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Play behaviour in domestic goat kids.

The influences of flooring surface and heat supplementation, and potential implications for welfare.

A thesis

submitted in partial fulfilment

of the requirements for the degree

of

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Abstract

Increased demand for commercial goat products and concern for welfare in farmed animals has led to a demand for further research in goat welfare. Animal behaviour is commonly used to assess animal welfare in farm animals. Both the elimination of negative welfare states and the improvements of positive welfare states are important in the assessment of animal welfare. The performance of play has been used as an indicator of positive welfare in several species. Research on play behaviour in goat kids is limited. The following thesis describes a study investigating play behaviour in domestic goat kids in response to flooring and provisional supplemental heat and then discusses the possible welfare implications of play behaviour for goat kids. In part 1 of the study an ethogram of play behaviour in domestic goat kids was developed from video recordings and live observations. Part 2 is a continuation of research conducted by Sutherland *et al.* (2019) in which 80 female Saanen goat kids were grouped into four treatments. The treatments were as follows; 1) floor covered in wood shavings without heat lamps, 2) wood shavings with two heat lamps, 3) metal mesh flooring without heat lamps, and 3) metal mesh with two heat lamps. Each treatment consisted of four pens (1.5mx3.5m) with five goats per pen. All pens were video camera recorded and replayed on Adobe Premier Pro. Play behaviour frequencies were observed during 30 min periods twice a day for eight days. Behaviour was continuously recorded as frequency per minute. The results indicated that flooring surface had an influence on play behaviour frequencies in goat kids with a significant increase in play behaviour found in wood shaving treatments ($p < 0.05$). Heat supplementation did not influence play behaviour with no significant difference between heat lamp and no heat lamp treatments ($p > 0.05$). Play behaviour could potentially be used as an indicator of good welfare in goat kids, however, more research is needed to assess change in play behaviour in response to other situations. The complexity of behaviour, such as the performance of play behaviours other than locomotor play, could also be used to indicate enhanced levels of welfare, exceeding the minimum standards, however, this requires more validation.

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I would like to dedicate this thesis to my parents

Kaye and Grant Kiddle

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Chapter 1: Introduction

1.1 Biology, ecology and domestication of goats

1.1.1 Domestication

Domestication is the evolutionary process by which populations of animals change morphologically and genetically in response to reduced natural selection and increased human selection pressures (Grandin & Deesing, 2014). A domesticated animal is said to have lost innate fear reactions to humans and all breeding, environment and food resources are under total human control (Clutton-Brock, 2012). The domestication of livestock has occurred progressively over 10,000 years and is considered the foundation for change in human culture and development of ‘society’ through a new-found sustainable, farming lifestyle (Clutton-Brock, 2012). It has been suggested that around 10,000 years ago, humans living within the “Fertile Crescent” moved from a predominant reliance on the meat of the mountain gazelle (*Gazella gazella*) to that of other ungulate species due to their easier capture and containment. From here the progression from meat products to the usage of milk and fur was slow. The first significant changes in bone and horn shape in ungulate species, including sheep and goat species, indicate that these were the first to be domesticated (Clutton-Brock, 2012). It is believed the Bezoar ibex (*Capra aegagrus aegagrus*) is the predominant, if not sole, ancestor to the modern domestic goat (*Capra aegagrus hircus*), although there is debate over where this species originated and domestication first occurred (Zeder & Hesse, 2000; Wasse, 2001; Clutton-Brock, 2012).

1.1.2 Biology and diet

The domestic goat (*Capra aegagrus hircus*) is an even-toed ungulate from the family Bovidae (Clutton-Brock, 1999). Considered one of the most versatile ruminants, goats are browsers that have adapted to harsh, mountainous environments and are highly efficient in assimilating food energy (Clutton-Brock, 1999; Zobel *et al.*, 2018). Lip, tongue and digestion adaptations, along with a high tolerance for toxic substances allow them to consume a highly variable diet (Zobel

et al., 2018). Morphological adaptations in goat hooves allow these species to climb and travel significant distances on difficult terrain (Zobel *et al.*, 2018). It has been suggested that the goat's adaptation to tough terrain made their instinctive fear towards predation less than that of other prey animals that lived in open plains, and that this could have led to an easier domestication (Clutton-Brock, 1999).

