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The effects of environmental enrichments, group size and confinement length on play behaviour in juvenile Norwegian dairy goats (*Capra hircus*)

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Abstract

Play is often considered as an indicator of good welfare in young mammals as it rarely occurs under harsh conditioåns. It would, therefore, be useful to know how changes in some normal production conditions affect play behaviours. In the current study, three experiments on the effects of environmental enrichment, group size and confinement length on behaviour frequencies, including play, were conducted on 20 young, female Norwegian dairy goats. It was hypothesised that play would occur more frequently under enriched rather than control conditions, and that it would increase with group size and confinement length.

The subjects were divided into temporary groups depending on the experiment and were observed in an outdoor enclosure for 30 min per observation session. Instantaneous scans of the whole group were performed every three minutes, and the behaviour of each goat was recorded. In-between the instantaneous scans, focal animal observations were carried out using 1-0 sampling. All goats were housed together in an indoor pen except during the observations sessions, which occurred between two to four times per observation day depending on the experiment.

A 1 m high wooden bridge, a suspended ball (underneath bridge) and a bucket full of sticks served as enrichments in the environmental enrichment experiment (experiment 1). The lack of these objects acted as a control condition. In groups of five goats, individuals played at higher frequencies and were more active under enriched conditions than under control conditions. Furthermore, agonistic interactions were reduced when enrichments were available. When the effect of repeated exposure to the different treatments was examined, play was seen to be more frequent in earlier than later exposures, while the frequency of agonistic interactions varied. In the second experiment, the subjects experienced exposures to group sizes of 2-8 familiar individuals. In general, play was seen to increase in response to increasing group size, while vigilance decreased as group size increased. Thus, goats used to be more active in larger group sizes. However, the individuals were not more socially tolerant in larger group sizes, as the group size did not significantly affect the frequencies of agonistic interactions. In the third experiment, goats were confined to their indoor home pen for 2-5 days before being given access to the outdoor enclosure. An increase of play and other active behaviours in the outdoor enclosure was not observed in response to longer indoor confinement lengths, as predicted. In contrast, some opposing results (increase of standing and vigilant behaviour) were registered.

Consequently, typical variations in management, such as regrouping of animals into different group sizes, confinement and the addition of enrichments, affected the frequency of play in Norwegian dairy goats, which might indicate changes in welfare of relevance to goat production.

Sammendrag

Lek blir ofte betraktet som en indikator på god velferd i unge pattedyr siden det sjelden forekommer under vanskelige forhold. Det vil derfor være nyttig å vite hvordan endringer i noen normale produksjonsforhold påvirker lekatferd. I denne studien ble det utført tre eksperimenter på effekten av miljøberikelse, gruppestørrelse og innesperringslengde på atferds frekvenser, inkludert lek, på 20 unge, norske meierigeiter. Lek var forventet å forekomme oftere under berikede forhold enn under kontrollforhold, og at det ville øke med gruppestørrelse og innesperringslengde.

Subjektene var delt inn i midlertidige grupper avhengig av eksperimentet og ble observert i en utendørs innhegning for 30 min per observasjonssesjon. Øyeblikksmålinger av hele gruppen ble utført hvert tredje minutt og atferden til hver geit ble registrert. Mellom øyeblikksmålinger ble fokale atferds observasjoner utført ved bruk intervallregistrering (1-0 sampling). Alle geitene var huset sammen i en innendørs innhegning, unntatt under observasjonssesjonene som forekom mellom to til fire ganger per observasjonsdag avhengig av eksperimentet.

En 1 m høy trebro, en hengende ball (under bro) og en bøtte full av pinner tjente som berikelser i miljøberikelseseksperimentet (eksperiment 1). Mangelen på disse objektene fungerte som kontrollforhold. I grupper på fem geiter lekte individer på høyere frekvenser og var mer aktive under berikede forhold enn under kontrollforhold. Dessuten ble agonistiske interaksjoner redusert når berikelse var tilgjengelige. Når effekten av gjentatt eksponering til de ulike forholdene ble undersøkt, var lek observert å ha høyere frekvenser i tidligere eksponeringer enn i forhold til senere eksponeringer, mens frekvensen av agonistiske interaksjoner varierte. I det andre eksperimentet ble subjektene eksponert til variable gruppestørrelser på 2-8 kjente geiter. Generelt sett så økte lek i respons til økende gruppestørrelse, mens årvåkenhet ble redusert. Imidlertid var individene ikke mer sosialt tolerante i større gruppestørrelser, da gruppestørrelse ikke påvirket frekvensene av agonistiske interaksjoner signifikant. I det tredje eksperimentet ble geitene stengt inne i sin innendørsinnhegning for 2-5 dager før de fikk tilgang til utendørsinnhegningen. En økning av lek og andre aktive atferder i utendørsinnhegningen ble ikke observert som en effekt av lengre innesperringsperioder, som antatt. Tvert imot ble noen motstridende resultater (økning av stående og årvåken atferd) registrert.

Som konsekvens kan man si at typiske variasjoner i forvaltningen av dyr, slik som omgruppering i variable størrelser, innesperring og tilsetning av berikelser, vil påvirke hyppigheten av led atferd hos norske meierigeiter noe som kan indikere endringer i velferden hos norske geiteproduksjoner.

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Regine Victoria Holt

Table of content

1. Introduction

Even though they are often nicknamed "the poor man's cow", domestic goats (*Capra hircus*) were ranked the third most common farm animal in world live animal production in 2013 (FAO, 2015). They are very versatile, utilised for various products and services, such as dairy and meat production and control of vegetation. Their small size and environmental adaptability also makes them very convenient and popular (Solaiman, 2010 p. 4-8). As a result quite a lot is known about their production (Barroso *et al.*, 2000), but less is known about the effects of their behaviour on production (Barroso *et al.*, 2000; Shank, 2010), and even less is known about their play behaviour. As play is often included as a welfare measurement, it is important to understand how different production procedures affect the frequency of play. In this study, three experiments were conducted examining how the addition of environmental enrichments, the size of groups and various confinement lengths affect how much young Norwegian dairy goats play.

2. Literature review

2.1 Play behaviour

A variety of motor patterns are recognized as play behaviour even though they vary between species (Bekoff, 1984). Play has been described in birds, reptiles and cephalopods (Bekoff & Byers, 1998), and in most mammalian orders (Spinka *et al.*, 2001). Examples of motor patterns described as play in mammals are: puppies chasing their tail, kittens pawing at moving objects, and baboons chasing each other and tumbling. Due to the variation between species, a precise definition of play has been hard to determine (Barnard, 2004 p. 305). As a consequence, several definitions of play exist. In example, Fagen (1981) listed 37 different definitions of play in an appendix alone, some broad and others more precise. A popular definition of play was formulated by Bekoff and Byers (1981). They defined play as "all motor activity performed postnatally that appears to be purposeless, in which motor patterns from other contexts may often be used in modified forms and altered temporal sequencing" (Bekoff & Byers, 1981, p. 300). In other words, play contains elements of other, functional behaviours such as predatory behaviour, avoidance and mating (Bekoff & Allen, 1998 p. 105), that are put together in new, varied and exaggerated ways. Together these elements form versions of play that change and adapt as the players and their play progresses and, due to the mixture of behavioural elements, may seem meaningless. Yet, due to the composition of the motor sequences used during play, and the inclusion of play signals (Bekoff & Allen, 1998), the animals rarely seem to confuse play with other behaviours (Bekoff & Byers, 1981).

Why most mammals play is unclear (Bekoff & Allen, 1998), but there are several hypotheses on the adaptive value of play. One of them is the motor training hypothesis, which proposes that, if the individual played a lot when it was younger, it would develop more muscle mass and more fine-tuned motor skills compared to other individuals that did not play as much during their younger days (Fagen, 1981, p. 278). Spinka *et al.* (2001) hypothesise that play is a mechanism for learning how to handle unexpected and spontaneous events. During play, self-handicapping and tumbling that can resemble life-threathening situations and injuries often occur. By playing in safer contexts, the individual would encounter similar events as under dangerous circumstances, such as being thrown off balance, and would develop skills to recover faster. This knowledge and experience would increase the individual's probability of survival during stressful short-term situations and decrease the negative effects of such situations in the long term (Spinka *et al.*, 2001). Play was also theorised to be important for the establishment and reinforcement of social bonds (Bekoff, 1977), although Hass and Jenni (1993) did not find support for this idea in bighorn sheep (*Ovis canadensis*). Additionally, it has been proposed that play is an approach to gain environmental information and a way to improve cognitive skills (Fagen, 1981, p. 278-355). Most likely, play will not have only one adaptive value, but may contribute to fitness in multiple ways that collectively make the behaviour adaptive (Barnard, 2004 p. 306).

Play comprises brief behavioural events (Thompson, 1998) and is most abundant in younger mammals (Hinde, 1966 p. 239; Fagen, 1981 p. 359; Bekoff & Allen, 1998). Over a mammal's life span, the frequency of play can be seen to follow an inverted-U curve, where the peak is located in the mammal's juvenile period (Pellegrini *et al.*, 2007).

Development of play behaviour follows emergebce of exploration ontogenetically (Pellegrini *et al.*, 2007). In a study by Belsky and Most (1981), human infants were reported to spend more time exploring than playing (age at beginning: 7 ½ months old), but this changed as the subjects got older and the babies spent more time playing instead (age at end of study: 21 months old). Exploration, a method for gathering information about the surroundings, is used to find resources and for identifying dangerous environmental components (Spinka *et al.*, 2001). Once something has been perceived as safe through exploration, the animal could use play to experiment and interact with the object or individual and possibly gain useful knowledge and develop more efficient and innovative behaviours. As the mammal grows older, the frequency of play declines as other urges take priority (especially those related to reproduction) and the environmental situation changes (i.e. the individual must meet its requirements for food and security independently as the parent's focus is now switched to caring for younger siblings) (Pellegrini *et al.*, 2007).

Sometimes, play is called an opportunity behaviour as it often occurs when the performance costs are low (Fraser & Duncan, 1998). This means play commonly occurs under good circumstances, when the animals feel secure (Fraser & Duncan, 1998; Burgdorf & Panksepp, 2006) and have enough energy to perform non-vital behaviours. Play is rarely seen under harsh environmental conditions (Buchenauer, 1981; Lawrence, 1987; Newberry *et al.*, 1988; Barrett *et al.*, 1992), and since the behaviour can be measured using non-invasive methods (Fraser & Duncan, 1998; Spinka *et al.*, 2001; Dawkins, 2006), play was suggested to be used as an indicator of good welfare. In line with this view, anything that increases the frequency of play is thought to be good for animal welfare. Nevertheless, just as the appearance of play varies between species (Barber, 1991), what increases the frequency of play in different species also varies. As better welfare could help improve the production of farm animals, play behaviour has been studied in several production species, such as cattle (*Bos taurus*) (Jensen *et al.*, 1998; Jensen & Kyhn, 2000), pigs (*Sus scrofa domesticus)* (Dobao *et al.*, 1985; Newberry *et al.*, 1988; Blackshaw *et al.*, 1997) , mink (*Mustela vison*) (Vinke *et al.*, 2005), and sheep (*Ovis aries*) (Hass & Jenni, 1993; Chapagain *et al.*, 2014; Vázquez *et al.*, 2014). However, little research has been done on play behaviour in goats.

2.2 Environmental enrichment

The environments wild terrestrial mammals occupy can vary from day to day (Wells, 2009) as well as season to season. Variables such as the weather and the actions of other animals result in a degree of unpredictability that stimulates varied behavioural responses. This variation is affected by natural selection forming adaptations at the population level that are shaped to environmental fluctuations and unpredictability. Examples of such adaptations are motivational systems that stimulate different behavioural forms and the capacity of learning, causing modifications to the behaviours. For animals in captivity, the variables that stimulate behavioural diversity may be limited (Newberry, 1995; Wells, 2009), as the enclosed environments are usually more static and less stimulating than those found in nature. Nevertheless, production procedures, such as dispersal of a breeding population to different captive environments and several transportations of animals throughout their lives, may result in selection pressures that maintain adaptations to environmental change in captive animals. Consequently, when animals are kept long-term in the same unvarying environment, limited exposure to environmental changes reduces the behavioural diversity and limits the opportunities to learn coping mechanisms for when changes do occur, which again may affect their welfare. Additionally, in a static or barren environment lacking opportunities to perform motivated behaviours, negative emotional states may increase (Oesterwind *et al.*, 2016) and abnormal behaviours are more likely to develop (Latham & Mason, 2010). By increasing

the environmental complexity such negative developments could be counteracted (Lawrence & Terlouw, 1993).

Adding biologically relevant features is one way of increasing environmental complexity (Abou-Ismail *et al.*, 2010; Abou-Ismail, 2011; Abou-Ismail & Mendl, 2016). To be biologically relevant, these features should be tailored to the specific species (Newberry, 1995 p. 234-235) and accommodate individual preferences (Wells, 2009). When modifications are made to an animal's environment with the aim of improving certain aspects of its life, one often uses the term "environmental enrichments" (Wells, 2009). These modifications are executed to fulfil several goals, some of which are: to improve mental and physical welfare conditions, as preventative measures against the development of abnormal behaviours, to improve (stress) coping mechanisms, and to encourage species-typical behavioural patterns (Newberry, 1995 p. 230-233; Young, 2003; Wells, 2009 p. 2). Environmental enrichment can be defined as methods of improving the biological functioning of captive animals by modifying their environment (Newberry, 1995).

Investigating the effects of environmental enrichment materials has been a popular research field for several decades (Wells, 2009). Even though the results and their interpretations might be variable (Newberry, 1995), the methods of environmental enrichment that have been investigated are generally reported to have positive effects on the biological functioning of their targets (Young, 2003; Abou-Ismail & Mendl, 2016). Environmental enrichment has been studied in most captive animals, including: laboratory animals (e.g. Abou-Ismail *et al.*, 2010), pets (e.g. Wells, 2004), farm animals (e.g. Vinke *et al.*, 2005; Gifford *et al.*, 2007; Oesterwind *et al.*, 2016), and zoo animals (e.g. Mallapur *et al.*, 2002; Markowitz *et al.*, 2005). While most of these studies do not specifically focus on the effects of play behaviour, a lot of them measure activity levels (e.g. Markowitz *et al.*, 2005; Trickett *et al.*, 2009; Oesterwind *et al.*, 2016) which can include play (e.g. Jensen & Kyhn, 2000; Vinke *et al.*, 2005; Bøe *et al.*, 2012).

The aspect of novelty has a large and important effect on animals' level of interest in enriched materials (Sambrook & Buchanan-Smith, 1997; Wells, 2004). A positive relationship between the effect of an enrichment and its novelty level has been noted several times (e.g. Wells, 2004; Gifford *et al.*, 2007; Trickett *et al.*, 2009). Nevertheless, it is interesting to note that some studies have found that some forms of enrichment have continued positive effects on indicators of better welfare (e.g. more sleep and weight gain) reducing the levels of indicators of poor welfare (e.g. aggression and being non-active while awake) regardless of the novelty level (Abou-Ismail *et al.*, 2010; Abou-Ismail, 2011; Abou-Ismail & Mendl, 2016). Consequently, a permanent addition of certain biologically relevant features can cause the environment to become more stimulating event though the novelty effect wears off. Permanent enrichment items increase the predictability

of the environment (Sambrook & Buchanan-Smith, 1997), which may reduce the levels of poor welfare indicators (Young, 2003) if the environment is otherwise too unpredictable or if the items structure the environment in ways that promote animal welfare.

A few studies have investigated possible sources of environmental enrichment for goats (e.g. Bøe *et al.*, 2012; Oesterwind *et al.*, 2016). Oesterwind *et al.* (2016) examined the effects of structural and cognitive environmental enrichment on learning, behavioural-, and physiological responses on 34 female dwarf goats. The goats were weaned when they were 5 weeks old and were then randomly divided into four groups of 8 or 9 individuals. Two groups were housed in barren conditions and the remaining two groups were housed in structural enriched conditions (straw litter, a climbing rack, a round feeder with concentrate, and a hayrack). The groups housed in enriched conditions also had to answer correctly on a visual discrimination task to obtain water (cognitive enrichment), while the groups housed in barren conditions were given access to a regular water bowl. After a 6-week training period, the animals were moved to experimental pens with similar housing conditions (for each group) as under the training period. The differences in the animals' behavioural reactions to external challenges in a combined open-field/novel-object test were recorded before the first and after each learning task. The learning performance of the groups housed in enriched conditions was seen to be positively affected by the presence of the enrichments. Alone, the structural enrichment caused an increase of motor activity, and the presence of cognitive enrichment resulted in an increase of curiosity and prolonged contact towards novel objects in the external test situation. Oesterwind *et al.* (2016) concluded that the particular combination of structural and cognitive environmental enrichments used in this experiment could improve the behavioural capability of dwarf goats in challenging situations and could result in beneficial welfare effects.

A previous study by Langbein *et al.* (2009) examined a similar cognitive enrichment as the one used by Oesterwind *et al.* (2016). Langbein *et al.* (2009), however, investigated whether 12 trained female Nigerian dwarf goats continued to utilize the cognitive enrichment to get the reward (water) even though the same reward was available without the need to manipulate the enrichment. The results indicated that dwarf goats search for cognitive challenges even though the reward can be fully accessed without the need to successfully complete the challenge. This is, however, connected to individual learning success, as positive feedback was likely received from successful actions when utilizing the cognitive enrichment (Langbein *et al.*, 2009).

Bøe *et al.* (2012) examined the effects of access to an outside enclosure and additional enrichment with branches on the behaviour of Norwegian dairy goats. The goats were given access to an outdoor enclosure for 8 h a day for 22 days in

April, and branches was added as enrichment for 19 days in the middle of that time period. The goats' behaviour were observed two days before and two days after they were given access to the outdoor enclosure, two days before branches were given, the last two days when branches were accessible, and on two days when the branches were no longer present. The results showed that the branches attracted considerable attention, especially in the beginning, although the level of interest in the same branches was significantly lower when the goats were observed 19 days later (Bøe *et al.*, 2012). However, preliminary observations (R.V. Holt, 2017) suggest that interest in sticks and small branches can be maintained if they are not available continuously.

Additionally, domestic goats seem interested in hanging objects (S.E. Moen, staff engineer, Senter for husdyr forskning, personal communication, 2017). Since goats are browsers (Aldezabal & Garin, 2000), hanging objects such as a ball that can be manipulated and chewed may act as enriching features. Furthermore, access to elevated areas and the opportunity to climb is often thought of as enriching as wild goats (*Capra aegagrus*) are seen to prefer sloped terrain, which may offer greater safety under predation pressure (Shams *et al.*, 2010) Siberian ibex (*Capra sibirica*) kids also preferred to play on sloped terrain rather than on flat surfaces (Byers, 1977). Therefore, providing an elevated platform with space for several goats to climb on could serve as a form of enrichment for goats. Andersen and Bøe (2007) reported that adult goats use platforms for resting and that their presence also reduces the level of agonistic interactions within indoor pens. For young goats it is possible that a platform that goats could jump on and off would be integrated into locomotor- and social play.

2.3 **Group size effect**

Living in groups comes with costs and benefits (Estevez *et al.*, 2007 p. 186-188; Davies *et al.*, 2012 p. 116-178). Communal defence, diluted predation risk and group vigilance are three of the advantages of group living (Davies *et al.*, 2012 p. 147-178), while increased competition and loss of food to scroungers are two of the disadvantages (Davies *et al.*, 2012 p. 116-146). The ratio of costs to benefits can affect wild animal decisions about joining and leaving a group (Estevez *et al.*, 2007). The cost-benefit ratio varies depending on the habitat and its resources (Liberg *et al.*, 2000; Davies *et al.*, 2012 p. 116-146) and, as a result, groups vary greatly in size.

An individual's behaviour is strongly affected by the size of the group in which it lives. An example of this is agonistic behaviour, which is often seen to change in relation to group size in captive animals (Kondo *et al.*, 1989; Van *et al.*, 2007). Kondo *et al.* (1989) aimed to investigate how the performance of agonistic behaviours and mean distance to the closest neighbour were related to group size and spatial allowance in calves and cattle. In the calves, there was a significant,

negative correlation between spatial allowance and the number of agonistic behaviours. However, no such correlation was seen between agonistic behaviours and group size. Yet, a linear relationship between group size and agonistic behaviours was observed in the adult subjects: the larger the group size the more occurrences of agonistic encounters per individual. In both the calves and the cattle, the mean distance to the closest neighbour increased as the groups got smaller and the spatial allowance increased (Kondo *et al.*, 1989). Similar studies were completed by Bryant and Ewbank (1972) on pigs and Al-Rawi and Craig (1975) on White Leghorn pullets (*Gallus gallus domesticus*). Both studies examined how group size and spatial allowance (or stocking rate) affected the level of agonistic interactions. Both of these studies found that individuals performed more agonistic behaviours when in larger groups, especially in feeding situations. It is important to note that group size was found to have an effect independent from that of spatial allowance (Al-Rawi & Craig, 1975; Kondo *et al.*, 1989).

Nevertheless, several studies have reported the opposite results - levels of aggression reduce with an increase of group size. Hughes *et al.* (1997) reported that the frequencies of agonistic interactions per individual were overall greater in smaller groups than in larger groups when they investigated the social relationships in 11 flocks of domestic hens through a series of four different experiments. They proposed there is in general no individual recognitions in large flocks and, as a result, the lack of social structure reduced the frequencies of agonistic interactions (Hughes *et al.*, 1997). Similar results were reported by Nicol *et al.* (1999) that examined the effects of flock size on feather pecking and aggression in 6 flocks of laying hens housed in percheries. The hens were 14-30 weeks old and the flock sizes investigated contained 72, 168, 264 and 368 individuals within similar sized percheries. Mild feather pecking was reported to increase with age and occurred at higher frequencies in greater flock sizes and stocking densities. Aggressive pecking, however, occurred more frequently in smaller flocks with low stocking density. They suggest that birds in small flocks were able to form social hierarchies, while larger flocks displayed greater social tolerance and adopted both non-social and non-aggressive behavioural strategies (Nicol *et al.*, 1999). Turner *et al.* (2001) examined the effect of group size on agonistic behaviour in 8 replicates of two group sizes of domestic pigs, 20 individuals and 80 individuals per group. The results indicated that domestic pigs housed in the larger groups (80 individuals) were less aggressive per pig and initiated fewer fights when introduced to unacquainted individuals in a barren test arena compared to those housed in smaller groups (20 individuals). Hence, even though the pigs could discriminate between familiar and foreign individuals in the test arena, the pigs from larger group sizes were usually less aggressive towards unknown individuals (Turner *et al.*, 2001). These results support the tolerance hypothesis of Estevez *et al.* (1997) as an explanation for the reduced frequency of aggression per individual in broiler chickens kept in large groups. The hypothesis

suggests that, as the number of animals increases in conditions where food is plentiful but difficult to defend, it is more efficient to scramble for food than to compete aggressively (Estevez *et al.*, 1997; Estevez *et al.*, 2007).

One of the most frequently observed correlations in ethology is a decrease of vigilance when group size increases (Roberts, 1995). There are two main hypotheses for the phenomenon. According to the many eyes-hypothesis, if many members are likely to be vigilant at any time, there is personally less need to be vigilant and thus a reduction occurs, while the individual risk hypothesis states that a reduced predation risks in larger groups results in a reduced need for vigilance (Roberts, 1996). Although many variables may confound the relationship between vigilance and group size (e.g. predator presence, habitat visibility) (Elgar, 1989; Beauchamp, 2013), variation in group size is often seen to correlate with the behavioural expression of vigilance (i.e. standing with head up in an alert posture). Roberts (1995) found evidence supporting real-time changes in behaviour as a result of variation of group size by observing the effect of departures or arrivals of single individuals in a flock of crested terns (*Thalasseus bergii*). Individuals increased their vigilance when the group size decreased (departures) and decreased their frequency of vigilant behaviour when the group size increased (arrivals). The duration of vigilance behaviour was not significantly affected by the changes in group sizes (Roberts, 1995).

