second study, Friend and Polan (1978) stress, that dominance can ”be important in determining access to feed” (p. 65). When other characteristics of the cows were regarded as well, dominance played a less important role. However, in a competitive situation, dominant cows had priority.

Under non-competitive housing conditions, O’Connell et al. (1989) and Miller and Wood-Gush (1991) only observed synchrony in feeding when fresh feed had recently been given. After one hour the percentage of animals feeding had fallen to 30% and remained at 25% for the rest of the day, as it was observed in the present study. A possible explanation of this lack of synchronisation could be that synchronisation indoors is much less prevalent than e.g. at pasture (O’Connel et al., 1989; Miller and Wood-Gush, 1991). Miller and Wood-Gush (1991) also regard the loss of synchrony indoors as an indicator of reduced welfare. However, only little research has been carried out on the effect of reduced synchrony on the welfare of animals. Nevertheless, synchrony in terms of the possibility that all animals can perform a behaviour at the same time (Miller and Wood-Gush, 1991), e.g. like at pasture, cannot be performed in a competitive situation like in the present study due to the impossibility for the animals to start feeding at the same time.

4.4.3 Feeding behaviour patterns

Feeding behaviour patterns such as active feeding, manipulating and smelling the silage were chosen in order to study possible effects of time of the day of access to the feeding rack on the quality of silage that was still at the manger. Since cattle try to select feed, a small change was expected in the cause of the day, with more smelling or manipulating in the late afternoon. But the proportion of each behaviour pattern did not change much during the three observation periods. The behaviour associated with feeding activity amounted to around 90 to 95% in this study, whereas active eating was recorded with 60 to 65% and manipulating silage with 20 to 25%. The rest of the time, (5%), was spent in doing something else, such as grooming, scratching at the rack and/or idling. These results are similar to those of Manson and Appleby (1990) who determined actual feeding with head down with 65%, manipulating feed with head up with 27% and grooming and looking around altogether with 9%. Schwartzkopf-Genswein et al. (1999) determined feeding and non-feeding activities in relation to the time at the feed bunk and found a rate of 84% of feeding activity.

The fact that there was no difference between the behavioural patterns during the day nor between the treatments in the present study could be attributed to the good quality of the silage and its sufficient quantity.

4.4.4 Changing feeding places

In this study, the rank class had no influence on the frequency of chances of feeding places. Wierenga (1990) reported that dominant cows displaced subdominant cows more often during overcrowded conditions in order to change their feeding place or to get some space to turn. Stumpf et al. (2000) also observed that dominant cows changed their feeding places more frequently and displaced subdominant cows more often as feed bunk density decreased.

The time of the day had a highly significant influence on the number of changing feeding places in terms of an increase in the afternoon. An explanation for that could be that the number of animals at the feeding rack was always less in the course of the day. So in the morning, when silage had been given and density at the feeding rack was highest, heifers tended to stay longer at one place. This was also described by Stumpf et al. (2000). Later in the day during the present study, when density at the feeding rack was less, heifers could move more freely, hence they also could change feeding places more easily.

4.5. Lying behaviour

In this study no difference of lying behaviour in the course of the day nor in the lying time budgets was observed between control and competition period. Olofsson (1999) obtained the same results in his study with cows, however with a higher competition level than in the present study. Metz and Mekking (1978) on the other hand found an alteration in the diurnal lying behaviour or rhythm of their cows, but lying time remained unchanged. Time budgets of lying time were alike, also compared with other recent studies, as they were around 50% of 24 hours (Friend and Polan, 1974; Hindhede at al., 1999; Olofsson, 1999).

A significant difference concerning the lying behaviour of the heifers occurred on the other hand when time patterns of higher and lower ranking heifers were compared. Both during control and competitive situation, the lower ranking heifers were lying for a longer time. Some lower ranking heifers stayed lying down, when silage was supplied (data not shown), which might be interpreted as avoidance of the (over-)crowding at the feeding rack. Wierenga (1990) found a significant difference between dominant and subdominant dairy cows for lying time only during overstocking. This is in contrast to Stumpf et al. (2000) because in the latter study no difference in resting time between dominant and subdominant heifers during their competitive situation at the feeding rack was observed.

The decreasing proportion of lying heifers mainly between 10 pm and 12 pm is because at that time heifers stood at the feeding rack. The high percentage of heifers lying during the night until in the early morning is also a behaviour pattern which has often been observed in cattle (Sambraus, 1971; Potter and Broom, 1987; Overton et al., 2002).

In this study, the percentage of lying periods of different duration was determined. Since most periods lasted between one and two hours, this is in accordance with former studies where the lying periods lasted on average between one hour and one and a half hour (Friend et al., 1977). The longer lying periods, in this study lasting for 5 hours and longer, were mostly observed during the second observation period of this study where silage was not sufficient throughout the night. So, shortly after midnight, a few heifers went to lie down and more heifers followed in the course of the night and did not get up until the next morning. An explanation for these few long lying periods could be that “clean bunks would presumably dissuade the cattle from attending” the feeding rack (Schwartzkopf-Genswein et al., 2002, p.185). This is supported by longer lying times of cows who were fed on alternate days compared with cows who were fed daily resulting in shorter lying time (Phillips and Rindt, 2001)

4.6. Standing at the feeding alley and the passageway

High ranking heifers stood on average significantly longer at the passages than low ranking heifers. This is surprising in the light of the results of Olofsson (1999) and Stumpf et al. (2000) with cows. Actually, there is no clear explanation for that, other than that lower ranking heifers chose to lie down or stayed lying more than higher ranking heifers, rather than standing around.

There was no difference in the time the heifers spent standing at the passages between control and competition periods. Olofsson (1999) and Stumpf et al. (2000) obtained contrary results, because standing time for subdominant cows increased during the competitive situation in these studies.

The peak which occurred between 10 pm and 11 pm (Figure 10) in the present study is mainly because during this period of the day silage was pushed up. Heifers reacted by attending the feeding rack like they do when fresh hay is supplied, but during the second observation period (after the cross over in November) of this study there was not enough silage for the night. In consequence of this unfortunate change in management routine the heifers stood on the feeding alley instead of eating silage.

4.7. Standing in the cubicles

The treatment did not have any influence on the time the heifers were standing in the cubicles, nor did the rank class. This is in contrast to Potter and Broom (1987), because in their study, low ranking cows stood longer in the cubicles. They concluded that cubicles were used as a safe standing area.

5. Conclusion

The heifers did not change their behaviour drastically in the course of the day when comparing their behaviour during control and competition but they also reacted quite individually to the competitive situation. There were only small adjustments or changes in the feeding behaviour because of the treatment. However, eating for half an hour less during competition than during control might lead to undesirably less food consumption, although not analysed in this study.

An important result was that agonistic behaviour patterns were five times higher during higher stocking density and competition than during the control situation. A high level of aggression is certainly not a way to ensure good animal welfare. The fact that there is competition for food in confinement anyway, confirmed by displacements during the control situation, should not be intensified by increasing competition. Furthermore, animals, especially low ranking animals, may avoid visiting the feeding rack, because of the increased possibility to get involved in aggressive encounters. Thus the feeding rack becomes an undesirable area to stay at, strengthened by the fact that aggressive interactions also take place during feeding. In addition, by reducing the feeding space, the natural motivation to eat synchronously is disturbed. However, if we accept that farm animal should be given the possibility to perform their natural behaviour as far as possible, this indicator may be viewed as an indicator of impaired welfare. Because of these results it is not advisable to keep heifers at higher stocking rates than feeding places are available.

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