1.1.3 Social Structures

Goat herds have loose matrilineal social systems with interchanging sex segregation within groupings throughout the year (Stanley & Dunbar, 2013). This complex, female dominant social hierarchy is maintained by aggression and social bonds (Zobel *et al.*, 2018). Interestingly, feral goats have been found to have preference for social partners and affiliates within a herd that are unrelated to environment, group structure or genetics, suggesting that social bonds in goats are more complex than in other ruminant species (Stanley & Dunbar, 2013). Horn physiology has also been found to have an important role in social behaviour in goats with the horn lengths of males being related to female preference, sexual interactions and agonistic displays among males (Dunbar & Shi, 2008).

1.1.4 Commercial farming

Goats have significant importance in human agriculture and religion, and are farmed worldwide for their meat, milk, hair, hides and weed control (Scholtens *et al.*, 2017a; Food and Agriculture Organisation of the United Nations (FAO), 2018). There are approximately 1 billion¹ domestic goats worldwide (FAO, 2018). The New Zealand goat industry is predominantly farmed for dairy and fibre (hair and hide) with approximately 98,000 goats farmed across the country and a livestock industry export value of \$5.6 million (Scholtens *et al.*, 2017a; Ministry for Primary Industries, 2019). Demand for research in the areas of goat biology and behaviour are increasing as global demand for goat-based products increases (Scholtens *et al.*, 2017b; Anzuino *et al.*, 2019).

¹ Rounded from the estimate of 1,045,915,764 calculated by the FAO statistic algorithm on the 03/04/2020 (FAO 2018).

1.2 Animal Welfare

Concern for the welfare of animals has been growing since the 19th century (Fraser & Duncan, 1998; Broom, 2011; Gilmour, 2020). Animal welfare as a concept has historically been divided into two; the first being scientific research based on biological systems and the other being the philosophy and ethical dilemmas around human treatment of animals (Fraser & Duncan, 1998; Fraser, 1999). Animal welfare is a multi-faceted concept that has proven difficult to define due to the influence of culture, scientific expertise and political differences (Pinillos *et al.*, 2016). Animal welfare as a scientific concept has been broadly defined as a measurable quality of living at a specific time for an individual animal (Broom, 2011). The ethical issue that parallels this definition is what humans can, and should, be doing about the quality of life that specific animals live (Broom, 2011).

Knowledge of animals as biologically functioning organisms, as opposed to machines, was only discovered in the 19th century (Fraser & Duncan, 1998; Broom, 2011). Suggestions that animals may have the ability to ‘feel’, and therefore experience forms of emotion, was proposed in the late 19th and early 20th century (Fraser & Duncan, 1998). Research on biological motivational systems and how an animal’s physiological and behavioural responses were influenced by surrounding environments helped start the first actions towards the protection and education around animal welfare in the 1960s (Broom, 2011). Early animal welfare movements were primarily focussed on minimising suffering with potential positive experiences a much lower priority (Fraser & Duncan, 1998). Animal welfare as an ethical concept was widely accepted by the 1980s with movements focussed on improving zoo, research and commercial animal welfare (Broom, 2011). The 1990s showed a shift in understanding as scientific research found methods of measuring animal affective state and potential welfare indicators, allowing animal welfare to become a scientific concept (Broom, 2011).

1.2.1 The five freedoms and the five domains

Traditionally, ethical dilemmas for animal welfare have been focussed around the moral obligation to maintain acceptable animal health and care. To address concerns around this obligation, the ‘five freedoms’ concept was

proposed in the Brambell Report (1965), a publication produced by the British Government with suggestions on husbandry practices relating to farm animal welfare (Carenzi & Verga, 2009). These five freedoms were revised in 1993 by the Farm and Animal Welfare Committee (FAWC) and are as follows: 1) freedom from thirst and hunger, 2) freedom from discomfort and exposure, 3) freedom from pain, illness and injury, 4) freedom from fear and distress, 5) freedom to express normal behaviours (Carenzi & Verga, 2009). These freedoms have been used in political documents and legislation worldwide since this revision (Mellor, 2016). Modern science has since criticized this concept for its lack of flexibility around individual or species variation and lack of encouragement towards a more positive environment and the consideration of an animal's affective state (Fraser & Duncan, 1998; Fraser, 1999; Carenzi & Verga, 2009; Broom, 2011; Mellor, 2016).