In the wild, goats tend to live in small herds with group size influenced by resource availability and distribution, in addition to predation pressures (Andersen *et al.*, 2011). Thus, animals of the *Caprini* tribe have been reported to group together in groups of 2-6 individuals (Smith & Raedeke, 1982; Pedevillano & Gerald Wright, 1987; O'Brien, 1988). Under captive conditions, however, goats may be kept in much larger herds. Van *et al.* (2007) studied the effect of group size on feed intake, agonistic behaviours and growth rate in goat kids and lambs in group sizes ranging from 1 to 5 individuals. They found that group size had a significant effect on all of the behavioural variables that were tested, with increased group size being associated with a linear increase in the number of agonistic interactions per group and per individual. When the group size increased, so did the feed intake, whereas the level of aggression also increased causing the growth rate to resemble to that in smaller groups (Van *et al.*, 2007). Sabek *et al.* (2017) studied how behaviour, haematological parameters, and body weight in domestic Shiba goats were affected by group sizes of 4 and 8 individuals. Their results showed that aggression per group was positively correlated with an increase of group size. Similar results regarding aggression were found in Mohammed and Mohamed (2013)'s study on the effect of group size on male goat behaviour. In contrast to these results, when expressing aggression on a per animal basis, Andersen *et al.* (2011) reported that the frequencies of most social behaviours per goat, including play and antagonistic behaviours, declined when the group size increased from 6 to 12 individuals, and

continued to decrease when the group size increased further to 24 individuals. However, this study did not distinguish between different social interactions in their results (Andersen *et al.*, 2011).

There is little evidence regarding the effects of group size on play behaviour, specifically. Færevik *et al.* (2007) reported there was no significant difference in the frequency of social- and locomotor play per individual weaned dairy calf in groups containing 4, 8 or 16 individuals. Nevertheless, larger group sizes could create more opportunities for individuals to play together because there are more potential play mates, and so the probability of more than one individual feeling playful at the same time might be higher. Additionally, there is a greater chance of behavioural contagion occurring in larger group sizes due to the animal's greater proximity (increased density) if the enclosure areal remains the same (McDougall & Ruckstuhl, 2018). Furthermore, a reduced level of vigilance in larger groups (Roberts, 1996) implies that individuals are more relaxed, which can be predicted to increase the likelihood of play (Spinka *et al.*, 2001).

2.4 **Confinement length**

When an individual's environment is altered by the sudden removal of a resource, a deprivation may occur. When the resource is reintroduced, the temporary deprivation could cause a short-term, exaggerated response in the opposite direction that possibly serves to restore balance. This is an example of the phenomenon called the rebound effect and has been observed in several scientific fields including medicine (e.g. Campbell, 1976), economy (e.g Berkhout *et al.*, 2000; Sorrell & Dimitropoulos, 2008) and biology (e.g. Nicol, 1987; Barnes, 2013 p. 122). It is often observed in animals whose routines have been temporarily disturbed (e.g. Hole, 1991; Jensen, 1999).

During a period of resource deprivation when a particular behaviour is constrained, the psychohydraulic model proposes a build-up of motivation to perform that behaviours (Lorenz, 1950 p. 251), with release from the constraint leading to a rebound in performance of the behaviour. If the resource is not renewed, the individual might be frustrated, showing restlessness or find release by performing displacement behaviours. Additionally, less stimulation may be required to reach the threshold at which a response occurs (Lorenz, 1950 p. 247). A motivational build up would suggest that the variable is influenced by internal factors (Lorenz, 1950 p. 251) and the longer the deprivation, the more easily the behaviours can be stimulated when conditions allow. However, there is little support for the psychohydraulic model in practice. Motivation helps explain the decisions animals make, but it is affected by physiological signals and sensory inputs helps (Mason & Bateson, 2009). As a consequence, motivation is actually an intervening variable that connects different inputs and behavioural outputs, but it is not the reason behind any decisions made (Mason & Bateson, 2009). Mason

and Bateson (2009) compared motivation to the weighing of costs and benefits, as both are used as models to predict aspects of behavioural decision makings. Therefore, a more modern interpretation is that the size of the rebound effect is determined by the perceived level of the contrast between the deprived environmental condition and the improved condition. Either way, the size of the rebound effect could be an important factor to help evaluate behavioural needs of an individual.

A rebound effect is commonly reported when locomotor play becomes possible after a period when spatial constrains make it difficult. For example, when comparing different methods of spatially confining calves, Dellmeier *et al.* (1985) observed a correlation between an increase in level of confinement and the amount of locomotor play performed in open field tests following a period of confinement. Jensen (1999) also studied how confined calves responded to different levels of spatial confinements and how this affected their locomotor behaviour when released from this confinement. The calves' spatial preferences were also tested. Since a previous study illustrated that calves will perform locomotor play if sufficient space is available (Jensen *et al.*, 1998), this study focused on the calves' motivation to perform the locomotor behaviour. It was found that the amount of locomotor play increased in step with the degree of previous confinement. Thus, evidence exist that the strength of motivation to perform locomotor play is related to the magnitude of the perceived improvement in condition when released from confinement.

Holloway and Suter (2004) conducted experiments on young rats to study the effects of social play deprivation without social isolation. To allow for social contact but to prevent physical play, the subjects were housed in pens separated by wire mesh. The separation prevented physical play, yet visual, auditory, olfactory and tactile interactions were possible. The possible rebound effect seen after a deprivation period could be a result of limited opportunity for physical activity during the deprivation period. Thus a second experiment incorporated the ability to engage in physical activity outside of social play by adding running wheels to the pens. A third experiment controlled for the effect of pen size. The social play deprivation was seen to lead to a rebound effect in all three experiments, with social play responses greatly increased. These findings suggest that social play is important enough to the animals to show a rebound effect after a period of deprivation.

A study by Chepko (1971) examined the effect of play deprivation in goats. By observing five pairs of infant Toggenberg goats (11-24 days old) with their corresponding mother, an increased frequency of play behaviour was reported following a period of play deprivation (Chepko, 1971). Three of the pairs were used as control groups. They experienced no deprivation, one of these pairs was 11-12 days old and the other two pairs were 18 days old. The two pairs remaining

were used as experimental groups, with one pair being 18 days old and the other pair being 24 days old. The first experimental group (18 days old) were kept from playing by shouting or being physically removed from play situation without being confined. The second experimental group (age: 24 days) were confined to a small shelter before being released. The exposure to the treatment lasted 24 hour before they were released, their behaviour was observed the following 24 h and the durations of each behaviour were summed together over one-hour periods. Play deprivation resulted in an increase of play frequency, the total amount of time spent playing and the number of play bouts per pair of kids (Chepko, 1971). However, as noted in the study, there were few replications, the age of the subjects was confounded with treatments and the sample size was too small to analyse statistically. Even so, based on these results and the findings in other species, it seems likely that young goats would show more play when introduced to a spacious, enriched outdoor environment the longer they are previously confined indoors.

3. **Hypotheses and predictions**

3.1 **Focus of study**

In the current study, I investigated play and other behaviours in sub-groups of young female Norwegian dairy goats in an outdoor pen for 30-minute observation sessions. Following a pilot study, three experiments were conducted to evaluate the effects of environmental enrichments (consisting of a bridge, a hanging ball and branches), group size (ranging from 2 to 8 individuals), and length of confinement (ranging from 2 to 5 days), respectively, on play and other behaviours. Data were collected using instantaneous scan samples to examine treatment effects on the proportion of time spent in various behavioural states. Focal animal observations with 1-0 sampling were utilized to examine the effects of the treatments on different types of play and other behavioural events.

3.2 **Environmental enrichment**

H1   The presence of environmental enrichments can stimulate a general increase in activity levels (Markowitz *et al.*, 2005; Trickett *et al.*, 2009), as a result of increased environmental complexity (Abou-Ismail *et al.*, 2010). Thus when the environmental enrichments are present, the goats are expected to be more active overall compared to when enrichments are absent.

Instantaneous scans   P1   Goats spend more time performing play and other active behaviours (explore/walking, aggressive interactions, foraging) under enriched conditions compared to control conditions.

	P2	Goats spend less time standing, ruminating, lying and being vigilant under enriched conditions compared to control conditions.
1-0 focal sampling	P3	Higher frequencies of social-, locomotor-, and object play are performed by goats, in addition to other active behaviours (exploration, agonistic interactions, climbing and tail wagging), under enriched conditions compared to control conditions.

H2   The effects of environmental enrichments are often most obvious when they are new (Sambrook & Buchanan-Smith, 1997; Wells, 2004). After the novelty effect wears off, habituation occurs and the enrichments are often seen to be perceived as less interesting (Gifford *et al.*, 2007; Bøe *et al.*, 2012). Consequently, behavioural differences between the two treatments (enriched and control) are hypothesized to decrease over successive exposures to the enrichments as the novelty wears off.

1-0 focal sampling	P1	Greater frequencies of active behaviours (social-, locomotor-, and object play, exploration, agonistic interactions, climbing, and tail wagging) are predicted to occur during early exposures to the enriched environment rather than in later exposures, with behaviours becoming more similar to those in the controlled environment over repeated times.

3.3 **Group size experiment**

H1   The larger the group - the higher the probability of multiple individuals being vigilant at any time, which enables the individual members to spend less time being vigilant (Roberts, 1995 p. 1371). This extra time enables the members to perform other behaviours. Thus, I hypothesize that young goats are less anxious in larger groups, enabling them to divert energy from short-term survival activities to activities stimulating long-term survival and growth.

Instantaneous Scans	P1	The time spent vigilant is expected to decrease as the group size increases.
	P2	Goats will spend more time exploring/walking, foraging, lying and ruminating as the group size increases.

H2   Larger group sizes (and higher animal densities) lead to more possible combinations of social interactions and greater opportunities for interactions and behavioural contagion to occur, while instilling a greater sense of security against external threats. However, the close proximity of more individuals may render local defence of resources less efficient, as a consequence goats are hypothesized to be more tolerant and less aggressive in larger groups.

| 1-0 focal sampling | P1 | The frequencies of social play, locomotor play, object play, and tail wagging will increase with the increase of group size. |
| | P2 | Agonistic interactions (aggression and avoidance) will decrease in frequency per goat with increasing group size. |

3.4 Confinement length experiment

H1   Increasing the length of confinement to a relatively unstimulating indoor environment is hypothesized to result in the perception of greater positive contrast in environmental conditions when given access to an enriched outdoor enclosure. This will result in an increased performance of active behaviours to reflect the positive perception.

Instantaneous Scans	P1	Increased length of indoor confinement will result in an increase in play, exploration/walking, and foraging when released into an enriched outdoor environment. A corresponding decrease of agonistic interactions, vigilance and other passive behaviours (standing, lying, ruminating) is predicted to occur.
1-0 focal sampling	P1	The performance of social-, locomotor-, and object play, exploration, climbing, and tail wagging when released in an enriched outdoor environment will increase in frequency depending on the duration of confinement indoors.
	P3	The decrease in frequencies of agonistic interactions (aggression and avoidance) when released in an enriched environment is related to length of preceding indoor confinement.

3.5 Age and weight gain

H1   Younger individuals have more to learn about their environments than older individuals

| 1-0 focal sampling | P1 | Later-born (younger) goats perform higher frequencies of social-, locomotor-, and object play, exploration, climbing, and tail wagging than earlier-born goats in the same cohort. |

H2 Higher playful and exploratory activity leads to a build-up of muscle mass and stimulates increased intake of feed, resulting in greater weight gain.

1-0 focal sampling	P1	The frequency of highly active behaviours such as social-, locomotor-, and object play, exploration, and climbing are connected to greater weight gain.

4. Materials and methods

4.1 Study system

4.1.1 Experimental animals and management

The research was carried out using 20 does of Norwegian dairy goats from Ås gård at the Senter for Husdyrforskning (SHF), a part of the NMBU (Norwegian University of Life Sciences) in Ås municipality. As young goats play more than older individuals (Hinde, 1966 p. 239; Fagen, 1981 p. 359), 20 subjects were chosen at random from among the approximately 30 young females at SHF at the beginning of the pilot study (September 2017). The facility were planning to remove eight of the younger individuals from the herd, but had yet not decided which individuals to remove or precisely when this would occur. As a result, two additional young, female goats were also habituated to the test area and treated the same as the 20 subjects, but not observed during the first experiment. Subsequently, two of the original 20 subjects were removed and so they were replaced by these two "extras".

The goats were born in February-April 2017, and were kept with their mothers until they were 7 weeks old. During this period, the juveniles drank milk from either their mother or, if feed intake was thought to be low, were fed milk from a bottle. They also had free access to silage and hay from when they were a few days old. All juveniles were weighed after birth. When they were 1 week old males were castrated and females with horns had them removed.

When 7 weeks old, all kids were weighted and weaned. They were removed from their mother and kept together in a separate pen with other juveniles of similar age. The pen was in close proximity to the mothers (who were grouped together in a separate pen), but no physical interaction could occur. Initially, after being separated from mother, a third of the pen contained a roof and straw bedding. As the kids got older, the roof and bedding were removed and after weaning, they were kept on a slatted floor with no bedding. Both during and after weaning, roughage were continuously accessible and concentrate was given around 08:00 and 15:00 each day.

In June-September, all goats were located on different pastures, mostly in large fields. Juvenile males were kept separate from the females. The goats returned to Ås gård the 13th of September.

Preparations for the study began the 15th of September 2017, and data collection lasted nine weeks in October-December the same year. At the beginning of the observation period the does were between the ages of 6-8 months. During the data collection, all young females were housed together in an indoor pen with slatted floors in close proximity to older female and male goats (who were grouped together by sex in separate pens in the same room). According to A. Klouman (Staff engineer, SHF, personal communication, 2016), the facility follows the proposal for ecological housing of sheep of Norsk Landbruksrådgiving, which proposes a minimum spatial density of 1.5 m^2 per individual (Berge, 2010; Jørgensen *et al.*, 2016). The size of the goats' home pen was adjustable and varied throughout the study as some individuals (both old and young) were moved around inside of the facility and between facilities. Consequently, the spatial density during the observations period was at a minimum 1.5 m^2 per individual. The younger individuals had access to two footballs on the floor of their pen, but these were rarely utilized. Hey and silage were continuously available. Concentrate was given at approximately 08:00 and 15:00. As a result all data collection occurred between these times. The females were mated in September-December 2017.

4.1.2 **Experimental area**
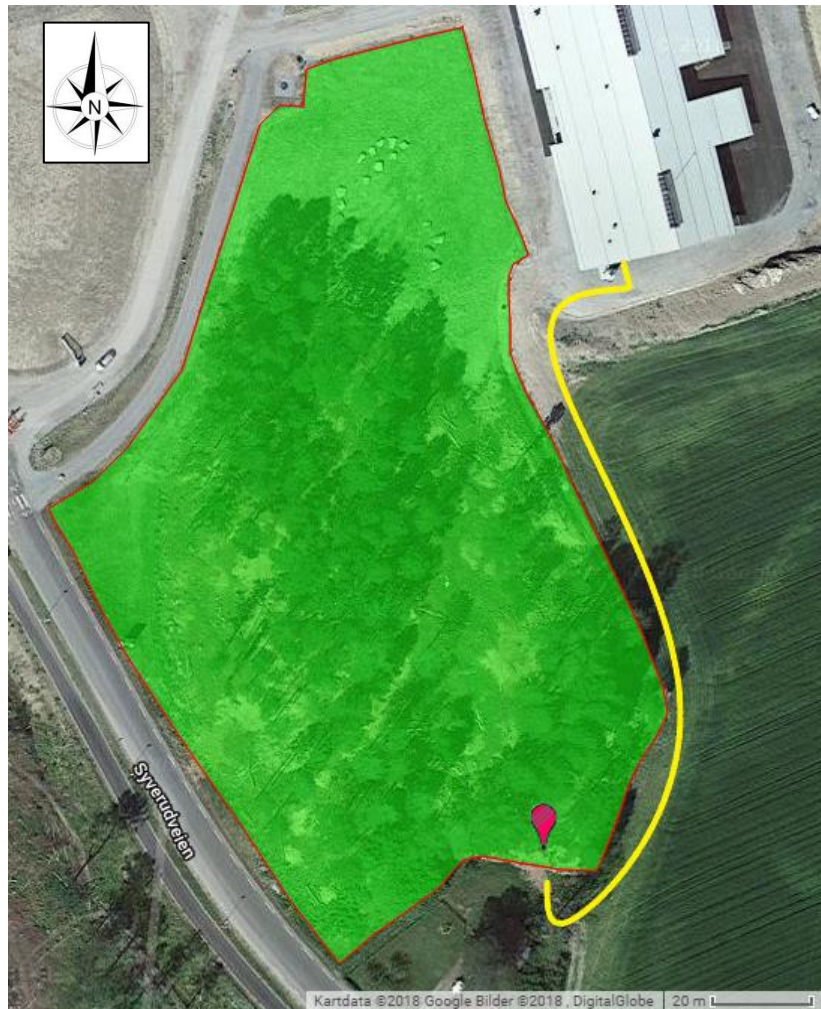
Figure 1. The goat yard. The bright green area is the permanent outside goat yard at Ås gård in Ås municipality, Norway. The area is 1.3 hectare (0.013 km²). The pink mark indicates the location of the 40 m^2 enclosure where data collection occurred. The building in the upper right corner is "småfefjøset", the goat house containing the home pen of the goats used in the study. The path from the home pen to the gate of the enclosure (yellow line) was approximately 170 m long. This figure was created in April 2018 using the free, online tool "Google Maps Area Calculator Tool" by Daft Logic (URL: https://www.daftlogic.com/projects-google-maps-area-calculator-tool.htm). Compass by Cadblocksfree (2015) added.

The outdoor enclosure where observations were conducted was located inside a permanent goat yard on the opposite side of a small road from the goat house (approximately 20 m to the gate). The goat yard was approximately 1.3 hectare (0.013 km²), which made observing the entire group at once difficult. As a result, a smaller 40 m^2 enclosure was created using electrical fencing, and all of the data collection occurred inside this enclosure.

The enclosure was located at the southeast end of the goat yard in an area that was relatively undisturbed by traffic and passers-by (Figure 1). It was situated on gently sloping land near the top of a hill, with a view towards the goat yard and goat house. The subjects had to be walked about 170 m from their home pen to the enclosure gate for each observation session. Between the gate and the enclosure was a corridor (holding area) in which they waited until everything was set up for the observation session to begin (Figure 2). Half of the corridor consisted of mud, which was covered up with gravel at the start of the study. Naturally growing vegetation, such as grass, stinging nettle (*Urtica dioica*) and leaves of hazel (*Corylus*) and birch (*Betula*), was available during the first two months of the observation period (October and early November) in the enclosure, the corridor and on the walk up to the enclosure. No additional food or water was accessible inside the corridor or the enclosure. Natural objects of interest, like sticks and rocks, were also available inside the enclosure. Deciduous trees, mostly birch, had branches hanging over the enclosure.
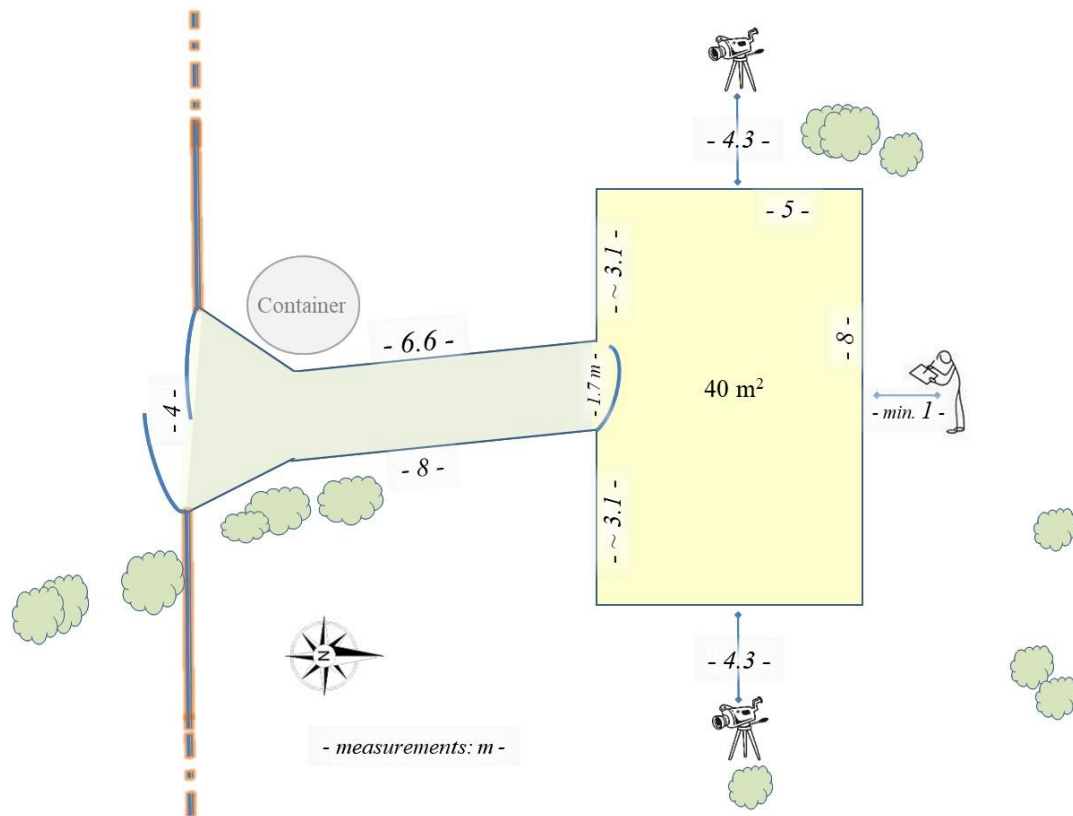
Figure 2. Illustration of setup of the outdoor enclosure (yellow rectangle) where observations were conducted. The connected green area is the corridor (holding pen). The blue line by the corridor illustrates the goat yard fence. The blue, bent lines illustrate entrance gates. The approximate locations of trees and shrubs are illustrated by the green bush-like shapes. The locations of two video cameras and the observer are also shown. The cameras were placed inside spectator tents, and a spectator tent was also present for use by the observer during inclement weather. This figure was created using Microsoft Excel (Microsoft Office Home and Student 2010, version 14.0.7195.5000, Microsoft Corporation, Redmond, WA, USA). Compass illustration in the figure originates from Cadblocksfree (2015), the camera illustration from ClipartXtras (Wallace, 2017), and the stick figure from Dreamstime.com (Binik1, 2018).

4.2 Data collection procedures

4.2.1 Pilot study

Four weeks (Figure 3) were used to set up the required materials and fences, and to train the 20 subjects and 2 "extras" to follow the observer back and forth from their home pen to the outdoor enclosure. The goats were given collars of various colour combinations, which made them easier to identify. They were habituated to the enclosure by gradually increasing their visits there to 4 times a week. They were also habituated to being observed by the observer at least 1 m away from the enclosure. The ethogram was tested and refined during this period.

September	18 – 24	25 – 1			
October	2 – 8	9 – 15	16 – 22	23 – 29	
November	30 – 5	6 – 12	13 – 19	20 – 26	27 – 3
December	4 – 10	11 – 17			

■ Pilot study   ■ Environmental enrichment experiment

■ Group size experiment   ■ Confinement length experiment

Figure 3. Data collection timetable, illustrating the dates of four experimental periods: pilot study (blue), environmental enrichment experiment (red), group size experiment (green), and confinement length experiment (purple). Each box represents a week, and the dates for that week are included inside the box. Data collection began on the 16th of October and ended the 17th of December 2017.

4.2.2 Ethogram

By modifying ethograms from two studies on goats by Andersen and Bøe (2007) and Andersen *et al.* (2008), a preliminary ethogram was created. This ethogram was extended and later finalised during the pilot study (Table 1).

In the current study, social play was thought to contain many elements that were similar to agonistic behaviours, but the interactions were directed towards familiar group members, occurred in non-competitive contexts (i.e. not feeding, or resting), were not as long-lasting and the goats usually had a more relaxed posture. If the participants got excited, the bristles could rise, but there were no serious (i.e. bleeding) injuries. Additionally, self-handicapping behaviours, which normally would cause a disadvantage (e.g. tumbling), and role reversals occurred. The tail could also wag laterally, either before, during or after the play behaviour, though tail wagging was not a sign of play on its own.