The 'five domains' is another concept regarding animal welfare that includes an aspect of animal mental wellbeing. The five domains model was developed by Mellor in 1994 as a more comprehensive and thorough assessment of the impact of negative welfare on animals (Mellor, 2016). The five domains include aspects of; 1) nutrition, 2) environment, 3) health, and 4) behaviour to understand the overall 5) mental wellbeing of an animal. This model was designed to encourage positive welfare and wellbeing in animals to provide a "life worth living" (Mellor, 2016). It is now understood that a balance between positive and negative experiences rather than a removal of all negative experiences for an animal is more realistic goal alongside the promotion of a 'good life' (Oliveira *et al.*, 2009; Mellor, 2016; Webber & Lee, 2020).

1.2.2 Animal affective state

A concept that has traditionally caused controversy is whether animals experience emotion and, therefore, have an affective state. Affective state, particularly positive affective state, has proven difficult to measure and so evidence of animal affective state has been difficult to prove. Jirkof *et al.* (2019) defined affective state as "a multifaceted phenomenon with neuronal, physiological, behavioural, cognitive and subjective aspects" (Jirkof *et al.*, 2019). Affective states have direct links to emotions, these being defined in animals as

psychological phenomena that influence behavioural decisions (Beckoff, 2000). Emotions and affective state are suggested to be an evolutionary adaptation due to their influence on motivation and motivationally driven behaviours (Beckoff, 2000; Jirkof *et al.*, 2019). Primary emotions such as joy, fear and grief have been observed in many animals (Beckoff, 2000; Jirkof *et al.*, 2019). Affective states and emotions linked to them can have varying levels of positive or negative arousal providing potential indicators of quality of life and overall welfare (Beckoff, 2000; Jirkof *et al.*, 2019).

1.2.3 One welfare

A modern approach to improving welfare initiatives has been the concept of “One Welfare” proposed by Pinillos *et al.* (2016). This concept promotes the improving of an animals environment with the understanding that the human handlers in contact with animals are a part of their environment (Pinillos *et al.*, 2016). Pinillos *et al.* (2016) developed the term “One Welfare” to acknowledge that the relationships between humans and animals may improve the lives of both parties. This concept involves an approach directed towards educating handlers involved in animals’ lives.

1.2.4 Stereotypic behaviour

Stereotypic or abnormal behaviour can occur in domesticated animals and is generally accepted as an indicator of poor welfare. The structure and form of stereotypic behaviours can present similarly to play behaviour, causing controversy in accurately separating definitions for both stereotypic and play behaviours (Burghardt, 2005). Stereotypic behaviour is broadly defined as repetitive behaviours that appear to have no immediate or future function or benefit to the animal (Mason & Rushen, 2006). Stereotypic behaviours have only been performed by animals in unnatural, captive environments, and may be self-harming or behaviours that cause damage to either themselves or their environment (Marsden, 2002). In contrast, play behaviours are performed by animals in both wild and natural or enriched captive environments and, although self-rewarding, are not typically self-harming or damaging behaviours (Burghardt, 2005; Burghardt, 2013). Stereotypic behaviours are prevalent in, and have been extensively studied across, domestic ungulate species used in human interests

(Bergeron *et al.*, 2006). These behaviours can present very differently across species, however ungulate species tend to perform oral-type stereotypies (Bergeron *et al.*, 2006). Examples include crib-biting in horses, tongue-rolling in cattle, sham-chewing in pigs and wool-chewing in sheep (Bergeron *et al.*, 2006; Lauber *et al.*, 2012). Stereotypic behaviours have been observed in domestic goats in the form of bar, bucket and crib-biting and chain-chewing (Tölü *et al.*, 2019). The most prominent reasons for these behaviours have been identified as restriction in the ability to perform natural behaviours such as foraging, lack of stimulation or enrichment, and presence of stress (Bergeron *et al.*, 2006; Swaisgood & Shepherdson, 2006; Lauber *et al.*, 2012; Tölü *et al.*, 2019).

1.2.3 Measures of animal welfare

Measuring animal welfare can be difficult due to the large amount of time needed, and questions of accuracy for subjective measures. Most animal welfare measures are evaluative and quantitative (EFSA, 2012). Animal welfare measures can be resource-based where they measure the environment an animal is in, management-based where they measure the management strategies around an animal, or animal-based where they measure the animal's response to their resource and management situations (EFSA, 2012). Animal-based measures are either direct, taken directly from the animal, or indirect and observed or collected through remote monitoring (EFSA, 2012). Traditional measures of animal welfare were concerned with an animal's environment and whether this met their minimum needs to survive (Vesel *et al.*, 2020). Other traditional methods of welfare measurement include body condition scoring and invasive cortisol measurements (Vesel *et al.*, 2020). Modern measures of animal welfare are more concerned with the animal's perception of its environment and how this affects their mental state (Andreasen *et al.*, 2013; Munsterhjelm *et al.*, 2015). The ability to express natural behaviour has been identified as an indicator of positive affective state and is a requirement for welfare in captive animals (Beckoff, 2000; Carenzi & Verga, 2009). The observation and analysis of animal behaviour is, therefore, a non-invasive method that can be used to predict the affective state, and consequent welfare, of an individual or group of captive animals.

1.3 Definitions of play

Across all animal research, ‘play’, as a concept has proven very difficult to define. Play behaviour varies dramatically between and within species, varies in complexity, covers many behavioural categories, and is strongly influenced by external environmental factors (Burghardt, 2005; Held & Špinka, 2011; Richter *et al.*, 2016). Burghardt (2005) proposed five key criteria for identifying play behaviour in animals.

-1) that the performance of the behaviour was not fully functional in its immediate form and context,

-2) that the behaviour was spontaneous, voluntary, intentional, pleasurable, rewarding reinforcing, or autotelic (in that it was performed for the sake of performing that specific behaviour),

-3) that the behaviour differed from a contextually serious performance due to it being incomplete or modified in motor pattern or sequencing,

-4) that the behaviour was repeated either in bout form or across the ontogeny of the individual without being stereotypic in nature,

-5) that the behaviour was performed when the individual was free from stress and in an optimal condition.

Although most research supports the first four of these criteria, there has been discussion regarding the fifth criterion that implies play is performed free from stress. Some research suggests that play can be used by juveniles to reduce aggression and provide coping strategies during times of high stress and competition (Gomendio, 1988; Palagi *et al.*, 2004; Richter *et al.*, 2016).

Therefore, for the purpose of this study the following definition of play was created and will be referred to.

Play behaviours are species specific, instinctive behaviours that have been modified in form and/or context and are performed voluntarily and repetitively throughout ontogeny. These behaviours appear to be spontaneous, self-reinforcing and of no immediate function or purpose within the present context.

Burghardt (2005) also described the three distinct types of play, first proposed by Robert Fagen in 1981 and now adopted by many ethologist researchers; these being 1) locomotor – rotational play (or locomotor play), 2) object play, and 3) social play.

Locomotor play is defined as play in the form of intense and/or sustained physical locomotor movements without any apparent immediate function. Locomotor play is often performed solitary and can involve direction reversal and overly exaggerated movements. This type of play is typically the first observed ontogenetically (Smith, 1982; Burghardt, 2005).

Object play is defined as play involving the manipulation of objects, beyond simple curiosity, that appear to provide no immediate benefit (Smith, 1982; Burghardt, 2005; Dugatkin, 2013). Commonly observed object play involves aspects of antipredator behaviour, predatory behaviour, nest building and sexual behaviour (Smith, 1982; Burghardt, 2005; Dugatkin, 2013). Object play can be encouraged as a form of ‘enrichment’ for both juvenile and adult captive animals, however, this play is different from stereotyped behaviour common in captive animals (Burghardt, 2005).

Social play is defined as play directed at a conspecific or another animal in the role of a conspecific (Burghardt, 2005). Social play behaviour is often quasi-aggressive involving chasing or play fighting (Burghardt, 2005). Social play attracts attention and can be performed in many forms. These forms can include: role reversal, where the roles of attack and defence in individuals are changed throughout the play; self-handicapping, where a more dominant individual will reduce their play intensity to match, or drop under, that of their partner; and play signalling, where individuals use postural, chemical or vocal signs to indicate play intent and avoid potential injury (Hass & Jenni, 1993; Power, 1999; Burghardt, 2005; Dugatkin, 2013). Within social play research play fighting has been the most commonly studied and it has been suggested that our knowledge of play behaviour as a whole could be largely skewed towards that of conflict based play behaviour (Burghardt, 2005).

Across the three main types of play behaviour, most playful species will showcase all three throughout their ontogeny with specific play behaviours having dramatic overlap across the three types (Burghardt, 2005).