Locomotor play was defined as movements that carry the individual around its environment that may seem sudden and spontaneous. It included rotational movements of various body parts, head shakes, bouncy running, bucking, kicking, and jumping. Rapid changes in direction (veers) were a component of this sort of play. The movements seemed spontaneous and rapid, so all gaits except walking were included. Locomotor play behaviours were recorded as either running or jumping (Table 1).

Object play was defined as manipulative behaviour that was aimed at familiar objects and materials that often seemed purposeless. Foraging and initial investigation of novel objects were excluded from this play category.

The entire ethogram was utilized for instantaneous scans whereas the behaviours walk, stand, lie, vigilance, forage, ruminate and other were grouped together to form the behaviour category "other" during focal observations (see below for details).

Table 1. Ethogram of various play and non-play behaviours of goats. Extended and modified from Andersen and Bøe (2007) and Andersen *et al.* (2008), and refined during pilot observations.

Social play	
Butt	Two goats push into one another with their heads and making contact somewhere on the other's body. This includes: head, sides, front and back. Lowering the head in attempt to butt within close proximity (around 10 cm) of another individual is also included. The goats do NOT rear. Excludes: Mouth and nose.
Frontal collision	Rearing, twisting the torso, landing hard on the forelegs and delivering a (forceful) blow forward and slightly downward against another goat's head or shoulders. The behaviour sequence is sometimes completed without the goats physically touching. The recipient bows her head to receive the blow.
Object play	
Oral manipulation	Head in close proximity (<5 cm) to objects, but requires tearing or chewing motions on an object, or attempts to move any object using the mouth. The object is not (fully) consumed. Includes movements directed towards: collars, earmarks, branches and enrichments.
Move object	Forehead, snout or one foot touching any objects in an attempt to move it with either a slight or strong movement. ONLY one foot, the snout OR the forehead used, NEVER anything else. Will use on the object: a butting movement with the forehead, a scraping/kicking movement with the leg, or a pushing movement with the snout. Objects could be sticks, piles of dirt, and enrichments.

Locomotor play	
Run	Fast movements of legs which carry the animal from one place to another in any one direction. Any pace above walking and at least two steps with both pairs of legs must be completed. Could be performed alone or in company of playmates. Body contact could be frequent between participants but is not a requirement. No agonistic behaviours (such as biting) occur during the performance. Relaxed posture, but bristles may rise if participants get very excited. All participants are active, no-one gets hurt, and the movement does not seem stressed, tense or stiff. Includes <u>veering/sharp turns</u>: Sudden change in the direction of movement, seems spontaneous. Excludes: running while frightened (startled, ears pointing forward, stiff and alert posture, sudden and quick movement away from stimulus, vocalisations may occur, seek security among group members, becomes vigilant afterwards, often behaviourally contagious).
Jump	Movement upward and all legs leave the ground or an object simultaneously at some point. The legs are used to push the animal up or away from the object. Can also carry the animal from one place to another, thus jumping off or on anything is included in this behaviour. Includes (but not limited to) jumping on/off other goats, the ground and enrichments.
Agonistic behaviour and responses	
Aggression	Frontal collision, butting, chasing and biting. Body posture tense, ears normally pointed backwards and bristles usually raised. Sometimes long-lasting (> 4 s), with few signs of breaks. Includes <u>threatening</u>: angling of the head towards the recipient, ears points backwards and forehead conspicuously presented. Often repeated towards the same individual(s) but could also be directed towards other target.
Avoid	Withdrawal from a social interaction. Includes being physically moved by another individual, replacement without physical contact, and moving away from other individual in a hurry with a stiff or tense body posture both with and without physical contact. Excludes: withdrawal from electric fence or environmental stimuli.
Non-play behaviours	
Explore	Objects or individuals are investigated and assessed. The mouth and nose are used for this assessment. The object is sniffed in close proximity (<5 cm).
Walk	Slow movements of legs which carry the animal from one place to another in any one direction. At least two steps with both pairs of legs must be completed.

Stand	The body is lifted off the ground, and all the legs are extended. The animal does not change her geographical position/she stays in the same place.
Lie	Lying down, head either down or up. Ears either relaxed (slightly hanging down) or angled (listening). The most common position is with forelegs underneath the body and the hindlegs out on one side, partly out from the body. Also includes lying on one side of the body with all limbs stretched out (usually short lasting, sometimes unintentionally rolling over onto their back).

Not mutually exclusive behaviours

Forage	Exploration of environment for food objects (ground, branches, and sticks), exploration of food objects (e.g. grass and leaves) and consumption of these objects. Excludes regurgitation (see ruminating).
Ruminate	Food regurgitated and chewed. Jawbones are moving in a circular manner, cheeks are filled and bulgy looking. No new food has been consumed immediately beforehand. Includes short breaks where the food is swallowed and new food materials are regurgitated. Eyes sometimes half-closed and ears relaxed (when not paired with vigilance).
Vigilant	At least one ear directed forward in the same direction as the gaze. Eyes open and alert. Movements are often ceased, but ruminating is sometime an exception. Focus on environmental stimuli (not always perceived by the observer).
Wag tail	Tail moves laterally. Two complete swings (one swing: point A to point B to point A again) must be completed (aka longer lasting) to count. Only one (short) swing often indicates irritation from e.g. insects and this is excluded.
Climb	A minimum of two legs or half the body on other goat, a bucket or a bridge. Includes also: moving all legs off the ground and on to an object AND any movement on the objects.

Other behaviours

Other	Any other behaviour not described above. Includes scratching, grooming and excretion.

4.2.3 General procedures

For each experiment, observations always occurred between 10:00 and 15:00, starting after the goats finished eating their morning meal. Groups of goats (described below) were taken sequentially to the

observation enclosure on each observation day. Each individual visited the enclosure no more than once a day. Each group was collected from their indoor home pen, led to the outdoor enclosure using feed as a lure and enclosed in the corridor for approximately 2-5 minutes while two video cameras (Handycam HDR-CX240E, Sony Corporation, Tokyo, JP) on tripods were set to record and data sheets were filled out with information about the session. The cameras were placed so all of the enclosure was covered, and were protected from rain and strong winds by placing them inside spectator tents.

When ready to begin the observation, the group was moved from the corridor into the enclosure. The observation period, which lasted 30 min, began as soon as the observer was in place. The same observer (R.V.H.) collected all data, while sitting quietly at least 1 meter from the enclosure, either outside or, if the weather was poor due to rain or strong wind, inside a spectator tent. Data were recorded manually on paper, while the video recordings were used to correct any mistakes that occurred and as back-up to enable a second opportunity to observe confusing events. During the observation session, at regular intervals, an instantaneous scan of the whole group was completed and between each instantaneous scan, focal scans utilising the 1-0 recording method were conducted (see below for experiment-specific details). Due to the utilisation of the 1-0 sampling method in the focal observations, none of the behaviours recorded were mutually exclusive whereas most behaviours were mutually exclusive for the instantaneous scans (Table 1). The timing was kept using a time interval beeper (Tabata Timer for HIIT, developed by mozygle@gmail.com; obtained from Google Play Store URL: https://play.google.com/store/apps/details?id=com. simplevision.workout.tabata&hl=no) on a mobile phone with ear buds so as not to disturb the subjects. After the observation session, the goats were collected from the enclosure using feed or fresh vegetation as a lure and led back to their home pen.

4.2.4 Environmental enrichment experiment

This study lasted three weeks, from the 16th of October to the 5th of November. Each of the 20 subjects and two "extras" visited the outdoor enclosure four times a week. As it was difficult to catch specific individuals at this time despite training during the pilot study, the subjects were pseudo-randomly divided into 4 groups of five goats each day, with each subject being observed once per observation day. Two groups per day contained an "extra" that was not observed. Thus, those groups had a total number of six individuals, but only five of them were observed. Because all the goats were kept together indoors, the

members of each observation group were always familiar with one another.

There were two treatments in this experiment, an enriched condition and a control condition. During the enriched condition, three environmental enrichments were added to the outdoor enclosure: a 1 m high wooden bridge, a ball hanging underneath the bridge, and a bucket full of various sized sticks and non-leafy branches (that were not replaced during the observation period) (specific details regarding enrichments are listed in Appendix 1). The placement of these enrichments did not differ significantly and as a result the goats learned quickly where to find them. During the control condition, the outdoor enclosure was in a similar state as during the pilot study with no added enrichment. The treatment and the control conditions were presented alternately across each pair of observation days, for a total of six pairs of days across the three-week experiment.

During the observation sessions, every 3 min an instantaneous scan of the 5 subjects in the group was completed. Between each instantaneous scan, two subjects were observed for 1 min, according to a pre-set random order for each observation session. These focal scans utilised the 1-0 sampling method with 15 s intervals. There were, in total, 11 instantaneous scans per 30-min observation session, and each subject was observed for a total of 4 min (focal observations) per observation session.

4.2.5 Group size experiment

For 4 days a week from the 6th to the 26th of November 2017, each of the remaining original 18 subjects and two new subjects (the former "extras") visited the outdoor enclosure once a day (total of 12 visitations per individual). Due to difficulties acquiring specific individuals, the subjects were pseudo-randomly divided into four different-sized observation groups each day, with each goat being observed once each day. Seven different group sizes were observed each week, comprising from two individuals to eight individuals per group.

During this study, the enclosure always contained the three enrichments used in the previous study (a wooden bridge, a ball hanging underneath the bridge, and a bucket full of various sized sticks and branches). These enrichments increased the environmental complexity of the enclosure, which was seen to induce higher activity levels and more

interactions in previous studies (Abou-Ismail *et al.*, 2010; Abou-Ismail, 2011; Abou-Ismail & Mendl, 2016).

During the observation sessions, instantaneous scans of the whole group were carried out every three minutes and, between those scans, one 15-second 1-0 focal observation was completed per subject, using a pre-determined random sampling order for the session. In total, there were 11 instantaneous scans and 10 focal observations (2.5 min) per individual.

4.2.6   Confinement length experiment

Over three weeks, from the 27th of November to the 17th of December 2017, the 20 subjects (same as in the group size experiment) experienced four different lengths of indoor confinement prior to each observation session. In this experiment, they each visited the outdoor enclosure a total of five times over three weeks, after being confined to the indoors for 2-5 days. The goats were randomly assigned to 6 groups, two of which contained four individuals while the remaining groups contained three individuals. The groups had fixed membership to ensure no individuals visited the enclosure on the wrong day. This was possible because, by this time, the goats were tame and it was relatively easy to select specific goats for each session. The order each group visited the enclosure was balanced to avoid time of day effects. The number of groups visiting the outdoor enclosure per day and their length of confinement were balanced over the three weeks of the experiment.

The enclosure always contained the three enrichments used in the environmental enrichment experiment (a wooden bridge, a ball hanging underneath the bridge, and a bucket full of various sized sticks).

Instantaneous scans of the whole group were carried out every three minutes during the observation session. Between those instantaneous scans, two 15-s focal 1-0 observations were completed per group member using a pre-determined random observation order. Per observation session there were in total 11 instantaneous scans per group and 20 focal observations per individual (5 min per subject).

4.3 Statistical analyses

The statistical software SAS Version 9.4 (SAS Institute Inc., Cary, NC, USA) was utilized for the data analyses. Some variables were grouped into arrays due to the rarity of some individual behaviours in the ethogram (Table 1). There were 3

array variables included in the analyses of the instantaneous scan data: Play, Agonistic interaction and Active. The Play array (Play.Inst.) included the data on the six different types of play behaviours (butt, frontal collision, run, jump, oral manipulation, and move object), while the Agonistic interactions array (Agonistic interactions,Inst.) included the data on aggression and avoid (i.e. sending aggressive signals and responding to them). The Active array (Active.Inst.) is comprised of explore and walk.

In the analyses of the 1-0 focal animal data, 4 array variables were included: Social play (including butt and frontal collision; Social play.1-0.), Object play (including oral manipulation and move object; Object play.1-0.), Locomotor play (including run and jump; Locomotor play.1-0.), and Agonistic interactions (including aggression and avoid, Agonistic interactions.1-0.).
Table 2 lists the names of all of the variables that could be used in the different models (see below) from both the instantaneous scan data and the 1-0 focal animal data. Which variables were used in the different models can be found in Table 3.

Table 2. Name of variables used in statistical analyses of instantaneous scans and 1-0 focal animal sampling and their corresponding ethogram behaviours. N/A = not applicable

Variable names Instantaneous scan data	Ethogram behaviour	Variable names 1-0 focal animal data
Play.Inst.	**Butt**	Social play.1-0.
	Frontal collision	
	Oral manipulation	Object play.1-0.
	Move object	(Oral manipulation.1-0. & Move object.1-0.)
	Run	Locomotor play.1-0.
	Jump	(Run.1-0. & Jump.1-0.)
Agonistic interactions.Inst.	**Aggression**	Agonistic interactions.1-0.
	Avoid	(Aggression.1-0. & Avoid.1-0.)
Active.Inst.	**Explore**	Explore.1-0.
	Walk	N/A
Stand.Inst.	**Stand**	N/A
Lie.Inst.	**Lie**	N/A
Forage.Inst.	**Forage**	N/A
Ruminate.Inst.	**Ruminate**	N/A
Vigilant.Inst.	**Vigilant**	N/A
N/A	**Wag tail**	Wag tail.1-0.
Climb.Inst.	**Climb**	Climb.1-0.

For each experiment, the behavioural variables were standardised as proportions of scans for analysis using generalized linear mixed models (GLMM) with a binomial distribution and logit link. Individual subject was used as the experimental unit and was a random factor in each model to account for repeated measures. For array variables, behaviour type within array was included as a second random factor. Maximum likelihood estimation with Laplace likelihood approximation was used to facilitate model convergence when the data contained many zeros.

For the environmental enrichment experiment (Experiment 1), two GLMMs were used (Table 3). In Model 1 and 2, the main effect of treatment (control vs enriched condition) was examined. However, Model 1 analysed the instantaneous scan data, while Model 2 analysed the focal animal data. In Model 3, the effects of treatment, pair of days, and their interaction, to account for the alternation between enriched and control conditions on successive days were examined in the 1-0 focal animal data. The pair-of-days variable was used to investigate how repeated exposure to the treatments affected the behavioural variables. Model 1, 2 and 3 treated the main effects as categorical fixed effects, allowing pairwise comparisons of least squares means adjusted for multiple comparisons using the Tukey-Kramer test. For the other two experiments: two GLMMs were used to examine the main effect of group size on the instantaneous scan data (Model 4) and the 1-0 focal animal data (Model 5; Experiment 2). Model 6 and 7 examined the main effect of length of confinement (Experiment 3) on the instantaneous scan data and the 1-0 focal animal data, respectively. The effect was treated as a category in all analyses in both experiments.

Two GLMMs were also used to evaluate the continuous effects of days of age at the start of the enrichment experiment, and growth (kg) from the start of the enrichment experiment to the end of the confinement length experiment, respectively (Table 3), on the overall mean proportion of scans engaged in social, locomotor and object play, exploring, and tail wagging in the 1-0 focal samples over all three experiments combined (the whole study period). Data from the two individuals that were removed after the first experiment were excluded from the analysis due to missing data.

The explanatory variables and response variables included in the different models are listed in Table 3. All graphics were created using least squares means and standard errors reported on the inverse linked scale (ILINK). The results were considered statistical significant when $P<0.05$.

Table 3. Variables included in the different models.

Experiment	Data sampling method	Model[1]	Explanatory variables	Response variables
Environmental enrichment	Instantaneous scans	1	Condition (control vs enriched)	Play.Inst. Agonistic interactions.Inst. Active.Inst. Stand.Inst. Forage.Inst. Lie.Inst. Ruminate.Inst. Vigilant.Inst. Climb.Inst.
Environmental enrichment	1-0 focal	2	Condition (control vs enriched)	Social play.1-0. Object play.1-0. Locomotor play.1-0. Run.1-0. Jump.1-0. Agonistic interactions.1-0. Aggression.1-0. Avoid.1-0. Explore.1-0. Wag tail.1-0. Climb.1-0.
Environmental enrichment	1-0 focal	3	Condition Pair of days Condition x Pair of days	Social play.1-0. Object play.1-0. Oral manipulation.1-0. Move object.1-0. Locomotor play.1-0. Agonistic interactions.1-0. Explore.1-0. Wag tail.1-0. Climb.1-0.
Group size	Instantaneous scans	4	Group size	Play.Inst. Agonistic interactions.Inst. Active.Inst. Stand.Inst. Forage.Inst. Lie.Inst. Ruminate.Inst. Vigilant.Inst. Climb.Inst.

Group size	1-0 focal	**5**	Group size	Social play.1-0. Object play.1-0. Locomotor play.1-0. Run.1-0. Jump.1-0. Agonistic interactions.1-0. Aggression.1-0. Avoid.1-0. Explore.1-0. Wag tail.1-0. Climb.1-0.
Confinement length	Instantaneous scans	**6**	Confinement length	Play.Inst. Agonistic interactions.Inst. Active.Inst. Stand.Inst. Forage.Inst. Lie.Inst. Ruminate.Inst. Vigilant.Inst. Climb.Inst.
Confinement length	1-0 focal	**7**	Confinement length	Social play.1-0. Object play.1-0. Locomotor play.1-0. Agonistic interactions.1-0. Explore.1-0. Wag tail.1-0. Climb.1-0.
Whole study period	1-0 focal	**8**	Age	Social play.1-0. Object play.1-0. Locomotor play.1-0. Agonistic interactions.1-0. Explore.1-0. Wag tail.1-0. Climb.1-0.
Whole study period	1-0 focal	**9**	Weight gain	Social play.1-0. Object play.1-0. Locomotor play.1-0. Agonistic interactions.1-0. Explore.1-0. Wag tail.1-0. Climb.1-0.

[1] Pair of days, group size and confinement length treated as categorical in Models 1-6. Age (Model 7) and weight gain (Model 8) were continuous variables.

Finally, as descriptive statistics, Pearson correlation coefficients among the variables totalled across the three experiments (the study period) were calculated. The variables included in this model (Model 10) were: age (at start of study period), weight gain (difference in weight before and after study period), mean

proportion (mp) of social play, object play, locomotor play, agonistic interactions, explore, climb, and tail wagging.

5. Results

5.1 Environmental enrichment experiment

5.1.1 Overall effect of enrichments on general activity levels regardless of exposure levels (H1)

5.1.1.1 Results from instantaneous scans (Model 1)

The treatment had a significant effect on all variables analysed in Model 1 (Table 4).

Table 4. Analysis results of Model 1.

Variable	F-value	Num DF	Den DF	P-value
Play.Inst.	85.33	1	1404	<0.001
Agonistic interactions.Inst.	8.17	1	458	0.004
Active.Inst.	33.51	1	458	<0.001
Stand.Inst.	87.87	1	219	<0.001
Lie.Inst.	16.75	1	219	<0.001
Forage.Inst	79.15	1	219	<0.001
Ruminate.Inst.	83.29	1	219	<0.001
Vigilant.Inst.	10.16	1	219	0.001
Climb.Inst.	∞	1	219	<0.001

When enrichments were available, the goats played more than under control conditions. Greater frequencies of agonistic interactions were more common under control than enriched conditions. Additionally, walking and exploring (active array) occurred at higher frequencies when enrichments were present (Figure 4a).

Under control conditions, standing and lying occurred more frequently than under enriched conditions. Furthermore, the occurrences of foraging under control conditions were higher than those under enriched conditions. When enrichments were available, the subjects ruminated more frequently than when enrichments were absent. On the other hand, vigilant behaviour was more common under control conditions than under enriched conditions. Climbing was almost exclusively seen under enriched conditions (Figure 4b).
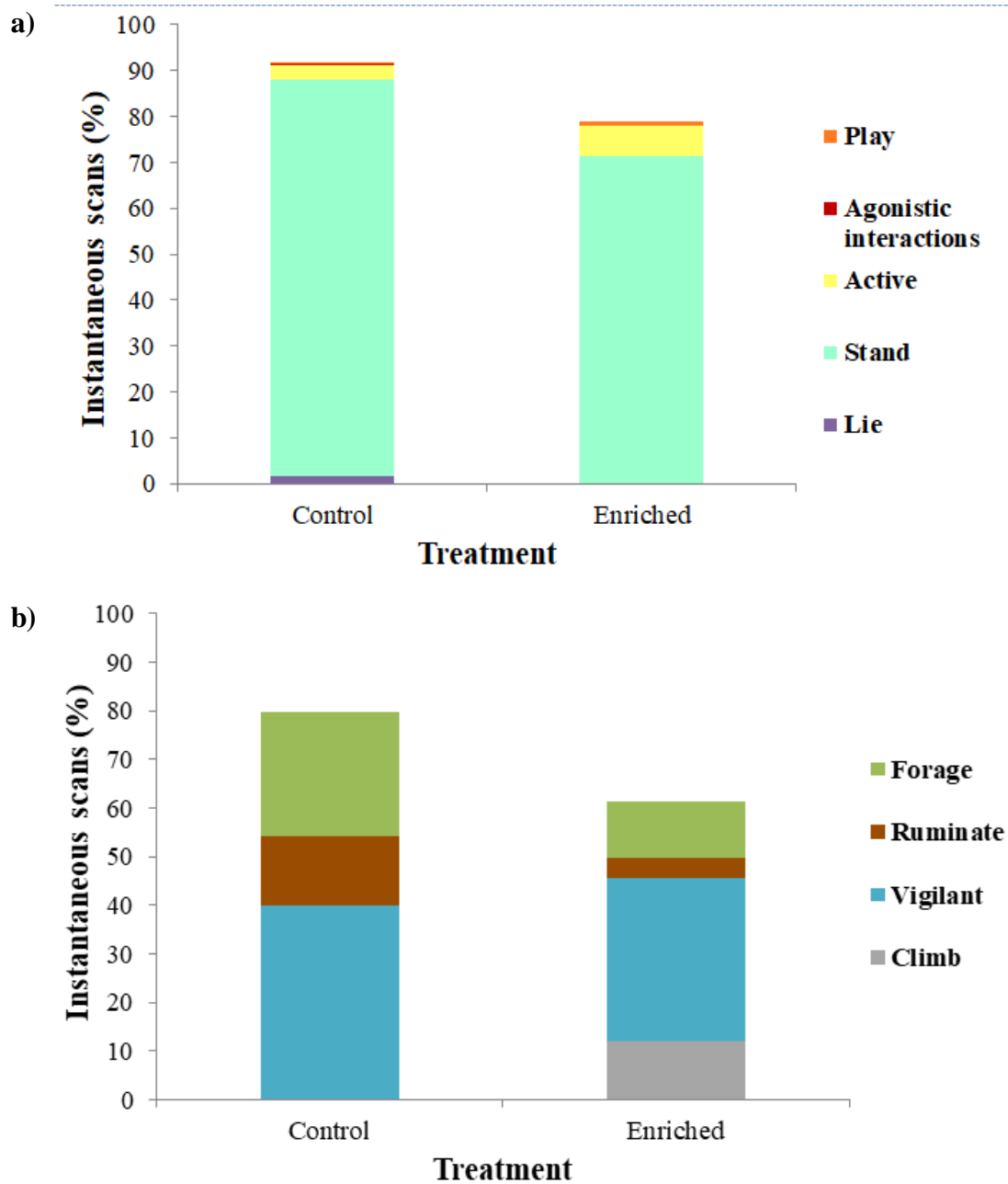
Figure 4. Effect of treatment (control vs enriched) on the behavioural time budget. Back-transformed least squares means proportion of instantaneous scans (in which juvenile female goats (n=20) performed a) mutually exclusive behaviours and b) non-mutually exclusive behaviours. In the Enriched condition, the goats had access to a bridge, a hanging ball, and a bucket full of sticks. Data were analysed using Model 1.

5.1.1.2 *Results from 1-0 focal animal data (Model 2)*

The treatment had a significant effect on most of the variables analysed from the 1-0 focal animal data (Table 5).

Table 5. Analysis results of Model 2. N/S = convergent criterion not satisfied

Variable	F-value	Num DF	Den DF	P-value
Social play.1-0.	95.39	1	458	<0.001
Object play.1-0.	138.68	1	458	<0.001
Locomotor play.1-0.	N/S	N/S	N/S	N/S
Run.1-0.	21.41	1	219	<0.001
Jump.1-0.	20.06	1	219	<0.001
Agonistic interactions.1-0.	0.44	1	458	0.509
Aggression.1-0.	4.34	1	219	0.039
Avoid.1-0.	3.21	1	219	0.075
Explore.1-0.	178.19	1	219	<0.001
Wag tail.1-0.	19.7	1	219	<0.001
Climb.1-0.	∞	1	219	<0.001

Without considering the effect of repeated exposure over time, the goats engaged in more social play and object play under enriched conditions than under control conditions. The frequency of social play under control conditions was 0.76 %, while under enriched conditions the frequency was 2.78 %. Under control conditions object play had a 0.16 % frequency, while under enriched conditions the frequency was 1.16 %. As, the convergence criterion for Model 2 was not satisfied when locomotor play (array) was analysed, its components were independently analysed. Both running and jumping (Table 5) were affected by the treatments, and both were almost exclusively observed under enriched conditions (Figure 5).

When analysed independently, performing aggressive behaviours (Aggression.1-0.) was significantly affected by the presence of treatment. Aggression was more frequent under enriched conditions (1.71 %) compared to control conditions (1.04 %). Exploration was performed at much higher frequencies when the goats were in an enriched environment compared to when they were in a control environment (Figure 5).Tail wagging had a higher frequency under enriched conditions (2.84 %) than under control conditions (1.05 %). Additionally, climbing almost only occurred under enriched conditions (Figure 5).
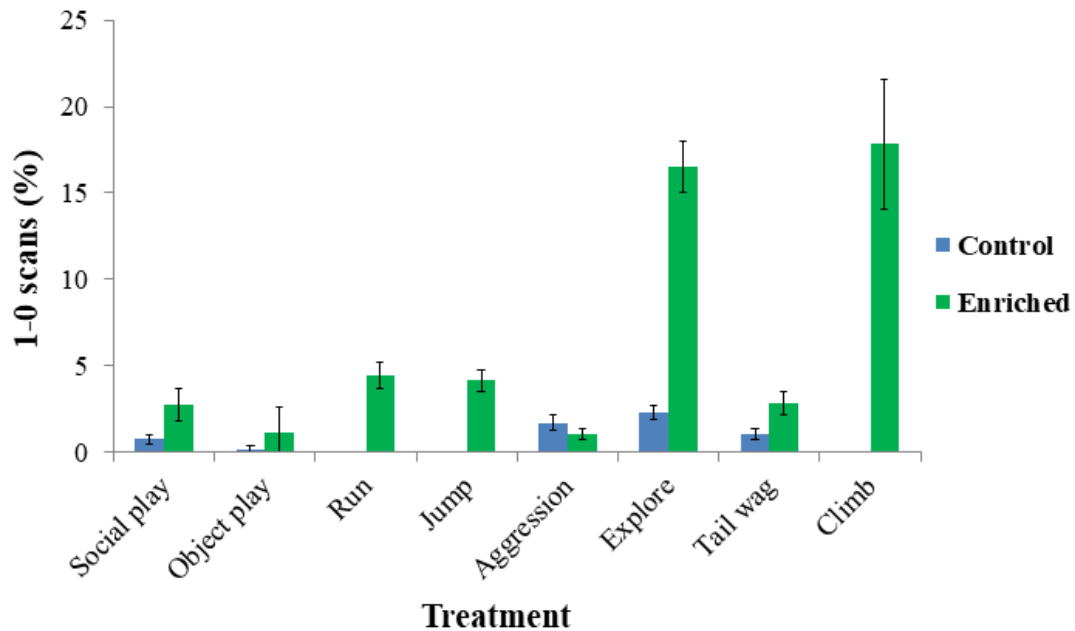
Figure 5. Back-transformed least squares means (± SE) proportion of 1-0 scans engaged in behavioural events under the control and enriched condition from Model 2.

5.1.2 Effect of repeated exposure over time on the behavioural difference between treatments (control and enriched conditions) (H2, Model 3)

The interaction between repeated exposure (Pair of days) and the two conditions had a significant effect on most of the variables analysed from the 1-0 focal animal data. The statistical results relevant for this hypothesis (H2) are reported in Table 6, while all statistical results from this model can be found in Appendix 2.

Table 6. Results of Model 3 for Hypothesis 2 (H1 – Repeated exposure to conditions on behavioural frequencies) in Environmental enrichment experiment. F-values refer to the interaction of Condition x Pair of Days.

Variable	F-value	Num DF	Den DF	P-value
Social play.1-0.	5.81	3	448	0.0007
Object play.1-0.	1.49	4	448	0.2050
Oral manipulation.1-0.	1.25	4	209	0.2927
Move object.1-0.	194.27	1	209	<0.001
Locomotor play.1-0.	∞	5	448	<0.001
Agonistic interactions.1-0.	4.47	5	448	0.0006
Explore.1-0.	5.71	5	209	<0.001
Wag tail.1-0.	7.33	3	209	0.0001
Climb.1-0.	∞	5	209	<0.001

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The difference in frequency of social play between the two treatments was seen to be significantly affected by repeated exposure (Table 6). As seen in Figure 6a, the frequency of social play was often higher in earlier exposures, especially under enriched conditions, but under control conditions the social play frequency started to increase again in later exposures. As object play was not significantly affected by repeated exposure to the two treatments over time, its components were independently analysed (Table 6). Only the results of moving objects (Move objects.1-0.) were significant, the frequency decreases over repeated exposures (Figure 6b). Locomotor play was almost exclusively seen under enriched conditions, its frequency decreased over time (Figure 6c).

a)
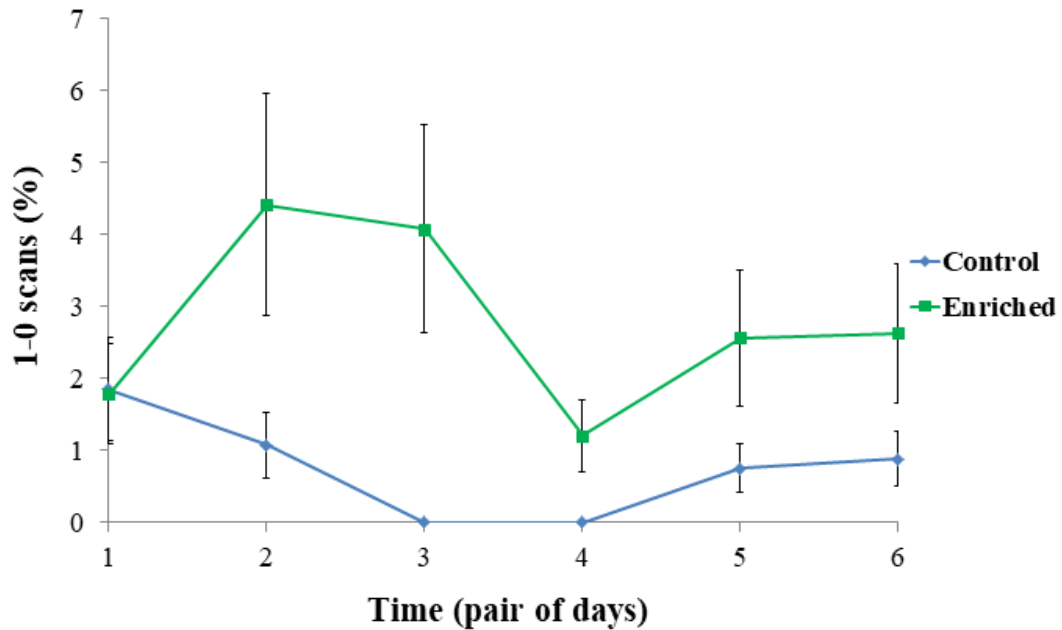
b)
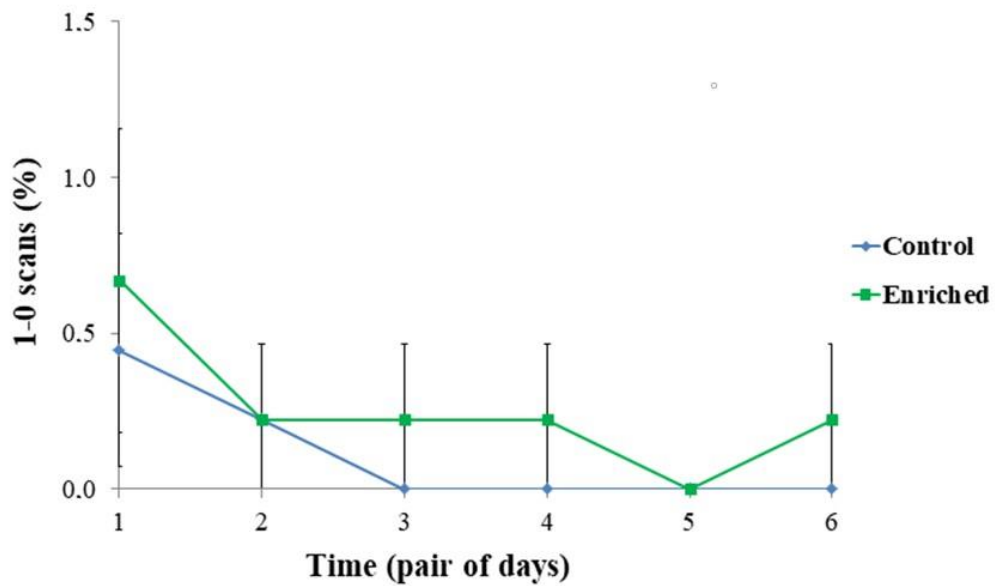
c)
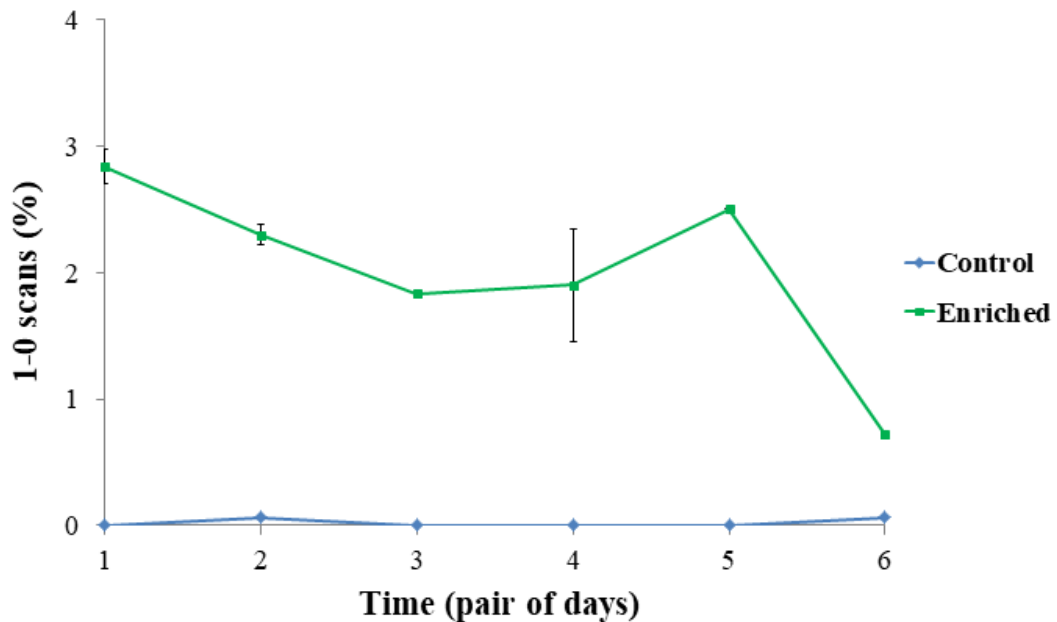
Figure 6. Back-transformed least square mean (± SE) proportion of 1-0 scans engaging in a) social play, b) move object and c) locomotor play over time (pairs of days). Model 3 data.

The frequency of both performing and receiving agonistic interactions (Agonistic interactions.1-0) and exploration in the two treatments was seen to be significantly affected by repeated exposure over time (Table 6). The frequency of agonistic interactions (Figure 7a) and exploration (Figure 7b) varied over time in the two treatments.
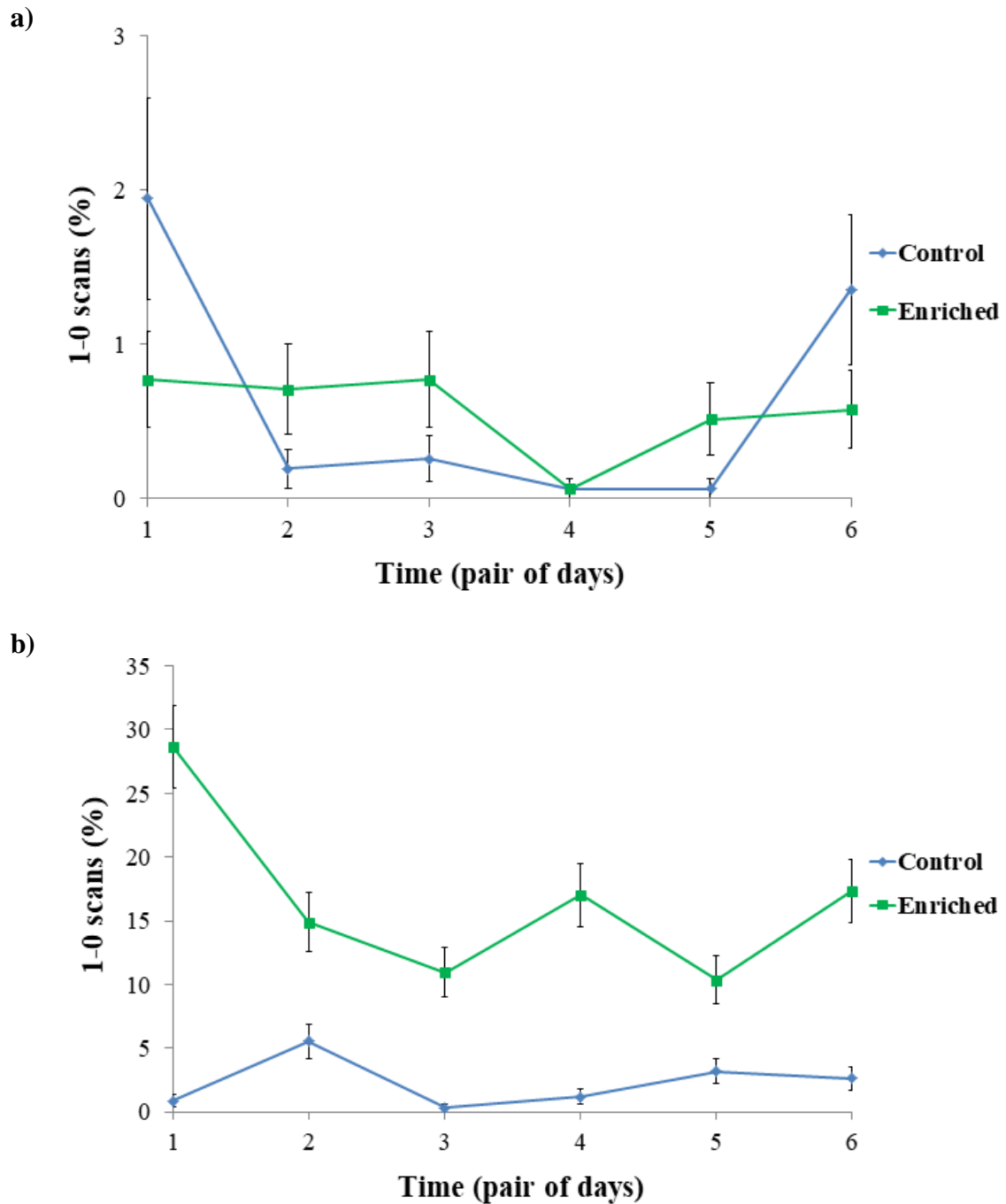
Figure 7. Back-transformed least square mean (± SE) proportion of scans engaged in a) agonistic interactions and b) exploration over day pair 1 to 6 (total of 12 days). Data were analysed using Model 3.

Tail wagging was also affected by the interaction between repeated exposure (Pair of days) and the conditions, it gradually declined in frequency before it suddenly started to increase in frequency again towards the end of the experiment (Figure 8a). Climbing was almost only seen under enriched conditions, and under those conditions it was seen to generally decrease in performance frequency over time (Table

5). However, the goats performed the least climbing during their third exposure to the enriched condition (Figure 8b).
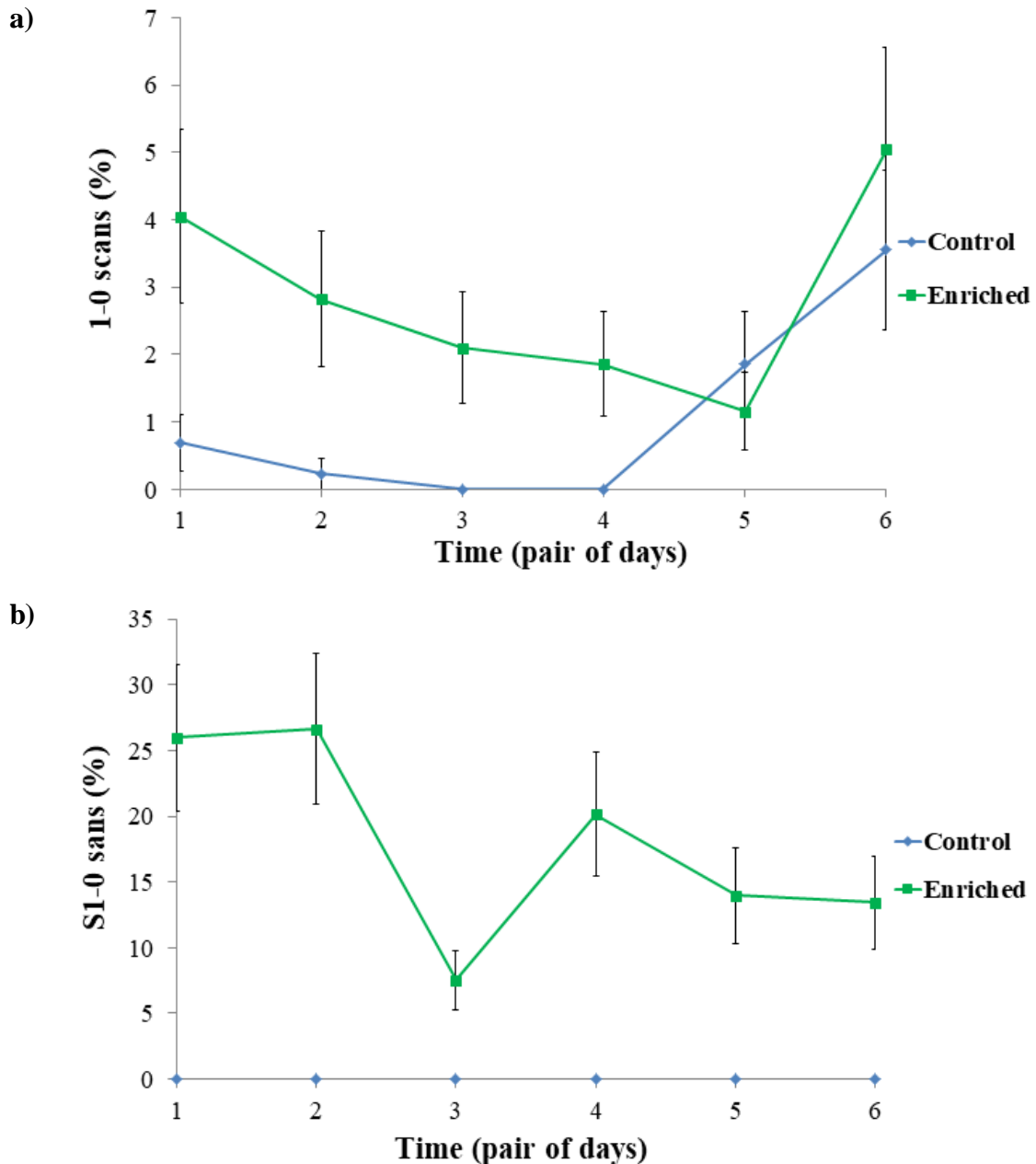
Figure 8. Back-transformed least square mean (± SE) proportion of scans performing a) tail wagging and b) climbing over time (pairs of days) from GLM-Model 3.

5.2 Group size experiment

### 5.2.1 Effect of group size on general activity levels (H1, Model 4)

Group size affected four out of the nine variables analysed in Model 4 (Table 7).

Table 7. Analysis results of Model 4.

Variable	F-value	Num DF	Den DF	P-value
Play.Inst.	4.25	6	1409	<0.001
Agonistic interactions.Inst.	0.04	1	453	0.842
Active.Inst.	1.50	6	453	0.176
Stand.Inst.	3.89	6	214	0.001
Lie.Inst.	1.21	4	214	0.309
Forage.Inst	2.57	6	214	0.020
Ruminate.Inst.	2.74	1	219	0.099
Vigilant.Inst.	20.55	6	214	<0.001
Climb.Inst.	2.00	6	214	0.067

The goats played more frequently in larger than smaller group sizes. An effect of group size was observed in the occurrences of standing (Table 7). In general, individuals in larger groups stood more than those in smaller groups. However, the effect of group size levelled out after group size 5 (Figure 9a).
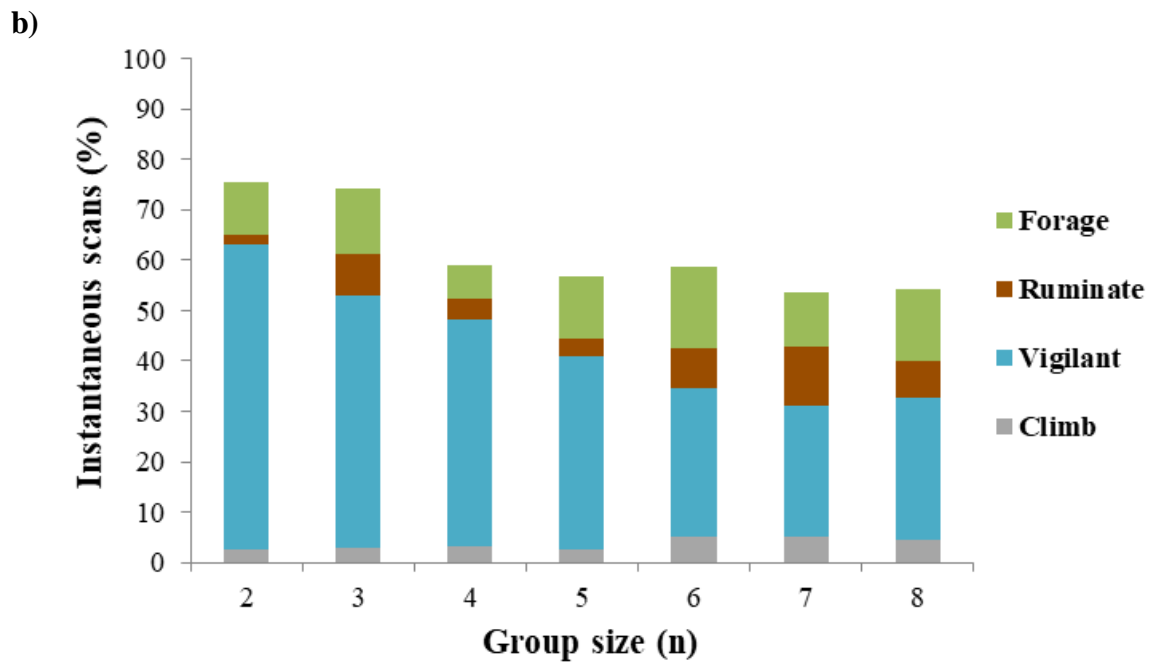
a)

b)
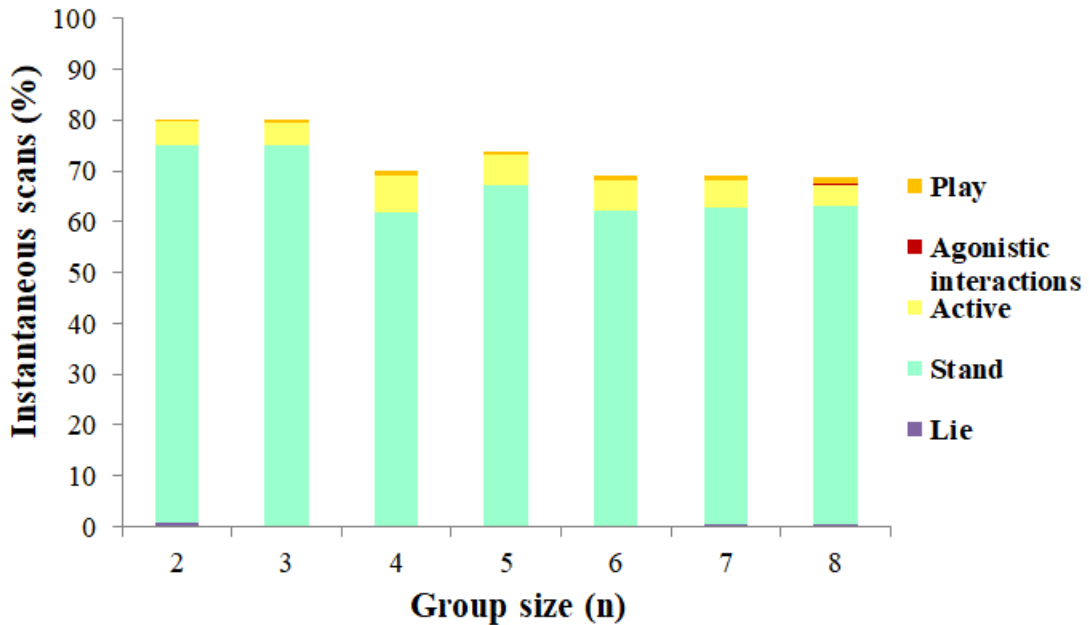
Figure 9. Effect of treatment (group size, 2-8 individual) on the behavioural time budget. Back-transformed least squares means proportion of instantaneous scans in which juvenile female goats (n=20) performed a) mutually exclusive behaviours and b) non-mutually exclusive behaviours. Data were analysed using Model 4.