1.4 Evolution and purpose of play

The natural selection of play behaviours in many species indicates that play behaviour has significant benefits to juveniles. Although most defined in mammals, play behaviour has been identified in many other animals (Bekoff, 1984; Oliveira *et al.*, 2009). Play behaviours are influenced by many factors including age, sex, health, environmental stimuli, habitat, resource ability and stress levels (Burghardt, 2005; Held & Špinka, 2011; Richter *et al.*, 2016).

1.4.3 Ultimate vs proximate functions of play

The purpose and/or function of play behaviour in animals is continuously debated and difficult to identify. This difficulty is due to the variable nature of play behaviours both between species and that it can be affected within species by sex, age, social relationships, context, individual variability and environment (Palagi *et al.*, 2004). Fagen (1974) proposed two views towards play. Fagen described the structuralist, or proximate, view as looking at the structure and form of the play as it is performed and proposing immediate benefits from its performance. The structural view suggests the function of play is an experimental form of learning through ‘trial and error’ where there is an immediate development in the animal’s motor patterns and neuromuscular system and an immediate understanding of environment and conspecific identification (Fagen, 1974; Bateson, 2017). An example of this would be locomotor play in gazelles to immediately develop muscle and motor patterns needed for predator avoidance in early, vulnerable stages of life (Gomendio, 1988). The functionalist, or ultimate, view suggests the function of play provides a longer-term benefit to the animal in the form of experimental practice and information gathering needed for survival later in life. An example of this being social play in chimpanzees aiding in the development and strengthening of social bonds (Palagi *et al.*, 2004).

The debate between ultimate and proximate causation of play behaviours in animals was strong during the beginning of ethological research into play behaviour. Smith (1982) proposed an ultimate view of the purpose of play

behaviour and suggested the importance of evolution and natural selection in driving the performance of play behaviours in juvenile mammals. Smith suggested that the high time budgets designated to the performance of play in these species indicated that the evolutionary benefits outweighed the costs and caused for them to be naturally selected. Smith was heavily criticised for this article by numerous, published ethologists, including those referenced in his article, for the lack of discussion towards proximate causation of behaviours, and his suggestions of functions being mutually exclusive (Baldwin, 1982; Bekoff, 1982; Burghardt, 1982; Fagen, 1982). Baldwin (1982) described this debate as the “nature-nurture controversy”. It has since been identified that the functions of play vary dramatically across species and are likely to interchange between proximate and ultimate benefit (Fagen & Fagen, 2004; Burghardt, 2005; Burghardt, 2016; Webber & Lee, 2020). Most modern ethologists suggest a combination of the two views and that the purpose of play is variable and interchangeable (Burghardt, 2005; Burghardt, 2016; Webber & Lee, 2020).

1.4.4 Modern theories on the function of play

The dominant current theories on the function of play include: 1) the development of physical skills and ability to practice these for later survival, 2) the development of social relationships and the skills to compete and cooperate with conspecifics; 3) the learning of the animal’s environment, 4) and the building of resistance to stress and stressful situations (Nahallage *et al.*, 2016; Richter *et al.*, 2016).

Multiple studies have suggested that locomotor play in juvenile animals, especially in the first few months after birth, provides immediate improvement to neural and motor skills that aid in predator avoidance (Gomendio, 1988; Caro, 1995; Jensen, 2011). Gomendio (1988) found that juvenile Cuvier’s gazelles (*Gazella cuvieri*) performed the highest frequencies of locomotor play in their hiding phase of ontogeny suggesting that the conspicuous nature of locomotor play had immediate benefits that could aid in the avoidance of predators in a similar way to hiding. Caro (1995) found a similar pattern in the frequency of locomotor play behaviours in the early months of life for cheetah cubs (*Acinonyx jubatus*), suggesting that neuro-motor strength development from locomotor play

was likely immediate to avoid predation. Caro (1995) also suggested that an increase in exploratory object play found throughout the ontogeny of juvenile cheetah cubs showed accumulative learning of environment as they aged.

Social play has been suggested to aid in the development of social skills and social bonding with conspecifics. Jensen (2011) found an increase in the frequency of social play between cows and their calves within the first few days of life and suggested this social play developed social bonding between the dam and calf, as well as a better understanding of conspecifics.

The types and functions of play are in no way mutually exclusive. Nahallage *et al.* (2016) suggested that cultural transmission from parent to offspring of stone manipulation, object play in Japanese macaques (*Macaca fuscata*) had social benefits for juveniles through imitation and observational-based social learning. It was found that the stone handling play behaviour was ‘contagious’ and increased in frequency with more performers present. Nahallage *et al.* (2016) also found that the stone handling behaviour was often integrated with other social behaviours such as social play and allo-grooming, suggesting social learning and relationship benefits for juvenile animals through this form of social, object play.

1.4.5 Benefit vs risk in play behaviour

Throughout the discussion of purpose and function of play behaviour is the discussion of cost vs benefit. By modern understanding, play behaviour appears to provide no immediate function or benefit, and the benefit vs cost of play behaviours is unclear. Play behaviours are present in juvenile and adults in many animal species, therefore, must have some benefit to be naturally selected for during evolution.

Play is costly in juvenile animals. Energy expenditure costs can increase over time spent playing. Additionally, social exchange costs include increased disease exposure, possibility of injury, distraction from vigilance and increased predation vulnerability (Webber & Lee, 2020). Play in some animals can reduce in frequency when time budgets for other high energy behaviours such as foraging, travel or predator vigilance increase (Webber & Lee, 2020). Fagen and Fagen (2004) analysed play behaviour in brown bears (*Ursus arctos*) over four

years. It was found that bear cubs that played more as juveniles were more likely to survive into adulthood. The study then suggested a “relatively intermediate cost-benefit trade-off strategy” (Fagen & Fagen 2004) for play in ‘slow’ life history animal species. This strategy suggested that short-term benefits such as increased stress resistance and neuromuscular strengthening, that could be provided immediately through play behaviour, could have lifetime fitness benefits due to the individual’s increased ability to survive into adulthood (Fagen & Fagen, 2004). This strategy provides an opposing view to the theory that the benefits of play are largely received in adulthood (Fagen & Fagen, 2004).

1.5 Animal behaviour ethogram research

Behaviour in any animal can be difficult to identify, describe and define, even when comparing within species. Play behaviour is no exception. An ethogram is a list of structural descriptions of the behaviours a species’ may exhibit (Burghardt, 2005; Rees, 2015). Ethograms are used to help identify, define and measure individual behaviours that are study or species specific (Burghardt, 2005; Rees, 2015). Overall (2014) stressed the importance of detailed ethograms to increase accuracy in animal behaviour research. Using a dog barking as an example of a behaviour that does not always carry the same information, Overall (2014) suggested that the use of ethograms allows a more accurate comparison across different research. Overall argued that a detailed ethogram can avoid the misinterpretation or inaccuracy of groupings and assumptions made from misleading ‘emotional states’ of researchers and/or readers. Overall suggested that pictorial ethograms and/or video footage could help show behaviours from the perspective of the animal and remove anthropomorphism or emotively lead perceptions.

Ethograms can be designed to study focal animals or focal groups with the information received from sample individuals or groups generalised to a population (Gordon, 1987). The observations of behaviours in an ethogram usually come under four categories of measurement; 1) latency, 2) frequency, 3) duration and 4) intensity (Rees, 2015).

For some research, the entire study revolves around the development of a detailed behavioural ethogram for a species. For example, a study of captive

bottlenose dolphin (*Tursiops truncatus*) mother-calf dyads was conducted to create a behavioural ethogram which included 51 behavioural patterns, both individual and interactive behaviours, separated into 18 categories (Von Streit *et al.*, 2011). This study used focal animal sampling with continuous recording over a set period.

Chapter 2: Play behaviour in the domestic goat

2.1 Introduction

Research on play behaviour in goat kids is limited and has been suggested as an area of further investigation towards the improvement of welfare (Sutherland *et al.*, 2019). The following study investigates play behaviour in domestic goat kids through the development of an ethogram and an experimental design determining the potential influence of supplementary heat source and flooring surface on these behaviours.

Sutherland *et al.* (2019) looked at the effects of temperature and flooring surface on dairy goat kid location preference, behaviour, and growth. The results of this study indicate that goat kids perform more active and lying behaviours on wood shaving floor surface and had a clear preference for lying near heat lamps. This suggests that wood shavings and the provision of a supplementary heat source provide a more optimum environment for penned goat kids and, therefore, suggest better welfare conditions. Sutherland *et al.* (2019) suggested that further research evaluating play behaviour in response to different surfaces and supplemental heat was needed. A play behaviour ethogram specific to dairy goat kids, however, does not exist and therefore this is needed before play behaviour can be evaluated properly. The following study is a direct continuation of this suggestion and uses the same treatment conditions, subjects, and recorded video footage used by Sutherland *et al.* (2019).