The rate of foraging varied between group sizes. Out of the seven treatments, the goats foraged the most in the group size of six individuals, while goats spent the least amount of time foraging in groups of four. On the other hand, as seen in Figure 9b, the proportion of time each individual spent vigilant decreased linearly as the group size increased.

5.2.2 Effect of group size on tolerance (H2, Model 5)

Only two of the 11 variables analysed in Model 5 were significantly affected by group size (Table 8).

Table 8. Effect of group size on behaviours measured by focal sampling (Model 5 analysis results).

Variable	F-value	Num DF	Den DF	P-value
Social play.1-0.	6.93	6	453	<0.001
Object play.1-0.	3.44	6	453	0.003
Locomotor play.1-0.	0.96	6	453	0.449
Run.1-0.	1.46	6	214	0.194
Jump.1-0.	3.23	6	214	0.779
Agonistic interactions.1-0.	0.55	5	453	0.737
Aggression.1-0.	0.32	5	214	0.898
Avoid.1-0.	1.05	4	214	0.384
Explore.1-0.	1.82	6	214	0.096
Wag tail.1-0.	0.57	6	214	0.756
Climb.1-0.	7.41	6	214	0.289

Group size significantly affected the frequency of both social play and object play (Table 8). As seen in Figure 10, the highest frequency of social play occurred in the groups with four individuals (4.87 %), while the groups with two individuals had the lowest frequency (1.51 %). In general, the social play frequency varied across group sizes. On the other hand, object play gradually increased as the groups got larger (Figure 10).
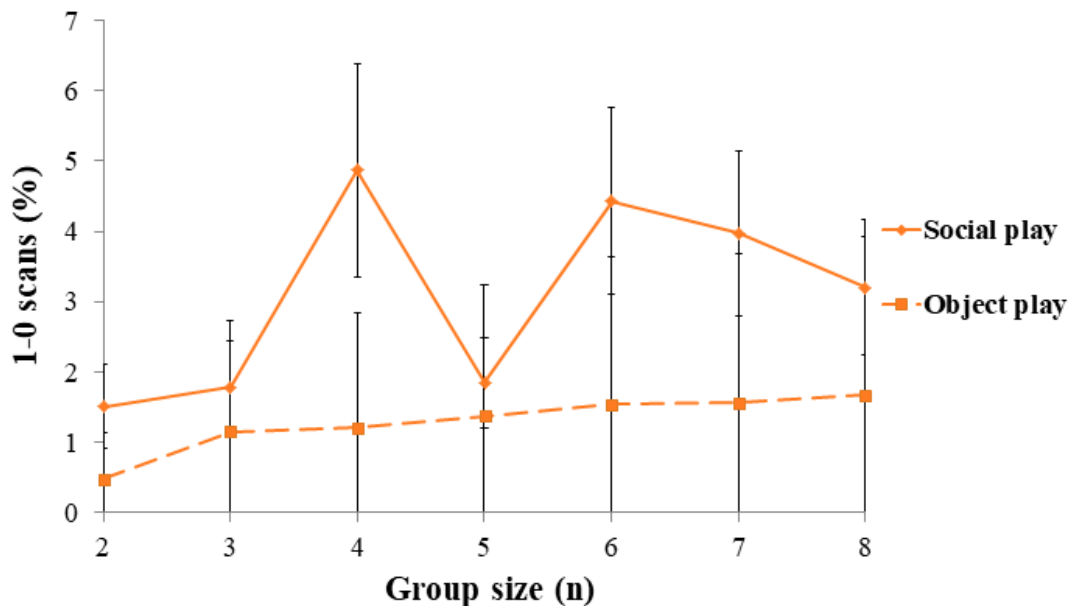

Figure 10. Back-transformed least squares means (+ SE) proportion of 1-0 scans engaged in social play and object play with group sizes varying from 2-8 individuals. Data were analysed using Model 5.

5.3 Confinement length experiment

5.3.1 Effect of indoors confinement length on the performance of behaviours in the outdoor enclosure (H1)

5.3.1.1 Results from instantaneous scans (Model 6)

Confinement length significantly affected four out of nine analysed variables in Model 6 (Table 9).

Table 9. Analysis results of Model 6.

Variable	F-value	Num DF	Den DF	P-value
Play.Inst.	3.52	4	571	0.008
Agonistic interactions.Inst.[1]	0.00	4	175	1.00
Active.Inst.	2.07	4	175	0.086
Stand.Inst.	4.42	4	76	0.003
Lie.Inst.	∞	4	76	<0.001
Forage.Inst	0.19	4	76	0.941
Ruminate.Inst.	1.95	4	76	0.111
Vigilant.Inst.	8.75	4	76	<0.001
Climb.Inst.	0.97	4	76	0.430

[1] Estimated G matrix not positive definite

In response to confinement length, the occurrences of play decreased linearly. The subjects played the least after being confined the longest (five days) and played the most after being confined the least (two days).
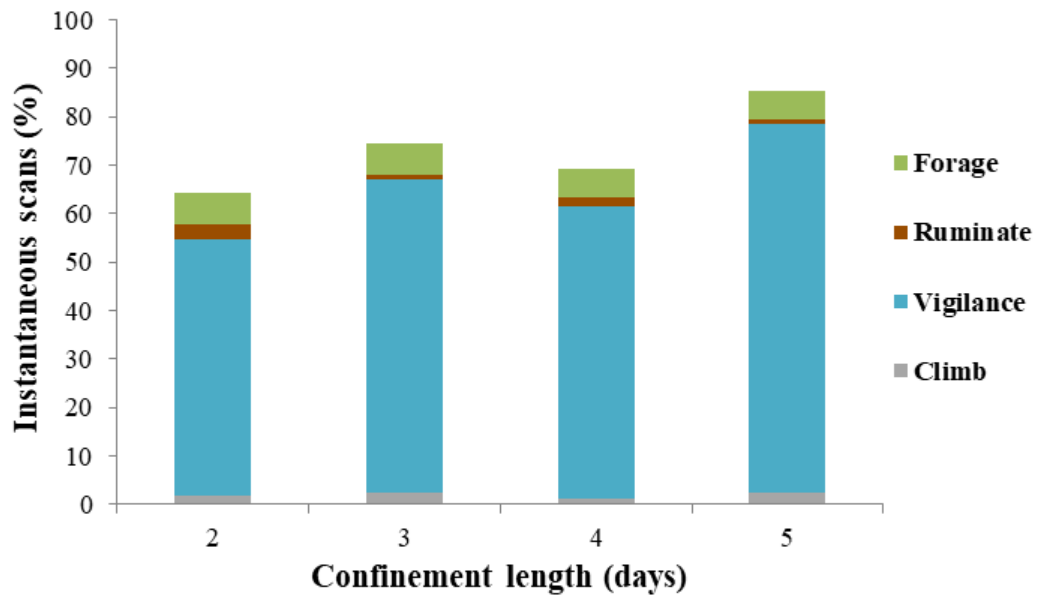
a)
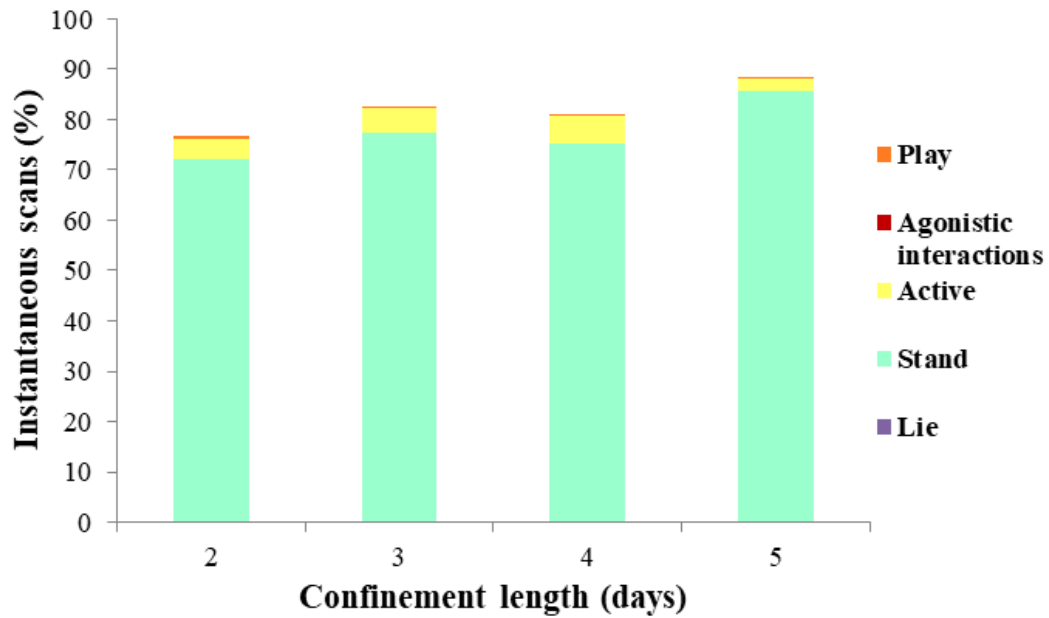
b)

Figure 11. Effect of treatment (confinement length, 2-5 days) on the behavioural time budget. Back-transformed least squares means proportion of instantaneous scans (in which juvenile female goats (n=20) performed a) mutually exclusive behaviours and b) non-mutually exclusive behaviours. Frequencies of Lie.Inst. are too small to be visible in a).

Standing rates were significantly affected by the confinement length (Table 9). As seen in Figure 11a, standing frequencies were higher after longer confinement durations. Furthermore, the goats' lying frequencies were significantly affected by the length of confinement (Table

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8). However, the proportions are too small for them to be visible in Figure 11a.

The length of indoor confinement did significantly affect the proportion of time spent vigilant after being released into an enriched environment (Table 9). As seen in Figure 11b, the rate of vigilant behaviour was higher after longer confinement durations.

5.3.1.2 *Results from 1-0 focal animal data (Model 7)*

The length of confinement significantly affected six of the nine analysed variables in Model 7 (Table 10).

Table 10. GLM-Model 7 analysis results from 1-0 focal animal data for Hypothesis 1 of the confinement length experiment (effect of indoor confinement length on behavioural frequencies).

Variable	F-value	Num DF	Den DF	P-value
Social play.1-0.	15.79	4	175	<0.001
Object play.1-0.	2.40	4	175	0.052
Oral manipulation.1-0.	3.39	4	76	0.013
Move object.1-0.	∞	4	76	<0.001
Locomotor play.1-0.	5.31	4	175	<0.001
Agonistic interactions.1-0.	∞	4	175	<0.001
Explore.1-0.	3.64	4	76	0.009
Wag tail.1-0.	1.10	4	76	0.362
Climb.1-0.	1.86	4	76	0.126

Only two of the three play array frequencies were affected by the confinement length the goats experienced (Table 10): social play and locomotor play. Social play decreased as the length of previous indoor confinement increased (Figure 12a), while locomotor play did not show obvious tendency and differed in frequency per individual over the different lengths of confinement.

Oral manipulation varied a lot in frequency after different lengths of confinement, but the frequencies usually grew smaller as lengths of indoor confinement were longer (Figure 12b). Moving objects (Move object.1-0.) also varied in frequency per individual as confinement length increased. The frequencies of Move object.1-0. are too small to be visible in Figure 12b.

Agonistic interactions also differed significantly in frequency between treatments (Table 10). Its frequency varied as the lengths of confinement increased and had no obvious trends (Figure 12a). The goats performed the most agonistic interactions after being confined for five days (0.17 %) and performed the least agonistic interactions after they had been confined for two days (7.1×10^{-12} %).
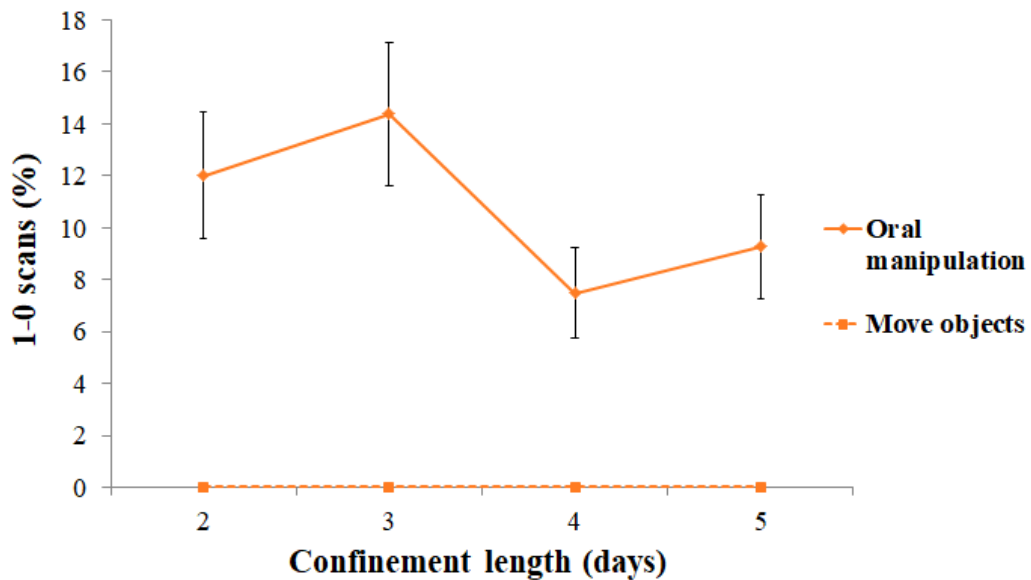
a)
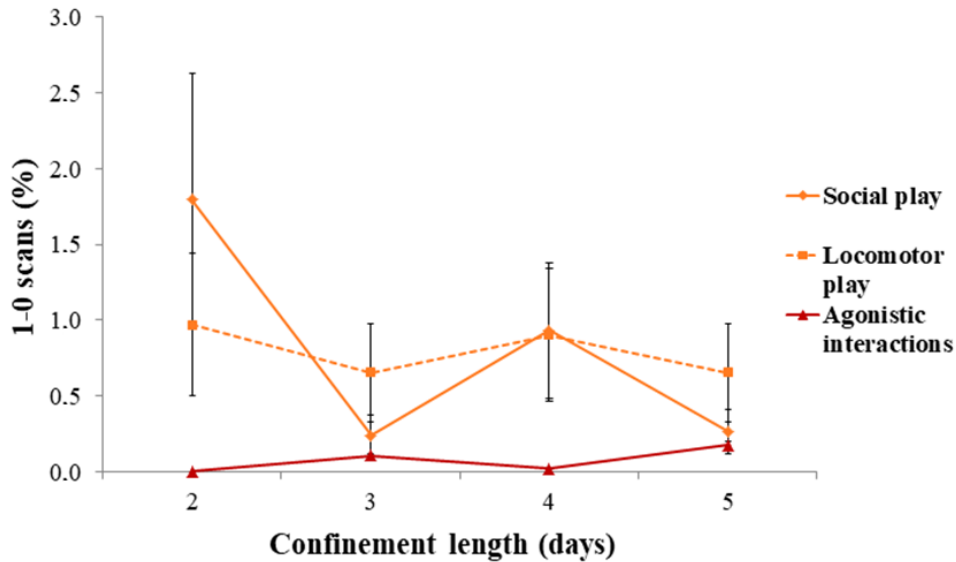
b)

Figure 12. Back-transformed least squares means proportions of a) different play behaviours and agonistic interactions and b) the two components of object play, oral manipulation and move objects, displayed by goats after experiencing different lengths of indoor confinement (2-5 days), with standard error bars. Results from Model 7, which analysed 1-0 focal animal data from the Confinement length experiment. Move object.1-0. frequencies are too small to be visible in b).

After experiencing a confinement length of two days, the subjects explored the least (5.31 %), while the exploration frequency was highest after three days of confinement (9.68 %, Figure 13). The exploration frequency declined after three days of confinements.
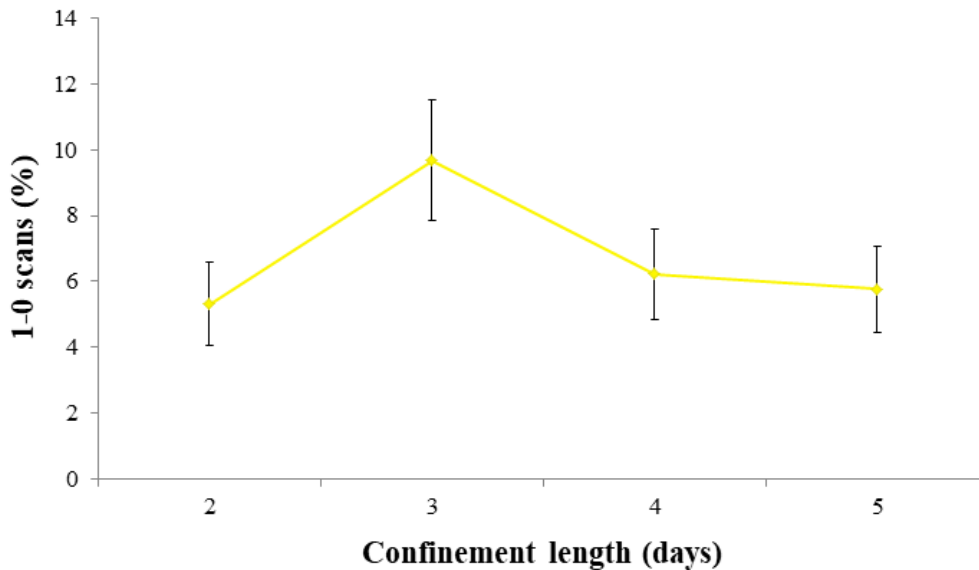

Figure 13. Back-transformed least squares means proportion of 1-0 scans engaged in exploration after different lengths of indoor confinement (1-5 days) with standard error bars.

5.4 **Age and weight gain**

5.4.1 **Effect of age on the frequencies of play and other behaviours (H1, Model 8)**

Age did not have any significant effect on the frequencies of any behaviour. All statistical results of the effect of age on the three different play types (social play, locomotor play, and object play), exploration, climbing and tail wagging (Model 8) can be seen in Table 11 below.

Table 11. The effect of age on the mean proportion of various behaviours at start of the observation period. Results of GLM-Model 8.

Behavioural categories		Type III Test of Fixed Effects			
Mutually exclusive	Non-mutually exclusive	Num DF	Den DF	F-value	P-value
Social play		1	16	0.02	0.904
Locomotory play		1	16	0.00	0.997
Object play		1	16	0.03	0.857
Explore		1	16	0.01	0.906
	Climb	1	16	0.00	0.993
	Tail wag	1	16	0.04	0.842

5.4.2 Effect of different active behaviours on the subjects' weight gain (H2, Model 9)

Only the frequency of object play significantly affected the weight gain of the subjects (F1, 16=8.51, P=0.01; Table 12).

Table 12. The effect of the frequencies of various behaviours on the weight gained by the subjects through the observation period. Data were analysed using Model 9.

Behavioural categories		Type III Test of Fixed Effects			
Mutually exclusive	Non-mutually exclusive	Num DF	Den DF	F-value	P-value
Social play		1	16	0.94	0.347
Locomotory play		1	16	0.62	0.441
Object play		1	16	8.51	0.010
Explore		1	16	0.09	0.765
	Climb	1	16	0.29	0.597
	Tail wag	1	16	2.02	0.175

5.5 Correlations between variables throughout all experiments (Model 10)

A few of the variables were significantly correlated with one another across the whole study period (Table 13). Tail wagging was correlated with social play, object play and exploration, but not locomotor play. However, locomotor play was correlated with climbing. The complete set of statistical results from Model 10 can be found in Appendix 3.

Table 13. Significant Pearson correlations between variables used (N = 18) over whole study period (from start of experiment 1 to end of experiment 3). Results of Model 10 from 1-0 focal animal data. mp = mean proportion of 1-0 scans.

Variables			Correlation coefficient	P-value
Weight gain (kg)	&	Object play (mp)	0.567	0.014
Social play (mp)	&	Tail wag (mp)	0.714	<0.001
Locomotor play (mp)	&	Climb (mp)	0.041	0.041
Object play (mp)	&	Tail wag (mp)	0.502	0.041
Explore (mp)	&	Tail wag (mp)	0.482	0.043

6. Discussion

6.1 Play

Even though play behaviour has become a popular study research topic the last few decades, it is not an easy field to study (Bekoff & Byers, 1998). Play is a rare behaviour. It does not occupy a large part of the animals' time budget (Bekoff & Byers, 1998; Lawrence *et al.*, 2017) and it mostly occurs when environmental conditions are perceived by the animal as acceptable (Buchenauer, 1981; Lawrence, 1987; Newberry *et al.*, 1988; Barrett *et al.*, 1992). It has also been hard to define and its adaptable value is still uncertain (Fagen, 1981; Bekoff & Allen, 1998) .

Fewer studies focus on the ethology of farm animals compared to studies that focus on their economic value and productivity. Animal behaviour studies on goats are scarce, and very few focuses on play behaviour. Consequently, further studies on goats and play behaviour are needed to fill the scientific gaps of knowledge.

6.2 Environmental enrichment experiment

6.2.1 The effect of environmental enrichments on general activity levels (H1, Model 1 and 2)

As predicted, the goats played more under enriched conditions than under control conditions. The frequency of social play, object play, running and jumping was greater when the environmental enrichments were present in the enclosure than when they were absent. An increase in locomotor activity in response to structural enrichments was also found in female dwarf goats by Oesterwind *et al.* (2016), who examined these effects in groups of 8-9 individuals at six different occasions. Another study, on groups of juvenile farmed minks, by Vinke *et al.* (2005) reported that the presence of swimming water, an environmental enrichment for minks, increased the frequency of social play and solitary play (the latter included locomotor play and object play) per group. The groups contained approximately six juvenile individuals each and the experimental period lasted five weeks. Rats (*Rattus norvegicus*) housed in cages with several different, rotating environmental enrichments have also been reported to displayed a higher frequency of social play per pair of siblings compared to individuals housed under not-enriched (control) conditions (Morley-Fletcher *et al.*, 2003). In other words, the play results of the current experiment are in trend with those found in existing studies and

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indicates that the enrichments used promoted play in young Norwegian dairy goats.