The following hypotheses have been developed for the current study:

H1. There will be a higher frequency of play behaviours in domestic goat kids in conditions with heat supplementation than in conditions without.

H2. There will be a higher frequency of play behaviours in domestic goat kids reared on the wood shaving surface than the metal mesh surface.

H3. Domestic goat kids will perform a higher frequency of play behaviour in more optimal welfare conditions.

H4. Play behaviour will be an implication of positive affective state, hence welfare.

2.2 Methods and materials

2.2.1 Part 1: Ethogram development and validation

Experimental design

Youtube

Seven videos from the site www.youtube.com were selected for pilot observation. These videos were selected using the search function within the website and included key word/s in their title or caption from the following list: goat, baby goat, goat kids, play, playing, plays; and contained content relating to the play behaviour of domestic goat kids. Eleven videos were watched in total with an average length of 4 min 20.

Each video was watched entirely, and all observed play behaviours were described and documented in the ethogram (Table 3).

Live observation

African (Boer) goats (*Capra aegagrus hircus*) (three adults, four juveniles, $n=7$) from a free-range enclosure on Lake Bohinj, Slovenia were continuously observed for a period of 30 minutes midday on two days in July 2019 (20/07/19 – 21/07/19) by one observer. All animals were observed, and all observed play behaviours were then described and documented in the ethogram (Table 3).

Video pilot observation

A sample day (24 hours) was selected at random from the eight days of continuously recorded video from Sutherland *et al.* (2019). All play behaviours performed by all individuals ($n=10$, 5 per pen) were recorded for each pen in the recording. All new play behaviours were described and documented in the ethogram (Table 3).

Ethogram validity

To validate ethogram suitability, two observers tested the ethogram by recording behaviours across a fixed 30-minute sample period within the sample

day video as specified above. The ethogram was then adjusted make it more appropriate for the project and to increase the likelihood of inter-observer reliability. These adjustments included broadening ethogram descriptions to include similar behaviours and eliminating subcategories, such as social behaviour, that were not considered relevant distinctions for the present study. The revised ethogram was approved by both observers and an external supervisor and used for the continued duration of the study (Table 1).

2.2.2 Part 2:

Experimental design from Sutherland et al. (2019)

The study was undertaken at the AgResearch Ruakura research farm, Hamilton, Waikato, New Zealand ((latitude 37°47'S, longitude 175°19'E) between July and August 2015 during Winter. The study subjects included 80 female Saanen goat kids (*Capra aegagrus hircus*) sourced from two commercial Waikato dairy goat farms. At approximately 3 days old, goat kids were allocated to one of 16 treatment pens (n = 4 pens per treatment, 5 kids per pen). Due to kid availability, kids were gradually enrolled into the study as they became available and consequently replicates were staggered relative to one another. The four treatment groups were as follows 1) wood shavings without heat lamps (WS), 2) Wood shavings with two heat lamps (WS+H), 3) Metal mesh without heat lamps (MM), and 4) Metal mesh with two heat lamps (MM+H). The two heat lamps were both placed at one end of the pen for the WS+H and MM+H treatments. Four replicates of all treatments were completed over eight days (Figure 1). To identify individual goat kids during video observation each kid was uniquely marked with marking paint.

The study design included four repetitions of each treatment. The four repetitions were separated into two groups where the pens in each group were numbered 1 to 8 (Figure 2). These eight pens were separated into four video channels where two pens were recorded under one overhead security camera (DS-2CD2332-I, Hikvision, Hangzhou, China). The pens were recorded continuously in real time (30 frames/second) over 24 hours for eight days.