Contrary to my prediction, the goats spent less time performing aggressive interactions under enriched conditions compared to under control conditions. Another study on Norwegian dairy goats by Bøe *et al.* (2012), which observed 20 1-2 year old individuals observed over ten five-hour occasions, reported that the access to an 750.0 m^2 outdoor pen area resulted in an increase of the mean agonistic interactions frequency per goats (Bøe *et al.*, 2012). Yet, Vinke *et al.* (2005) found no significant difference in the frequency of aggression per group when the farm mink had access to swimming water or not. Bøe *et al.* (2012) hypothesised that the increased aggression in the outdoor pen might be a consequence of easily defendable resources (added branches). It is, therefore, possible the low levels of aggression in the current experiment indicated a good distribution and availability of the enrichments under the enriched conditions. Additionally, any resources (e.g. twigs or forage-materials) that could be of interest in the control conditions could be limited in number and, therefore, easily defendable. Note that the outdoor data from Bøe *et al.* (2012) was based on a 750 m^2 outdoor pen, eight-hour access per day, and 23 days of exposure (ten occasions of data recording), while my results were based on a 40 m^2 outdoor enclosure, 30 min access four times a week, and 12 days of exposure to the outdoor pen (regardless of treatment conditions). Additionally, Bøe *et al.* (2012) only added one enrichment (branches) to their outdoor pen, in one area, while the current experiment introduced several environmental enrichments, which probably made them harder to defend. Furthermore, the subjects in Bøe *et al.* (2012) were older (1-2 years old) than the subjects used in the current experiment (6-8 months old). In Mountain goats, the frequency of agonistic interactions positively correlate with social rank, and social rank was the mainly determined by age (Côté, 2000). It is, therefore, also possible the differences in results between (2012) and the present experiment could be an effect of age.

Goats rarely lie next to one another (Andersen & Bøe, 2007), they seem to prefer a larger personal space than sheep (Lyons *et al.*, 1993), and keep longer distances between one another if given the opportunity to do so (Vas & Andersen, 2015). When resting space is limited, the frequency of aggression is often seen to increase (cattle: Nielsen *et al.*, 1997; Schütz *et al.*, 2015), (sheep: Bøe *et al.*, 2006). So, by increasing the spatial allowance in the enclosure with the use of a platform, the agonistic interaction frequency would be expected to decrease. A decrease of the mean frequency of aggressive interactions per group of

four Norwegian dairy goats (n = 24) has been reported by increasing the number of resting areas with the use of platforms by Andersen and Bøe (2007). Thus, it is possibly the platform available in the enriched condition in the current experiment provided enough space for each individual to feel comfortable.

It is important to note that neither Andersen and Bøe (2007) nor Bøe *et al.* (2012) report any results for social play. They report all butting and frontal collisions as aggressive behaviours. Even though play-fighting and agonistic interactions might be hard to distinguish in goats, the current study found significant differences between the two behavioural arrays and there was no significant correlation between the two variables. In other words, it should be possible to distinguish between social butting and frontal collision and aggressive interactions. In comparison, Loretz *et al.* (2004) only recorded direct and indirect displacement behaviours of goats when examining the effects of spatial allowance on agonistic interactions. They found no significant effect of spatial allowance on agonistic interactions (Loretz *et al.*, 2004).

The presence of the environmental enrichments also resulted in an increase of environmental exploration and walking. This result is in accordance with those of Oesterwind *et al.* (2016), who reported that the presence of a cognitive enrichment resulted in an increase of curiosity and prolonged contact towards novel objects in female dwarf goats, and Bøe *et al.* (2012), who found that Norwegian dairy goats spent more time exploring and walking around the environment when branches (structural enrichment) were available in the enclosure.
As tail wagging was seen to be closely tied to social play, object play and exploration, it is not unexpected that tail wagging had a higher frequency under enriched conditions.

The goats were more inactive under the control conditions than under enriched conditions, they both stood and laid more when enrichments were absent. My results are in accordance with those of Bøe *et al.* (2012). Bøe *et al.* (2012) reported that 20 Norwegian dairy goats had a smaller frequently of stand and rest when given access to an outdoor enclosure for 8 h a day over 23 days, and that the frequency of stand declined even more when branches became available after two days of outdoor access. Although "rest" is not defined or expanded upon in Bøe *et al.* (2012), it is most likely similar to the behaviour "lie" in the current study. On the other hand, no difference in the frequency of lying were reported in four groups of 13 cows by Loberg *et al.* (2004) when cattle were given access to a 3220 or 3040 m^2 outdoor enclosure for 1 h either seven, two or one days a week. The experiment also included a

control treatment in which the cows did not gain any access to the outdoor enclosures, each individual (n = 52) was observed for 65 min per week over six months (12 occasions) (Loberg *et al.*, 2004). They also reported a decrease in the frequency of standing per individual cow when given outdoor access (Loberg *et al.*, 2004). The results of the currents study might suggest that the control condition of the current experiment was perceived as less interesting or bare compared to the enriched condition and that the enrichments provided opportunities to perform motivated behaviours.

Similarly, in the present study, goats spent more time foraging and ruminating under control conditions than under enriched conditions. This might indicate that there was not much else to do under control conditions other than forage, ruminate and observe the surroundings, which might possibly be similar to the options when inside of the home pen. These results are in accordance with the findings of Bøe *et al.* (2012) and Loberg *et al.* (2004).

Climbing almost exclusively occurred under enriched conditions, this is most likely due to the limited options to perform the behaviour under control conditions. The goats could only climb on other goats in these conditions, which rarely occurred and were often seen to be annoying by the receiver. Consequently, more climbing options should have been available (i.e. rocks) under the control conditions.

6.2.2 Effect of repeated exposure to treatments over time on the effects of environmental enrichments (H2, Model 3)

As predicted, social play occurred at greater frequencies during earlier exposures compared to later exposures. Furthermore, repeated exposure to the control- and the enriched treatment over time resulted in a declining difference in the frequency of social play in Norwegian dairy goats between the two treatments. To my knowledge, there is only one study that focuses on the changes in social play over time in relation to the presence of environmental enrichments (Renner & Rosenzweig, 1986). This study examine whether social interactions result in differences in brain structures of 12 and 10 pairs of male littermates Berkeley S_1 strain rats as a consequence of the presence of environmental enrichments in two experiments. In enriched cages the rats had 9 toys available at all times, two of these were toys were replaced daily, and a shelf, while the control groups only had access to food and water, the subjects were exposed to the treatments for 30 days in both experiments (Renner & Rosenzweig, 1986). In the second experiment, another treatment was included where individual rats lived

in cages that allowed for visual and olfactory communication, but no physical contact between rats. Renner and Rosenzweig (1986) found no significant difference in the frequency of social play between the conditions in any of the two experiments. They did, however, report a decrease in social play over time, but this was probably due to the effect of age rather than habituation. Nonetheless, social play is seen to decrease over time, but further studies are required to examine whether this is an effect of age or habituation. The effect of age in the current study will be discussed below.

Locomotor play was almost exclusively observed under enriched conditions, and the repeated exposure to the treatment resulted in a frequency decline over time. A decline in frequency of locomotor play due to repeated exposure have also been reported in cattle by Loberg *et al.* (2004), who investigated the effects of outdoor access in four groups of 13 individual over six months. The individuals with the most restricted access, they, therefore, had the least exposure to the enclosure, played the most and that the individuals with the least restricted access played the least. Bøe *et al.* (2012) does not report any decline in the frequency of locomotor play with repeated exposure to the outdoor enclosure, but they do report that locomotor play was only observed in the outdoor enclosure and never inside. An increase in spatial allowance increases the frequency of locomotor play (Dellmeier *et al.*, 1985; Jensen *et al.*, 1998; Jensen & Kyhn, 2000), so does the presence of enrichments (Vinke *et al.*, 2005; Oesterwind *et al.*, 2016). Consequently, the goats should display greater frequencies of locomotor play when enrichments were accessible, which they did. Repeated exposure to the enriched treatment resulted in habituation to the enrichments and, as a result, the amount of time spent performing locomotor play decreased.

The frequency of object play was not seen to be significantly affected by the repeated exposure to the two conditions in the current experiment. However, playfully moving objects around (Move object.1-0.) declined in frequency over time. Bøe *et al.* (2012) reported a declining interest in branches over time (23 days) in 20 Norwegian dairy goats. Enrichment-directed behaviours in eight individually kept domestic horses (*Equus caballus*) declined rapidly in frequencies over time (4-5 h), however, six groups containing 3-6 individuals did not differ significantly in the frequencies of enrichment-directed behaviours between day 1 and day 4 (Jørgensen *et al.*, 2011). In this study, enrichment-directed behaviours includes object manipulation and movements of objects (Jørgensen *et al.*, 2011). Consequently, the decline in movement of objects over repeated exposures to treatments

over time in the current experiment coincide with the results of previous studies, and is most likely an effect of habituation.

However, as object play (array) and oral manipulation (component) was not seen to be significantly affected by repeated exposures to the control and enriched conditions, interest could possibly be maintained if the enrichments are not continuously available. In pigs, interest in enrichments were reported to be maintained for longer if they were rotated rather than when they were continuously available (Gifford *et al.*, 2007; Trickett *et al.*, 2009). Gifford *et al.* (2007), who studied the novelty effect of enrichments in 36 5-week-old pigs, suggest to limit the availability to enriching objects to two days or less and waiting at least a week before re-exposure, as it might maintain the novelty effect for longer. This rotation of enriching objects is also thought to be of importance for kennelled, adult dogs (*Canis familiaris*) to keep interest in provided toys (Wells, 2004).

As predicted, the frequencies of agonistic interactions changed due to the repeated exposure. However, in contrast to my prediction, there was no clear trend line and the difference in frequencies between the two treatments did not declined over time, thus earlier exposures had similar frequencies as later exposures. Loberg *et al.* (2004) found, when four groups of 13 dairy cows were given different levels of access to an outdoor enclosure (1 h access once, twice, seven times a week or not at all) over a six months period, that cows with more restricted access (less exposure) had a greater frequency of agonistic interactions per individual than those who had access to the enclosure more frequently (Loberg *et al.*, 2004). In contrast, Bøe *et al.* (2012) reported higher frequencies of agonistic interactions in 20 1-2 year old Norwegian dairy goats when given access to an outdoor enclosure for 23 days. However, the frequency was not reported to decline in relation to the repeated exposure (P<0.10).

The frequency of exploration and novelty is closely related (Gifford *et al.*, 2007; Tarou & Bashaw, 2007). Anything new must be explored to determine whether or not it may be dangerous (Hutt, 1966, cited in Pellegrini et al., 2007). As the individual becomes habituated to the object/individual, the need for exploration declines. Even though the repeated exposure to the treatments had an affect on the frequency of exploration, it was unexpected that there was no clear trend in the data. In contrast, Bøe *et al.* (2012) reported a decline in the interest in branches in 20 Norwegian dairy goats after being exposed to the enrichment for 23 day, and Van de Weerd *et al.* (2003) observed a decrease of exploration of the various 74 objects examined over 5 days

in 222 groups of three weaning pigs and 222 groups of three growing pigs when trying to find appropriate environmental enrichments to stimulate exploratory behaviour. Additionally, Loberg *et al.* (2004) noted that groups of cattle, 13 individuals per group, with access to an outdoor enclosure only one or two days per week displayed greater frequencies of exploration than cattle with continuous access to an outdoor enclosure over a six-months period. In studies of pigs, a decrease of exploration after repeated exposure was even reported when enrichments were rotated (Gifford *et al.*, 2007; Trickett *et al.*, 2009) or replaced (Wood-Gush & Vestergaard, 1991). It is possible external variables, such as the weather, caused enough variation to maintain the level of exploration. Another explanation could be that the rotation of the control and enriched condition was sufficient enough to counteract the effect of the repeated exposure to the treatments and therefor maintain a level of exploration over time. Further testing is required to properly evaluate these results.

The difference between tail wagging in the two treatments declined as the goats repeatedly experienced both conditions, which is to be expected as it correlates closely with the presence of social play and locomotor play. However, the frequency change in tail wagging does not resemble those differences in social- and locomotor play. To my knowledge, there are no other studies that report a change in frequency of tail wagging as a result of repeated exposure to the presence or absence of environmental enrichments.

As control conditions offered few possibilities to perform climbing, the behaviour was mostly observed under control conditions. Even so, climbing was performed in greater frequencies in earlier rather than later exposures and the difference between the two treatments declined over time, which is likely due to habituation.

It is important to note that any results and suggestions only apply to the composition of environmental enrichment presented in the current study.

6.3 Group size experiment

6.3.1 Effect of group size general activity levels (H1, Model 4)

In Mohammed and Mohamed (2013), group size significantly affected most of the behavioural variables examined in 28 castrated male goats. However, in the current study, group size did not have a significant effect on the activity levels of many behavioural variables. The

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proportion of time spent playing in young, female Norwegian dairy goats increased with increasing group size. However, no significant relationship between the group size and the frequency of (social- and locomotor) play behaviour per individual dairy calves (n = 84) were reported in Færevik *et al.* (2007), who studied the effect of group size and familiarity influence in mixed groups of 4, 8 and 16 male and female animals over three occasions (1, 3, and 11 days after grouping). Nevertheless, the positive relationship between the proportion of time spent playing and group size could possibly be explained by the increased chance of social contagion due to increased population density (McDougall & Ruckstuhl, 2018), better group vigilance (Roberts, 1996) resulting in more relaxed individuals, and more opportunities to initiate play bouts. However, further studies are required to find how group size affects play behaviour, and not only in goats but all farm animals.

In contrast to my prediction, the proportion of time spent on long-term survival activities, such as exploring the surroundings and lying, did not differ significantly between treatments. Færevik *et al.* (2007) found no significant effect on the frequency of resting (= Lie.1-0.) in relation to group size in groups of dairy calves, and Andersen *et al.* (2011) reported no significant effect of group size (group sizes 6, 12, and 24) on the frequency of exploration in 2-5 year old Norwegian dairy goats after a week-long exposure to each group size. By contrast, Mohammed and Mohamed (2013) reported that the frequency of lying per group of castrated male Balady goats (n =28) decreased as group size increased (from 4, 6, 8, to 10 individuals) in a three month study. Note that Mohammed and Mohamed (2013) lacks replications of the results in the different groups sizes. Perhaps longer studies, with more exposure to the different group sizes, are required to see significant changes in the frequencies of exploration and lying in response to group size? Or, the lack of replications in Mohammed and Mohamed (2013) confound their results, and group size do in fact not affect the frequency of exploration and lying.

Standing, on the other hand, was found to decrease in proportion of time before levelling off in response to group size, the three largest group sizes (6-8 goats/group) had very similar frequencies of standing. Goats increase the distances between nearest neighbours in response to increasing spatial allowance (Vas & Andersen, 2015). Consequently, the declining frequency of standing in the current study could be due to the increased density in larger group sizes, which leads to the goats moving more often to avoid others. However, Loretz *et al.* (2004) reported no significant difference in the frequencies of individual

displacements in female goats as an effect of group size. Still, perhaps the increased opportunity of behavioural contagion, due to the reduced spatial allowance per individual (McDougall & Ruckstuhl, 2018), resulted in less individuals standing when activity levels increased (see discussion of play above) in response to increasing group size?

Foraging was reported to have a lower frequency under high population densities (1 m^2) in nine groups of six pregnant Norwegian dairy goats, when compared to medium population densities (2 m^2) (Vas & Andersen, 2015). However, the frequency of foraging did not differ significantly between low population density (3 m^2) and high population density conditions (1 m^2). In the current experiment, foraging varied over group sizes, but the frequency per individual was generally higher in larger group sizes. Thus, it is doubtful the population density had any effect on foraging in this experiment. Mohammed and Mohamed (2013) reported an increase in foraging frequency per group of castrated male balady goats (n =28) in response to an increase in group size (from 4, 6, 8, to 10 individuals) over a three month study. However, this study lacks replicates (Mohammed & Mohamed, 2013), and Færevik *et al.* (2007) reported no significant effects of group size on feeding rates in dairy calves. The results of the current experiment indicate that group size does affect feeding rates, but that this effect might vary.

One of the benefits of living in groups is group vigilance (Davies *et al.*, 2012 p. 147-178), an increase of group size often result in a corresponding decrease of the amount of time spent vigilant per individual (Roberts, 1995). The results of the current experiment support this, as the amount of time each goat spent vigilant decreased with increasing group size. This result agrees with Elgar (1989) who stated that the need for vigilance was reduced with increased group size. It also agrees with the finding of Roberts (1995) who found that the frequency of vigilance in a colony of crested terns changed continuously in respond to variations in group sizes, and that when the group size was low the terns increased the frequency of vigilant behaviour.

It is important to note that in the current experiment, subjects only experienced the different group sizes for a short time period (30 min x 4/week for three weeks) and had different levels of exposure each group size (Appendix 4), while the subjects in the studies described in this section experienced the group sizes continuously as they were housed according to their treatment. It is, therefore, possible the effects of

group size in the current study could be different or less significant than those reported in previous studies.

6.3.2 **Effect of group size on social tolerance (H2, Model 5)**

The present experiment indicate that the social tolerance of young Norwegian dairy goats was not affected by group size, even though social play and object play were seen to significantly change in relation to group size.

As previously stated, few studies have examined the effects of group size on play behaviours. To my knowledge, only one study by Færevik *et al.* (2007) on dairy cows examines how group size (4, 8, 16 individuals) affect different types of play behaviour (social- and locomotor play). Moreover, this study did not find a significant correlation between the size of the groups and the frequencies of the different play types (Færevik *et al.*, 2007). Consequently, further examination is required to fully determine how play is affected by group size. In the present experiment, the frequency of social play in Norwegian dairy goats was seen to vary significantly between group sizes ranging from 2-8 individuals. Furthermore, the frequency of object play per individual also increased with increasing group size. Explanations for these positive correlations could be increased behavioural contagion due to increased density (McDougall & Ruckstuhl, 2018) or because larger groups results in more opportunities for goats to play together as the number of possible playmates increases. Additionally, benefits of living in groups (i.e. group defence and vigilance) becomes more effective in larger groups that could result in individuals feeling more secure and this could stimulate play (Spinka *et al.*, 2001). The decrease in vigilance reported in the section (5.3.1) above supports this hypothesis.

Group size is known to affect the frequency of agonistic interactions, but the effect varies. In domestic chickens, the frequency of aggression has been reported to both increase (Al-Rawi & Craig, 1975) and decrease (Hughes *et al.*, 1997) as group size increases. The different effects are most likely due to the variations in the tested group sizes, in example: compared to Hughes *et al.* (1997), who increased the group size from 300 to 600 individual laying hens, the group sizes examined in Al-Rawi and Craig (1975), 4, 8, 14 and 28 chickens, are rather small. In very large group sizes, such as those in Hughes *et al.* (1997), the individuals would probably have difficulties with individual recognition and, therefore, be more social tolerant. While smaller group sizes, such as those examined in Al-Rawi and Craig (1975), a social hierarchy

could easily be established and maintained, resulting in less tolerant individuals and more agonistic interactions. This Tolerance hypothesis (Estevez *et al.*, 1997), has been reported in both domestic pigs (Turner *et al.*, 2001) and broiler chickens (Estevez *et al.*, 1997).

In domestic goats, three studies (Van *et al.*, 2007; Mohammed & Mohamed, 2013; Sabek *et al.*, 2017) report aggression frequencies per individual and per group increase with increasing group sizes, while one study by Andersen *et al.* (2011) report declining social interactions with increasing group size. It is important to note, however, that the latter study (Andersen *et al.*, 2011) do not distinguish between agonistic social interactions and other social interactions (i.e. playing and social grooming). Additionally, the conclusions of Andersen *et al.* (2011) are based on limited replications. In the current experiment, the frequency of aggressive interactions per individual goat did not differ significantly between treatments, in contrast to my prediction. This result is in accordance with that of Kondo et al. (1989) who examined how group sizes affected the individual frequency of agonistic interactions and mean distance to nearest neighbour in calves and cattle. In adult cattle, Kondo *et al.* (1989) reported that the frequency of agonistic interactions increased with increasing group size (ranging from 8-81 individuals). However, no such relationship was found when examining the effects of group sizes ranging from 2-12 individuals in 6-13 months old calves, individuals in the approximately same life stage as the subjects. The lack of correlation between aggression frequency and group size could be explained by a lack of fully established social hierarchy. According to Orgeur *et al.* (1990), male domestic goats first assume a rank in the social hierarchy of a herd when they are 6 months old. The individuals in the current experiment were between 6-8 months old at the start of the study, and it could be possible female goats start competing for social ranks later than males. However, as the goats were all housed together in one home pen, a more likely explanation would be that the social hierarchy was already established, resulting in a reduced need for aggression regardless of the variation in group size. Subsequently, the results of the current study do not indicate an increased social tolerance in larger groups.

6.4 Confinement length experiment

6.4.1 Effect of indoors confinement length on behavioural performances in an outdoor enclosure (H1, Model 6 and 7)

Even though the analyses of Model 6 and 7 resulted in a total of 11 significant results, these behavioural variables rarely displayed an obvious response to confinement length.

Contrary to my predictions, increasing confinement length did not increase the frequency of play behaviours. Both play (Play.Inst.) and the subcategory social play (Social play.1-0.) decreased as the length of indoor confinement increased. The amount of time spent playing (Play.Inst.) delined linearly with increasing length of confinement. While social play varied between confinement lengths, it usually had lower frequencies after longer confinements and higher frequencies after shorter confinements. On the other hand, Holloway and Suter (2004) reported an increase of social play frequency after a 14-day long deprivation in three experiments of rats with controls for pen size and opportunities to perform physical activities outside of social play. Consequently, the social play result of the current study does not coincide with that of Holloway and Suter (2004). Nor does it coincide with the (although not statistically analysed) results of Chepko (1971), who found signs of social play increasing in pairs infant goats in response to play deprivation.

Even though object play (Object play.1-0.) was not significantly affected by the confinement length, the results of its components (Oral manipulation.1-0. and Move object.1-0.) were both significant. Oral manipulation varied after different lengths of confinement, but longer confinement lengths usually had lower frequencies than shorter confinement lengths. Moving objects on the other hand, varied a lot between confinement lengths, similar to the results of locomotor play. A greater frequency of locomotor play has been reported to follow both longer confinements (Jensen, 1999) and more constricting housing (Dellmeier *et al.*, 1985) in calves. Jensen (1999) confined 36 calves and 48 heifers, which were used to large pens, in smaller pens either for a duration of four weeks, two weeks, or one week, or they stayed in a similar sized pen as they were used to. They reported that individuals, who were confined for longer, displayed a significantly higher frequency of locomotor play compared to those confined for a shorter period. Dellmeier *et al.* (1985) found that 46 individually housed calves, which were housed under four different levels of confining enclosures (Stalls – most constricting, pens, hutches, and yards – least

constricting), displayed more locomotor play after being released from the most confining enclosure type. In other words, the results of the current study oppose those of previous experiments in calves.

A possible explanation for the lack of increased rebound effect after longer confinement lengths is based on methodology. As previously stated, fixed groups of subjects of the current study were collected from their home pen, walked 170 m to the outdoor enclosure, and held in a corridor for approximately 2 min before entering the test area. This means the subject had opportunities to perform play and other motivated behaviours before they were observed in the outdoor enclosure. As a consequence, any changes in behavioural frequencies observed in this experiment may represent a rebound of any rebound effect that occurred on the way to the outdoor enclosure. This might also explain why the proportion of time spent standing and spent vigilant increases as length of confinement increased, and why agonistic interactions (1-0), exploration frequency (1-0) and the proportion time spent lying (instantaneous scans) varies significantly in different confinement lengths. Dellmeier *et al.* (1985) found no significant effect of the different confining levels of housing conditions on the total amount of time spent standing in calves after five weeks of exposure to the different treatments.

Increased nervousness as a response to longer confinement lengths could be another explanation for the current results. All groups were exposed to the different lengths of confinement, but different groups experienced the confinement lengths at different times. As a consequence, the goats could notice that some individuals were allowed outside at different days and, as the lengths of confinement varied per individual, it would be hard to predict when they would be allowed outside. This unpredictability could have caused the goats to become more nervous as the confinement length increased, which could have affected their behaviour in the outdoor enclosure. Furthermore, as this experiment took place in November-December 2017, the weather might have affected the goats' interest to visit the outdoor enclosure. The frequency of play are known to be affected by food availability (Brown *et al.*, 2015), when less food becomes available play frequency decrease (i.e. white-tailed deer (*Odocoileus virginianus*; Muller-Schwarze *et al.*, 1982) and meerkats (*Suricata suricatta*; Sharpe *et al.*, 2002)). Therefore, the cold weather and the lack of foliage could have reduced their interest and, as a consequence, affected their behaviour when outdoors. Further studies could observe indoor behaviour and the behaviours displayed on the way to the outdoor enclosure to find out more.

6.5 **Age and weight gain**

6.5.1   **Age (H1, Model 8)**

Play typically follows an inverted U-curve over an animal's life span and its peak is located during the animal's juvenile period (Pellegrini *et al.*, 2007). As young animals have more to learn about their environment, one of the possible adaptive values of play, than older animals do, younger individuals would be expected to play more than older individuals in the current study. However, none of the variables included in Model 8 were significantly affected by the subjects' age.

When studying the effects of heterogeneous and homogenous age groups in 72 Norwegian dairy goats on the distance between individuals while resting and foraging, Bøe *et al.* (2013) found no significant effect of age on the distance between goats. Half of the goats in the study of Bøe *et al.* (2013) were younger individuals (< 2 years) and the other half were older individuals (> 3 years), they were divided into six homogenous groups of younger goats, six homogenous groups of older goats, and six heterogeneous groups consisting of four individuals of different ages (Bøe *et al.*, 2013). Das *et al.* (2000) reported a decline of cross-suckling as the 36 calves grew older, observed at 1 month and 6 month of age. Additionally, exploration and play were seen to increase as the calves grew older (Das *et al.*, 2000). Chepko (1971), on the other hand, reported that the age range used in their experiment on play deprivation in goats was not wide enough to be significant. The goats were 11-12 days, 18 days and 24 days old.

In consequence, the lack of effect of age on the behavioural frequencies over the whole study is in contrast with previous findings on play behaviour (Hinde, 1966 p. 239; Fagen, 1981 p. 359; Bekoff & Allen, 1998 p. xiii). It is possible the age difference between the individuals, all of which were of the same cohort, was too limited to gain significant results, similar to the conditions found in Chepko (1971).

6.5.2   **Weight gain (H2, Model 9)**

As animals grow older, their size tends to increase as they gain weight. The data collection lasted for three months in the current study, during which all subject were weighed three times: at the beginning of the data collection, before the eight individuals were removed from the herd, and at the end of the data collection period. The individuals' weight gain was found by calculating the difference between the first and last measurements of their weights (between weight at start and weight at

end of data collection). How this weight gain was affected by the individuals' behaviour over the whole study was examined in Model 9, which found only one significant effect. The frequency of object play was significantly associated with the weight gain of the 20 subjects in the current study. The correlation coefficient from Model 10 indicates a positive relationship between the two.

Few studies have examined the effects of behavioural frequencies on weight gain, especially with the focus on play behaviours. Most studies seem to focus on how weight gain responds to a treatment and rarely include how the behavioural frequencies affect the growth. Some non-play behaviours have been reported to correlate with weight gain, including the number of lying periods in 80 heifers (Mogensen *et al.*, 1997) and aggression in pigs (Stookey & Gonyou, 1994; D'Eath, 2002). High levels of aggression, often a result of mixed groups of familiar and unfamiliar individuals in pigs (Stookey & Gonyou, 1994; D'Eath, 2002), cause the feed-intake to decline as individuals must be more vigilant to avoid agonistic interactions are more often displaced, which again reduced the weight gain.

Brown *et al.* (2015) investigated whether variations in play behaviour could affect measures of pre- and postnatal development in seven litters of domestic pigs in a three-week study. They found that birth weight positively correlated with the total amount of play per individual. Additionally, postnatal growth (% of birth weight) to the age of weaning was reported to be positively associated with both the total amount of play per individual and the frequencies of individual play categories per pig, including object play (Brown *et al.*, 2015).

It is possible play, including object play, stimulates appetite, which could lead to a greater feed-intake and growth. It is also possible playful animals are more relaxed and, thus, they grow at a faster rate than stressed animals. Nevertheless, it would be interesting to see if the current results could be replicated in future studies.

6.6 Correlations between variables over the whole study period (Model 10)

Tail wagging is considered by goat caretakers to be a sign of content or enjoyment in goats (A. Klouman, staff engineer, Senter for husdyr forskning, personal communication, 2016). In the current study, it was rarely found to be significantly affected by the treatments in the three experiments, but it correlated positively with social play, object play and exploration. Thus, tail wagging is not a sign of play on its own, but seems to be an indication of enjoyment. Perhaps goats wag

their tails as a way of maintaining or reinitiate play with other individuals or to draw the attention of others to the object they play with? As tail wagging was also positively correlated with exploration, it could possibly also indicate curiosity. To my knowledge, changes in the frequency of tail wagging have not been investigated in any studies of goats previously.

Locomotor play and climbing correlated significantly with one another throughout the whole study. Climbing was rarely significantly affected by the treatments in any of the experiments, but both locomotor play and climbing was almost exclusively seen under enriched conditions in the Environmental enrichment experiment. Probably the presence of objects that allowed for more opportunities to climb (i.e. a bridge) stimulated locomotor play in Norwegian dairy goats.

6.7 Limitations and future studies

In all experiments, the subjects experienced the different treatments a limited number of times. In the Environmental enrichment experiment, the goats were exposed to each condition (control and enriched) six times. The number of times each individual experienced the different group sizes in the Group size experiment varied, but all individuals experienced the larger group sizes more frequently than the smaller ones. The exact number of times each individual visited the different group sizes can be found in Appendix 4. In the Confinement length experiment, each individual only experienced the different indoor confinement lengths once. Additionally, as the outdoor enclosure was located near a hilltop, the subjects had a clear view to the surrounding areas and all of the environmental disturbances that occurred there. As a result of this limited exposure and the open surroundings, random factors might have had a significant effect on the study results. Future studies should try to limit this effect either by using a more secluded area, shielded from many disturbances, or by exposing the subjects to the different treatments for longer.

As all of the subjects were housed together in one home pen, and so they all knew one another and had probably already established a social ranking system for the whole herd of young individuals. This may have reduced the need for further agonistic interactions, even if the group composition varied. Subtle threats could be used to avoid confrontations. The threats might be subtle enough to be overlooked or short enough to be missed if not examined in detail. In consequence, some agonistic interactions (threats) might have been unconsciously overlooked or interpreted incorrectly, which may have affected the results.

As previously mentioned, the control condition in the Environmental enrichment experiment should have provided more features to direct climbing behaviours towards. In the current experiment, the goats only had the opportunity to climb on one another, which was a rare occurrence. This might have resulted in climbing to

almost exclusively have been observed under enriched conditions. Additionally, when testing for a rebound effect after a period of confinement, future studies should observe behaviour as soon as the animals leave their home pen.

Though weather details were recorded for the whole data collection period, due to time constraints, they were not analysed. Goats do not enjoy poor weather (A. Klouman, staff engineer, Senter for husdyr forskning, personal communication, 2016), as seen in Chepko (1971) when the goat kids elected to stay in a shelter due to heavy rain even after being deprived of play behaviour 24 hours before. Thus, differences in weather conditions would most likely affect the results of the current study, and future outdoor studies should take weather variables into account.

The data in the current study could be used to investigate individual differences and the effect of the individual environmental enrichments on the behavioural variables. Time constraints prevented this. Nevertheless it would be very interesting if future studies investigated these effects.

6.8 **Conclusion**

Studies on the ethology of goats are scarce and very few focus on play behaviour. Consequently, scientific results must be compared to those from other species, and precise conclusions are harder draw. Therefore, further studies on goats and play behaviour are needed to fill the scientific gaps of knowledge. However, future studies should also take care to distinguish between agonistic interactions and social interactions, like play. The current study found no correlation between agonistic interactions and social play, and their frequencies rarely followed similar trends. This indicates it should be possible for future studies to distinguish between the two behaviours.

In the present study, play and other behaviours in Norwegian dairy goats were affected by common production procedures that results in changes to the animals' environment. All of the environmental changes examined in this study (addition of environmental enrichments, differences in group sizes and confinement lengths) had an effect on play behaviour, which might affect the goats' welfare and, therefore, their production values.

The results of the environmental enrichment experiment demonstrate that regulated access to various enrichments (a bridge, hanging ball and a bucket of sticks) increases the level of play and exploration in Norwegian dairy goats. Enriched conditions also resulted in lower levels of aggressive interactions and inactive behaviours. The effect of the enrichments is, however, often affected by repeated exposure, so changing the added enrichment could be beneficial to maintain the level of interest.

The group size experiment results indicate that group size only affected some proportions of time domestic goats spent on different long-term survival activities, and that vigilance decreases in response to group size. Additionally, as the frequency of (social- and object) play in Norwegian dairy goats increases in response to increasing group size, larger groups lead to greater opportunities for social interactions. However, as agonistic interactions were not seen to be affected by group size, the current results do not indicate a higher social tolerance in larger groups of goats.

The Confinement length experiment did not find any results that indicates a perception of greater positive contrast in environmental conditions when goats were given access to an outdoor enclosure after being confined indoors for a longer time periods. In fact, the current results indicate an opposite effect - greater activity after shorter confinement lengths.

7. References

Abou-Ismail, U. A. (2011). Are the effects of enrichment due to the presence of multiple items or a particular item in the cages of laboratory rat? *Applied Animal Behaviour Science*, 134 (1): 72-82. doi: https://doi.org/10.1016/j.applanim.2011.06.007.

Abou-Ismail, U. A., Burman, O. H. P., Nicol, C. J. & Mendl, M. (2010). The effects of enhancing cage complexity on the behaviour and welfare of laboratory rats. *Behavioural Processes*, 85 (2): 172-180. doi: https://doi.org/10.1016/j.beproc.2010.07.002.

Abou-Ismail, U. A. & Mendl, M. T. (2016). The effects of enrichment novelty versus complexity in cages of group-housed rats (Rattus norvegicus). *Applied Animal Behaviour Science*, 180: 130-139. doi: https://doi.org/10.1016/j.applanim.2016.04.014.

Al-Rawi, B. & Craig, J. V. (1975). Agonistic behavior of caged chickens related to group size and area per bird. *Applied Animal Ethology*, 2 (1): 69-80. doi: https://doi.org/10.1016/0304-3762(75)90066-8.

Aldezabal, A. & Garin, I. (2000). Browsing preference of feral goats (Capra hircus L.) in a Mediterranean mountain scrubland. *Journal of Arid Environments*, 44 (1): 133-142. doi: https://doi.org/10.1006/jare.1999.0573.

Andersen, I. L. & Bøe, K. E. (2007). Resting pattern and social interactions in goats – The impact of size and organization of lying space. *Applied Animal Behaviour Science*, 108 (1): 89-103.

Andersen, I. L., Roussel, S., Ropstad, E., Braastad, B. O., Steinheim, G., Janczak, A. M., Jørgensen, G. H. M. & 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 Behaviour Science*, 114 (1): 132-148.

Andersen, I. L., Tønnesen, H., Estevez, I., Cronin, G. & Bøe, K. (2011). The relevance of group size on goats' social dynamics in a production environment. *Applied Animal Behaviour Science*, 134 (3-4): 136-143. doi: https://doi.org/10.1016/j.applanim.2011.08.003.

Barber, N. (1991). Play and energy regulation in mammals. *The quarterly review of biology*, 66 (2): 129-147. doi: https://doi.org/10.1086/417142

Barnard, C. (2004). *Animal behaviour: Mechanism, development, function and evolution*. Essex, UK: Pearson Education Limited. 760 pp.

Barnes, J. (2013). *Essential biological Psychology*. London, UK: SAGE Publications Ltd. 416 pp.

Barrett, L., Dunbar, R. I. M. & Dunbar, P. (1992). Environmental influences on play behaviour in immature gelada baboons. *Animal Behaviour*, 44 (1): 111-115. doi: http://doi.org/10.1016/S0003-3472(05)80760-2.

Barroso, F. G., Alados, C. L. & Boza, J. (2000). Social hierarchy in the domestic goat: Effect on food habits and production. *Applied Animal Behaviour Science*, 69 (1): 35-53.

Beauchamp, G. (2013). Is the magnitude of the group-size effect on vigilance underestimated? *Animal Behaviour*, 85 (1): 281-285. doi: https://doi.org/10.1016/j.anbehav.2012.10.023.

Bekoff, M. (1977). Mammalian dispersal and the ontogeny of individual behavioral phenotypes. *The American Naturalist*, 111 (980): 715-732. doi: https://doi.org/10.1086/283201

Bekoff, M. (1984). Social play behaviour. *BioScience*, 34 (4): 228-233. doi: https://doi.org/10.2307/1309460.

Bekoff, M. & Allen, C. (1998). Intentional communication and social play: How and why animals negotiate and agree to play. In Bekoff, M. & Byers, J. A. (eds) *Animal Play: Evolutionary, Comparative, and Ecological Perspectives*, pp. 97-114. Cambridge, UK: Cambridge University Press.

Bekoff, M. & Byers, J. A. (1981). A critical reanalysis of the ontogeny and phylogeny of mammalian social and locomotor play: An ethological hornet's nest. In Immelmann, K., Barlow, G. W., Petrinovich, L. & Main, M. (eds) *Behavioral Development: The Bielefeld Interdisciplinary Conference*, pp. 296-337. New York: Cambridge University Press.

Bekoff, M. & Byers, J. A. (eds). (1998). *Animal play: Evolutionary, comparative, and ecological perspectives*. New York, NY, US: Cambridge University Press. 274 pp.

Belsky, J. & Most, R. K. (1981). From exploration to play: A cross-sectional study of infant free play behavior. *Developmental Psychology*, 17 (5): 630-639. doi: https://doi.org/10.1037/0012-1649.17.5.630

Berge, K. (2010). *Notat om økologisk sau med fokus på velferd og bygningskrav [Note of ecological sheep with focus on welfare and building requirements]*. Landbruksrådgiving, N. https://www.mattilsynet.no/planter_og_dyrking/okologisk/landbruk/regelverksutvalget _for_okologisk_produksjon.5587 [online] Accessed 02.04.18: Mattilsynet. 4 pp.

Berkhout, P. H. G., Muskens, J. C. & W. Velthuijsen, J. (2000). Defining the rebound effect. *Energy Policy*, 28 (6): 425-432. doi: https://doi.org/10.1016/S0301-4215(00)00022-7.

Binik1. (2018). *Stick figure man writing or making notes*. [online] https://www.dreamstime.com/stock-illustration-stick-figure-man-writing-making-notes-vector-image86014065: dreamstime.com.

Blackshaw, J. K., Swain, A. J., Blackshaw, A. W., Thomas, F. J. M. & Gillies, K. J. (1997). The development of playful behaviour in piglets from birth to weaning in three farrowing environments. *Applied Animal Behaviour Science*, 55 (1): 37-49. doi: http://dx.doi.org/10.1016/S0168-1591(97)00034-8.

Brown, S. M., Klaffenböck, M., Nevison, I. M. & Lawrence, A. B. (2015). Evidence for litter differences in play behaviour in pre-weaned pigs. *Applied Animal Behaviour Science*, 172: 17-25. doi: https://doi.org/10.1016/j.applanim.2015.09.007

Bryant, M. J. & Ewbank, R. (1972). Some effects of stocking rate and group size upon agonistic behaviour in groups of growing pigs. *British Veterinary Journal*, 128 (2): 64-70. doi: https://doi.org/10.1016/S0007-1935(17)37133-6.

Buchenauer, D. (1981). Parameters for assessing welfare, ethological criteria. In Sybesma, W. (ed.) *The Welfare of Pigs: A Seminar in the EEC Programme of Coordination of Research on Animal Welfare held in Brussels, November 25–26, 1980*, pp. 75-94. Dordrecht, Netherlands: Springer.

Burgdorf, J. & Panksepp, J. (2006). The neurobiology of positive emotions. *Neuroscience & Biobehavioral Reviews*, 30 (2): 173-187. doi: http://doi.org/10.1016/j.neubiorev.2005.06.001.

Byers, J. A. (1977). Terrain preferences in the play behavior of Siberian ibex kids (Capra ibex sibirica). *Zeitschrift für Tierpsychologie*, 45 (2): 199-209. doi: https://doi.org/10.1111/j.1439-0310.1977.tb02117.x [URL: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1439-0310.1977.tb02117.x].

Bøe, K. E., Berg, S. & Andersen, I. L. (2006). Resting behaviour and displacements in ewes – Effects of reduced lying space and pen shape. *Applied Animal Behavioural Science*, 98 (3-4): 249-259. doi: https://doi.org/10.1016/j.applanim.2005.10.001

Bøe, K. E., Ehrlenbruch, R. & Andersen, I. L. (2012). Outside enclosure and additional enrichment for dairy goats – a preliminary study. *Acta Veterinaria Scandinavica*, 54 (1): 68. doi: https://doi.org/10.1186/1751-0147-54-68

Bøe, K. E., Ehrlenbruch, R., Jørgensen, G. H. M. & Andersen, I. L. (2013). Individual distance during resting and feeding in age homogeneous vs. age heterogeneous groups of goats. *Applied Animal Behaviour Science*, 147 (1): 112-116. doi: https://doi.org/10.1016/j.applanim.2013.04.024.

Cadblocksfree. (2015). *North Arrow (single 3)*. [online] https://www.cadblocksfree.com/en/north-arrow-single-3.html: Cadblocks free.

Campbell, I. W. (1976). The somogyi phenomenon. A short review. *Acta diabetologia latina*, 13 (1-2): 68-73. doi: https://doi.org/10.1007/bf02591583

Chapagain, D., Uvnäs-Moberg, K. & Lidfors, L. M. (2014). Investigating the motivation to play in lambs. *Applied Animal Behaviour Science*, 160: 64-74. doi: http://doi.org/10.1016/j.applanim.2014.08.004.

Chepko, B. D. (1971). A preliminary study of the effects of play deprivation on young goats. *Zeitschrift für Tierpsychologie*, 28 (5): 517-526. doi: http://dx.doi.org/10.1111/j.1439-0310.1971.tb00835.x [URL: https://onlinelibrary.wiley.com/doi/full/10.1111/j.1439-0310.1971.tb00835.x].

Côté, S. (2000). Dominance hierarchies in female Mountain goats: Stability, aggressiveness and determination of rank. *Behaviour*, 137 (11): 1541-1566. doi: https://doi.org/10.1163/156853900502718.

D'Eath, R. B. (2002). Individual aggressiveness measured in a resident-intruder test predicts the persistence of aggressive behaviour and weight gain of young pigs after mixing. *Applied Animal Behaviour Science*, 77 (4): 267-283. doi: https://doi.org/10.1016/S0168-1591(02)00077-1.

Das, S. M., Redbo, I. & Wiktorsson, H. (2000). Effect of age of calf on suckling behaviour and other behavioural activities of Zebu and crossbred calves during restricted suckling periods. *Applied Animal Behaviour Science*, 67 (1): 47-57. doi: https://doi.org/10.1016/S0168-1591(99)00115-X.

Davies, N. B., Krebs, J. R. & West, S. A. (2012). *An introduction to behavioural ecology*. 4th ed. Oxford, UK: Wiley-Blackwell. 506 pp.

Dawkins, M. S. (2006). A user's guide to animal welfare science. *Trends in Ecology & Evolution*, 21 (2): 77-82. doi: https://doi.org/10.1016/j.tree.2005.10.017

Dellmeier, G. R., Friend, T. H. & Gbur, E. E. (1985). Comparison of four methods of calf confinement. II. Behavior. *Journal of Animal Science*, 60 (5): 1102-1109. doi: https://doi.org/10.2527/jas1985.6051102x

Dobao, M. T., Rodrigañez, J. & Silio, L. (1985). Choice of companions in social play in piglets. *Applied Animal Behaviour Science*, 13 (3): 259-266. doi: http://dx.doi.org/10.1016/0168-1591(85)90049-8.

Elgar, M. A. (1989). Predator vigilance and group size in mammals and birds: A critical review of the empirical evidence. *Biological Reviews*, 64 (1): 13-33. doi: https://doi.org/10.1111/j.1469-185x.1989.tb00636.x

Estevez, I., Andersen, I.-L. & Nævdal, E. (2007). Group size, density and social dynamics in farm animals. *Applied Animal Behaviour Science*, 103 (3): 185-204. doi: https://doi.org/10.1016/j.applanim.2006.05.025.

Estevez, I., Newberry, R. C. & De Reyna, L. A. (1997). Broiler chickens: A tolerant social system? *Etologia*, 5 (5): 19-29. doi: none [URL: https://www.researchgate.net/publication/260602632].

Fagen, R. (1981). *Play animal behaviour*. New York: Oxford University Press. 684 pp.

FAO. (2015). *FAO Statistical Pocketbook 2015 World Food and Agriculture*. FAO Rome: Food & Agriculture Organization of the United Nations (FAO). 236 pp.

Fraser, D. & Duncan, I. J. H. (1998). 'Pleasures','pains' and animal welfare: Toward a natural history of affect. *Animal Welfare*, 7 (4): 383-396. doi: none [URL: https://www.researchgate.net/publication/233698105_%27Pleasures%27%27Pains%27_and_Animal_Welfare_Toward_a_Natural_History_of_Affect?ev=publicSearchHeader&_sg=u0N5Ey4irnYTI2_mZcOFL2qjrKPAgDV1HMrGyPc4-RC1Xjc7Vb0Nu8hRBwmj84tnAD0pyibpksXFMFE].

Færevik, G., Andersen, I. L., Jensen, M. B. & Bøe, K. E. (2007). Increased group size reduces conflicts and strengthens the preference for familiar group mates after regrouping of weaned dairy calves (Bos taurus). *Applied Animal Behaviour Science*, 108 (3): 215-228. doi: https://doi.org/10.1016/j.applanim.2007.01.010.

Gifford, A. K., Cloutier, S. & Newberry, R. C. (2007). Objects as enrichment: Effects of object exposure time and delay interval on object recognition memory of the domestic pig. *Applied Animal Behaviour Science*, 107 (3): 206-217. doi: https://doi.org/10.1016/j.applanim.2006.10.019.

Hass, C. C. & Jenni, D. A. (1993). Social play among juvenile Bighorn sheep: Structure, development, and relationship to adult behavior. *Ethology*, 93 (2): 105-116. doi: https://doi.org/10.1111/j.1439-0310.1993.tb00982.x

Hinde, R. A. (1966). *Animal behaviour: a synthesis of Ethology and Comparative psychology* New York, USA: McGraw-Hill. 534 pp.

Hole, G. (1991). The effects of social deprivation on levels of social play in the laboratory rat (Rattus norvegicus). *Behavioural Processes*, 25 (1): 41-53. doi: https://doi.org/10.1016/0376-6357(91)90044-Z.

Holloway, K. S. & Suter, R. B. (2004). Play deprivation without social isolation: Housing controls. *Developmental Psychobiology*, 44 (1): 58-67. doi: https://doi.org/10.1002/dev.10151

Hughes, B. O., Carmichael, N. L., Walker, A. W. & Grigor, P. N. (1997). Low incidence of aggression in large flocks of laying hens. *Applied Animal Behaviour Science*, 54 (2): 215-234. doi: https://doi.org/10.1016/S0168-1591(96)01177-X.

Hutt, C. (1966). Exploration and play in children. *Symposia of the Zoological Society of London*, 18: 61-81. Cited by Pellegrini & Smith 2007.

Jensen, M. B. (1999). Effects of confinement on rebounds of locomotor behaviour of calves and heifers, and the spatial preferences of calves. *Applied Animal Behaviour Science*, 62 (1): 43-56. doi: https://doi.org/10.1016/S0168-1591(98)00208-1.

Jensen, M. B. & Kyhn, R. (2000). Play behaviour in group-housed dairy calves, the effect of space allowance. *Applied Animal Behaviour Science*, 67 (1–2): 35-46. doi: http://doi.org/10.1016/S0168-1591(99)00113-6.

Jensen, M. B., Vestergaard, K. S. & Krohn, C. C. (1998). Play behaviour in dairy calves kept in pens: The effect of social contact and space allowance. *Applied Animal Behaviour Science*, 56 (2–4): 97-108. doi: http://doi.org/10.1016/S0168-1591(97)00106-8.

Jørgensen, G. H. M., Hansen, I. & Bøe, K. E. (2016: 46). *Utredning økologisk produksjon - gulv til sau og alternative liggeunderlag [Review ecological production - Flooring of sheep and alternative bedding]*. NIBIO. https://www.mattilsynet.no/planter_og_dyrking/okologisk/landbruk/regelverksutvalget_for_okologisk_produksjon.5587 [online] Accessed 02.04.18: Mattilsynet. 48 pp.

Jørgensen, G. H. M., Liestøl, S. H.-O. & Bøe, K. E. (2011). Effects of enrichment items on activity and social interactions in domestic horses (Equus caballus). *Applied Animal Behaviour Science*, 129 (2): 100-110. doi: https://doi.org/10.1016/j.applanim.2010.11.004.

Kondo, S., Sekine, J., Okubo, M. & Asahida, Y. (1989). The effect of group size and space allowance on the agonistic and spacing behavior of cattle. *Applied Animal Behaviour Science*, 24 (2): 127-135. doi: https://doi.org/10.1016/0168-1591(89)90040-3.

Langbein, J., Siebert, K. & Nürnberg, G. (2009). On the use of an automated learning device by group-housed dwarf goats: Do goats seek cognitive challenges? *Applied Animal Behaviour Science*, 120 (3): 150-158. doi: https://doi.org/10.1016/j.applanim.2009.07.006.

Latham, N. & Mason, G. (2010). Frustration and perseveration in stereotypic captive animals: Is a taste of enrichment worse than none at all? *Behavioural Brain Research*, 211 (1): 96-104. doi: https://doi.org/10.1016/j.bbr.2010.03.018.

Lawrence, A. (1987). Consumer demand theory and the assessment of animal welfare. *Animal Behaviour*, 35 (1): 293-295. doi: http://doi.org/10.1016/S0003-3472(87)80236-1.

Lawrence, A., Newberry, R. & Spinka, M. (2017). *Positive welfare: What does it add to the debate over pig welfare?* Advances in Pig Welfare. Kidlington, UK: Woodhead Publishing. 506 pp.

Lawrence, A. B. & Terlouw, E. M. C. (1993). A review of behavioral factors involved in the development and continued performance of stereotypic behaviors in pigs. *Journal of Animal Science*, 71 (10): 2815-2825. doi: https://doi.org/10.2527/1993.71102815x

Liberg, O., Sandell, M., Pontier, D. & Natoli, E. (2000). Density, spatial organisation and reproductive tactics in the domestic cat and other felids. In Turner, D. C. & Bateson, P. P. G. (eds) *The domestic cat: The Biology of its behaviour*, pp. 119-148. Cambridge, UK: Cambridge University Press.

Loberg, J., Telezhenko, E., Bergsten, C. & Lidfors, L. (2004). Behaviour and claw health in tied dairy cows with varying access to exercise in an outdoor paddock. *Applied Animal Behaviour Science*, 89 (1): 1-16. doi: https://doi.org/10.1016/j.applanim.2004.04.009.

Lorenz, K. Z. (1950). The comparative method in studying innate behavior patterns. In *Society for Experimental Biology, Physiological mechanisms in animal behavior (Society's Symposium IV)*, pp. 221-268. Oxford, UK: Academic Press.

Loretz, C., Wechsler, B., Hauser, R. & Rüsch, P. (2004). A comparison of space requirements of horned and hornless goats at the feed barrier and in the lying area. *Applied Animal Behaviour Science*, 87 (3-4): 275-283. doi: https://doi.org/10.1016/j.applanim.2004.01.005

Lyons, D. M., Price, E. O. & Moberg, G. P. (1993). Social grouping tendencies and separation-induced distress in juvenile sheep and goats. *Developmental Psychobiology*, 26 (5): 251-259. doi: https://doi.org/10.1002/dev.420260503

Mallapur, A., Qureshi, Q. & Chellam, R. (2002). Enclosure Design and Space Utilization by Indian Leopards (Panthera pardus) in Four Zoos in Southern India. *Journal of Applied Animal Welfare Science*, 5 (2): 111-124. doi: https://doi.org/10.1207/s15327604jaws0502_02

Markowitz, H., Aday, C. & Gavazzi, A. (2005). Effectiveness of acoustic "prey": Environmental enrichment for a captive African leopard (Panthera pardus). *Zoo Biology*, 14 (4): 371-379. doi: https://doi.org/10.1002/zoo.1430140408

Mason, G. & Bateson, M. (2009). Motivation and the organization of behaviour. In Jensen, P. (ed.) *The ethology of domestic animals: an introductory text, modular texts.* , pp. 38-56. Oxfordshire, UK: CAB International.

McDougall, P. L. & Ruckstuhl, K. E. (2018). Doing what your neighbour does: Neighbour proximity, familiarity and postural alignment increase behavioural mimicry. *Animal Behaviour*, 135: 177-185. doi: https://doi.org/10.1016/j.anbehav.2017.11.009.

Mogensen, L., Krohn, C. C., Sørensen, J. T., Hindhede, J. & Nielsen, L. H. (1997). Association between resting behaviour and live weight gain in dairy heifers housed in pens with different space allowance and floor type. *Applied Animal Behaviour Science*, 55 (1): 11-19. doi: https://doi.org/10.1016/S0168-1591(97)00041-5.

Mohammed, H. & Mohamed, E.-S. (2013). Studying the behaviour and performance of Balady male goats managed in different group sizes within the same individual floor space uner egyptian conditions. *Behha Veterinary Medical Journal*, 24 (1): 34-42. doi: none [URL: http://bvmj.bu.edu.eg/issues/24-1/5.pdf].

Morley-Fletcher, S., Rea, M., Maccari, S. & Laviola, G. (2003). Environmental enrichment during adolescence reverses the effects of prenatal stress on play behaviour and HPA axis reactivity in rats. *European Journal of Neuroscience*, 18 (12): 3367-3374. doi: https://doi.org/10.1111/j.1460-9568.2003.03070.x

Muller-Schwarze, D., Stagge, B. & Muller-Schwarze, C. (1982). Play behavior: Persistence, decrease, and energetic compensation during food shortage in Deer fawns. *Science*, 215 (4528): 85-87. doi: https://doi.org/10.1126/science.215.4528.85

Newberry, R. C. (1995). Environmental enrichment: Increasing the biological relevance of captive environments. *Applied Animal Behaviour Science*, 44 (2): 229-243. doi: https://doi.org/10.1016/0168-1591(95)00616-Z.

Newberry, R. C., Wood-Gush, D. G. M. & Hall, J. W. (1988). Playful behaviour of piglets. *Behavioural Processes*, 17 (3): 205-216. doi: http://dx.doi.org/10.1016/0376-6357(88)90004-6.

Nicol, C. J. (1987). Behavioural responses of laying hens following a period of spatial restriction. *Animal Behaviour*, 35 (6): 1709-1719. doi: https://doi.org/10.1016/S0003-3472(87)80063-5.

Nicol, C. J., Gregory, N. G., Knowles, T. G., Parkman, I. D. & Wilkins, L. J. (1999). Differential effects of increased stocking density, mediated by increased flock size, on feather pecking and aggression in laying hens. *Applied Animal Behaviour Science*, 65 (2): 137-152. doi: https://doi.org/10.1016/S0168-1591(99)00057-X.

Nielsen, L. H., Mogensen, L., Krohn, C., Hindhede, J. & Sørensen, J. T. (1997). Resting and social behaviour of dairy heifers housed in slatted floor pens with different sized bedded lying areas. *Applied Animal Behaviour Science*, 54 (4): 307-316. doi: https://doi.org/10.1016/S0168-1591(96)01211-7.

O'Brien, P. H. (1988). Feral goat social organization: A review and comparative analysis. *Applied Animal Behaviour Science*, 21 (3): 209-221. doi: https://doi.org/10.1016/0168-1591(88)90110-4.

Oesterwind, S., Nürnberg, G., Puppe, B. & Langbein, J. (2016). Impact of structural and cognitive enrichment on the learning performance, behavior and physiology of dwarf goats (Capra aegagrus hircus). *Applied Animal Behaviour Science*, 177: 34-41. doi: https://doi.org/10.1016/j.applanim.2016.01.006.

Orgeur, P., Mimouni, P. & Signoret, J. P. (1990). The influence of rearing conditions on the social relationships of young male goats (Capra hircus). *Applied Animal Behaviour Science*, 27 (1): 105-113. doi: 10.1016/0168-1591(90)90010-B.

Pedevillano, C. & Gerald Wright, R. (1987). The influence of visitors on mountain goat activities in Glacier National Park, Montana. *Biological Conservation*, 39 (1): 1-11. doi: https://doi.org/10.1016/0006-3207(87)90002-4.

Pellegrini, A. D., Dupuis, D. & Smith, P. K. (2007). Play in evolution and development. *Developmental Review*, 27 (2): 261-276. doi: https://doi.org/10.1016/j.dr.2006.09.001.

Renner, M. & Rosenzweig, M. R. (1986). Social interactions among rats housed in grouped and enriched conditions. *Developmental Psychobiology*, 19 (4): 303-13. doi: https://doi.org/10.1002/dev.420190403

Roberts, G. (1995). A real-time response of vigilance behaviour to changes in group size. *Animal Behaviour*, 50 (5): 1371-1374. doi: https://doi.org/10.1016/0003-3472(95)80052-2.

Roberts, G. (1996). Why individual vigilance declines as group size increases. *Animal Behaviour*, 51 (5): 1077-1086. doi: https://doi.org/10.1006/anbe.1996.0109.

Sabek, A., Satoh, T., Karousa, M. M. & E, A. (2017). *Using behavior, performance and blood profile to evaluate the effect of group size on domestic goat*, vol. 7. 1381 pp.

Sambrook, T. D. & Buchanan-Smith, H. M. (1997). Control and complexity in novel object enrichment. *Animal Welfare*, 6 (3): 207-216. doi: none [URL: https://www.researchgate.net/publication/233591649_Control_and_Complexity_in_Novel_Object_Enrichment].

Schütz, K. E., Huddart, F. J., Sutherland, M. A., Stewart, M. & Cox, N. R. (2015). Effects of space allowance on the behavior and physiology of cattle temporarily managed on rubber mats. *Journal of Dairy Science*, 98 (9): 6226-6235. doi: 10.3168/jds.2015-9593.

Shams, B., Karami, M., Hemami, M.-R., Riazi, B. & Sadough, M.-B. (2010). Habitat associations of wild goat in central Iran: Implications for conservation. *European Journal of Wildlife Research*, 56 (6): 883-894. doi: https://doi.org/10.1007/s10344-010-0386-9

Shank, C. C. (2010). Some aspects of social behaviour in a population of feral goats (Capra hircus L.). *Zeitschrift für Tierpsychologie*, 30 (5): 488-528. doi: https://doi.org/10.1111/j.1439-0310.1972.tb00876.x

Sharpe, L. L., Clutton-Brock, T. H., Brotherton, P. N. M., Cameron, E. Z. & Cherry, M. I. (2002). Experimental provisioning increases play in free-ranging meerkats. *Animal Behaviour*, 64 (1): 113-121. doi: https://doi.org/10.1006/anbe.2002.3031.

Smith, C. A. & Raedeke, K. J. (1982). *Group size and movements of a depressed low density goat population with comments on inbreeding and human impact*. Northern Wild Sheep and Goat Council 3, Colorado, US: Biennial Symposium Northern Wild Sheep and Goat Council. 54-67 pp.

Solaiman, S. G. (ed.) (2010). *Goat science and production*: Wiley-Blackwell. 444 pp.

Sorrell, S. & Dimitropoulos, J. (2008). The rebound effect: Microeconomic definitions, limitations and extensions. *Ecological Economics*, 65 (3): 636-649. doi: https://doi.org/10.1016/j.ecolecon.2007.08.013.

Spinka, M., Newberry, R. C. & Bekoff, M. (2001). Mammalian play: Training for the unexpected. *The quarterly review of biology*, 76 (2): 141-168.

Stookey, J. M. & Gonyou, H. W. (1994). The effects of regrouping on behavioral and production parameters in finishing swine. *Journal of Animal Science*, 72 (11): 2804-2811. doi: https://doi.org/10.2527/1994.72112804x

Tarou, L. R. & Bashaw, M. J. (2007). Maximizing the effectiveness of environmental enrichment: Suggestions from the experimental analysis of behavior. *Applied Animal Behaviour Science*, 102 (3): 189-204. doi: https://doi.org/10.1016/j.applanim.2006.05.026.

Thompson, K. V. (1998). Self assessment in juvenile play. In Bekoff, M. & Byers, J. A. (eds) *Animal play: Evolutionary, comparative, and ecological perspectives*, pp. 183-204. New York, NY, US: Cambridge University Press.

Trickett, S. L., Guy, J. H. & Edwards, S. A. (2009). The role of novelty in environmental enrichment for the weaned pig. *Applied Animal Behaviour Science*, 116 (1): 45-51. doi: https://doi.org/10.1016/j.applanim.2008.07.007.

Turner, S. P., Horgan, G. W. & Edwards, S. A. (2001). Effect of social group size on aggressive behaviour between unacquainted domestic pigs. *Applied Animal Behaviour Science*, 74 (3): 203-215. doi: https://doi.org/10.1016/S0168-1591(01)00168-X.

Van de Weerd, H. A., Docking, C. M., Day, J. E. L., Avery, P. J. & Edwards, S. A. (2003). A systematic approach towards developing environmental enrichment for pigs. *Applied Animal Behaviour Science*, 84 (2): 101-118. doi: https://doi.org/10.1016/S0168-1591(03)00150-3.

Van, D. T. T., Mui, N. T. & Ledin, I. (2007). Effect of group size on feed intake, aggressive behaviour and growth rate in goat kids and lambs. *Small Ruminant Research*, 72 (2): 187-196. doi: https://doi.org/10.1016/j.smallrumres.2006.10.010.

Vas, J. & Andersen, I. L. (2015). Density-dependent spacing behaviour and activity budget in pregnant, domestic goats (Capra hircus). *PLoS ONE*, 10: e0144583. doi: https://doi.org/10.1371/journal.pone.0144583.

Vázquez, R., Orihuela, A. & Aguirre, V. (2014). A note on the effect of number (single or twin) and sex of contemporary siblings on male-like play behavior of lambs (Ovis aries). *Journal of Veterinary Behavior: Clinical Applications and Research*, 9 (3): 132-135. doi: http://doi.org/10.1016/j.jveb.2014.01.003.

Vinke, C. M., van Leeuwen, J. & Spruijt, B. (2005). Juvenile farmed mink (Mustela vison) with additional access to swimming water play more frequently than animals housed with a cylinder and platform, but without swimming water. *Animal Welfare*, 14 (1): 53-63. doi: none [URL: http://www.ingentaconnect.com/contentone/ufaw/aw/2005/00000014/00000001/art00007].

Wallace, M. A. (2017). *Video Camera Clipart*. [online] https://clipartxtras.com/download/00b1cc68d066b72df1d92d9fccb267bdd42f325f.html: clipartxtra.com.

Wells, D. L. (2004). A review of environmental enrichment for kennelled dogs, Canis familiaris. *Applied Animal Behaviour Science*, 85 (3): 307-317. doi: https://doi.org/10.1016/j.applanim.2003.11.005.

Wells, D. L. (2009). Sensory stimulation as environmental enrichment for captive animals: A review. *Applied Animal Behaviour Science*, 118 (1): 1-11. doi: https://doi.org/10.1016/j.applanim.2009.01.002.

Wood-Gush, D. G. M. & Vestergaard, K. (1991). The seeking of novelty and its relation to play. *Animal Behaviour*, 42 (4): 599-606. doi: https://doi.org/10.1016/S0003-3472(05)80243-X.

Young, R. J. (2003). *Environmental enrichment for captive animals*. UFAW animal welfare series. Oxford, UK: Blackwell Science Ltd. 240 pp.

Appendix 1 – Details regarding the three environmental enrichments
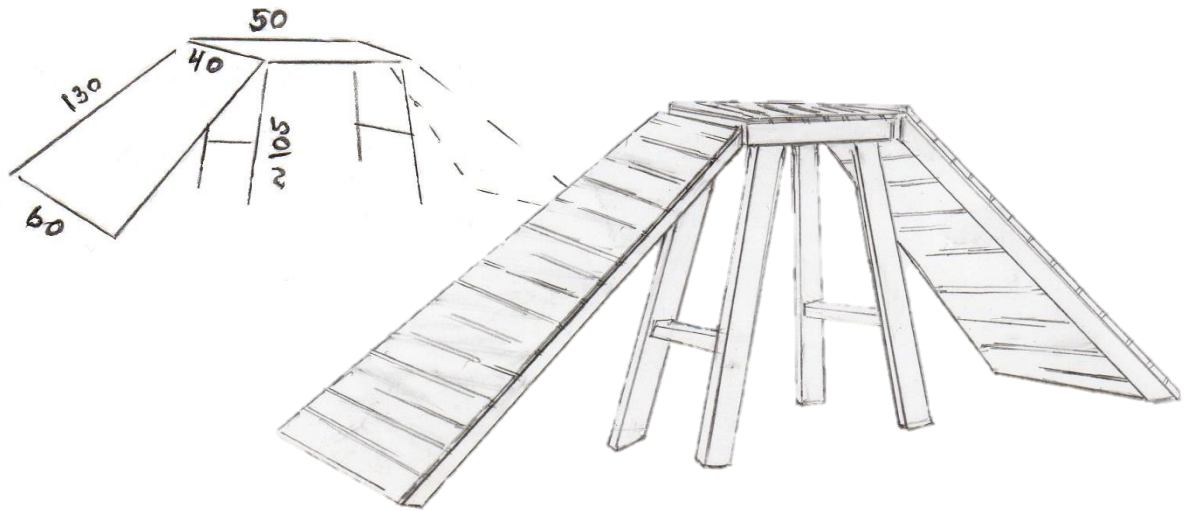
Appendix figure 1. Illustration of the wooden bridge used as enrichment under enriched conditions in the Environmental enrichment study. They were continuously present in the outdoor enclosure in the other two experiments. Measurements are in cm.

Suspended ball:

- Were suspended underneath the bridge using nails.
- Inside of a bag, created out of a white singlet from Cubus, size Large
- Model: Lilliput handball from Select Sport AS, Denmark
- Diameter: 50 cm

Bucket with sticks:

- Sticks were collected from the surroundings
- The bucket:
    - Model: Industri- og murerbalje from Felleskjøpet Agri
    - Dimentions: 65 L, Height – 34.5 cm, Diameter – 56 cm
    - Material: Plastic
    - URL: https://www.felleskjopet.no/butikk/bygg-og-verktoey/verktoey-og-verksted/haandverktoey/murbalje-65l-rund-sort-50217681/

Appendix 2 – All statistical results from Model 3

Appendix table 1. Analysis results of Model 3.

Variable	Explanatory variable	F-value	Num DF	Den DF	P-value
Social play.1-0.	Condition	2871.95	1	448	<0.001
	Pair of days	1009.95	5	448	<0.001
	Condition*pair of days[1]	5.81	3	448	0.0007
Object play.1-0.	Condition	923.56	1	448	<0.001
	Pair of days	765.98	5	448	<0.001
	Condition*pair of days[1]	1.49	4	448	0.2050
Locomotor play.1-0.	Condition	∞	1	448	<0.001
	Pair of days	203550	3	448	<0.001
	Condition*pair of days[1]	∞	5	448	<0.001
Agonistic interactions.1-0.	Condition	1.75	1	448	0.1859
	Pair of days	7.28	5	448	<0.001
	Condition*pair of days[1]	4.47	5	448	0.0006
Explore.1-0.	Condition	109.71	1	209	<0.001
	Pair of days	3.23	5	209	0.0079
	Condition*pair of days[1]	5.71	5	209	<0.001
Wag tail.1-0.	Condition	648.42	1	209	<0.001
	Pair of days	180.44	5	209	<0.001
	Condition*pair of days[1]	7.33	3	209	0.0001
Climb.1-0.	Condition	∞	1	209	<0.001
	Pair of days	20.28	5	209	<0.001
	Condition*pair of days[1]	∞	5	209	<0.001

[1] Results for hypothesis 2 (H2 – repeated exposure to conditions on general activity levels) in Environmental enrichment experiment

Appendix 3 – Correlations between variables throughout study (Model 10)

Appendix table 2. Pearson correlation coefficients among the variables totalled across the three experiments (the study period).

	Age	Growth (kg)	Social play (mp)	Locomotor play (mp)	Object play (mp)	Agonistic interactions	Explore (mp)	Climb (mp)	Wag tail (mp)
Age	1.00000	-0.34194 / 0.1649	-0.21052 / 0.4017	0.01014 / 0.9681	-0.38809 / 0.1115	-0.04057 / 0.8730	0.30560 / 0.2175	0.01052 / 0.9670	-0.31809 / 0.1983
Growth (kg)	-0.34194 / 0.1649	1.00000	0.22279 / 0.3742	-0.18310 / 0.4671	0.56650 / 0.0142	-0.02138 / 0.9329	0.07146 / 0.7781	-0.12599 / 0.6184	0.31747 / 0.1992
Social play (mp)	-0.21052 / 0.4017	0.22279 / 0.3742	1.00000	0.18980 / 0.4506	0.14787 / 0.5582	0.40325 / 0.0970	0.43006 / 0.0749	0.37365 / 0.1267	0.71367 / 0.0009
Locomotor play (mp)	0.01014 / 0.9681	-0.18310 / 0.4671	0.18980 / 0.4506	1.00000	0.37660 / 0.1234	-0.14042 / 0.5784	0.17830 / 0.4790	0.48534 / 0.0412	0.21874 / 0.3832
Object play (mp)	-0.38809 / 0.1115	0.56650 / 0.0142	0.14787 / 0.5582	0.37660 / 0.1234	1.00000	-0.18822 / 0.4545	0.13251 / 0.6002	0.16180 / 0.5212	0.50205 / 0.0337
Agonistic interactions	-0.04057 / 0.8730	-0.02138 / 0.9329	0.40325 / 0.0970	-0.14042 / 0.5784	-0.18822 / 0.4545	1.00000	0.35338 / 0.1503	0.24454 / 0.3281	0.17314 / 0.4920
Explore (mp)	0.30560 / 0.2175	0.07146 / 0.7781	0.43006 / 0.0749	0.17830 / 0.4790	0.13251 / 0.6002	0.35338 / 0.1503	1.00000	0.36020 / 0.1420	0.48202 / 0.0428
Climb (mp)	0.01052 / 0.9670	-0.12599 / 0.6184	0.37365 / 0.1267	0.48534 / 0.0412	0.16180 / 0.5212	0.24454 / 0.3281	0.36020 / 0.1420	1.00000	0.39173 / 0.1079
Wag tail (mp)	-0.31809 / 0.1983	0.31747 / 0.1992	0.71367 / 0.0009	0.21874 / 0.3832	0.50205 / 0.0337	0.17314 / 0.4920	0.48202 / 0.0428	0.39173 / 0.1079	1.00000

Appendix 4 – Exposure to different group sizes

Goat ID	Week 1				Week 2				Week 3			
	6.11.	7.11.	8.11.	9.11.	13.11.	15.11.	16.11.	17.11.	20.11.	21.11.	22.11.	24.11.
77114	8	5	7	6	2	8	3	4	8	7	6	7
77081	4	2	8	7	6	7	8	5	7	3	5	6
77057	4	6	7	5	8	3	7	8	2	8	6	7
77042	6	5	8	7	6	7	8	4	2	8	5	3
77087	4	7	8	6	4	8	3	5	7	2	6	7
77008	6	6	2	7	8	7	8	8	7	3	5	4
77029	8	6	7	5	8	3	7	4	8	2	5	6
77086	8	7	3	5	8	7	8	4	8	7	6	7
77038	6	5	8	7	4	8	2	8	7	3	6	7
77084	8	6	2	7	6	7	3	5	8	7	4	7
77088	2	7	8	6	8	8	7	5	7	8	4	3
77013	8	5	7	6	4	7	2	8	3	7	6	3
77051	8	6	7	2	6	8	7	3	8	8	5	4
77024	6	6	8	7	2	7	8	3	7	8	5	4
77026	8	7	8	2	6	8	7	3	8	8	5	6
77043	4	7	8	5	6	2	8	8	3	7	5	7
77117	6	2	7	5	8	8	7	8	3	8	4	6
77113	6	5	7	7	8	3	8	8	8	7	4	6
77022	8	7	3	6	4	2	7	8	7	8	5	6
77010	2	7	3	6	8	8	8	5	8	7	5	4