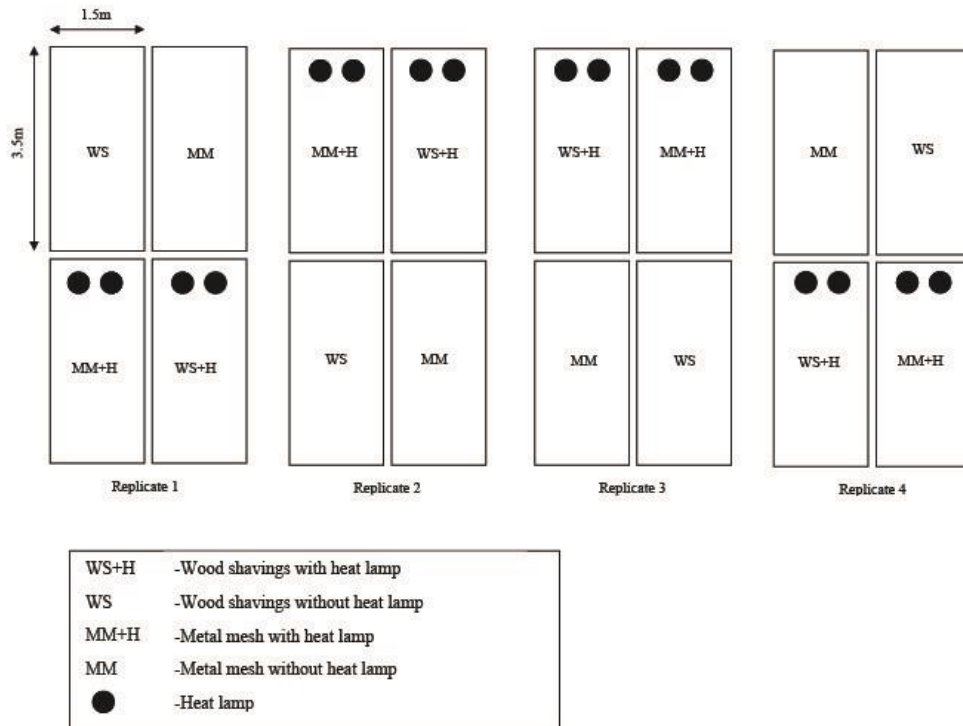


Figure 1. Experimental layout depicting each pen across four replicates (Sutherland et al., 2019).

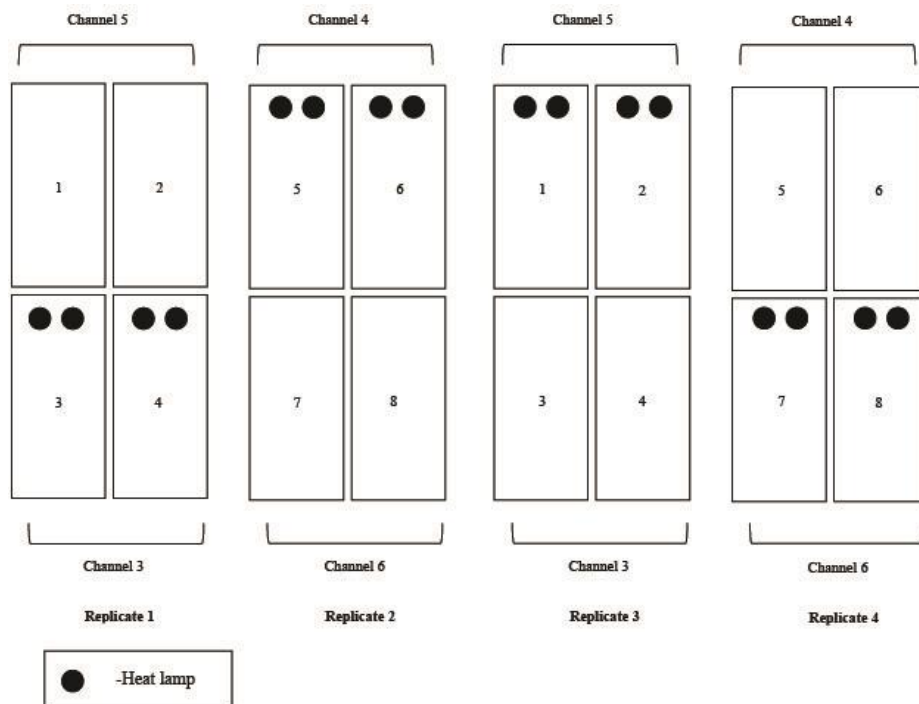


Figure 2. Experimental layout from above edited to depict pen numbers and video channels.



Figure 3. Example screenshot of the Adobe Premier Pro screen display in which two pens with the treatments Wood shavings (top) and Metal mesh (bottom) are being displayed.

Materials

The treatment pens measured 1.5x3.5 m with solid wooden walls on all four sides. The flooring of each pen was constructed on a raised metal platform (22.5 cm above the ground) with solid wood walls. WS and WS+H treatment pens were constructed on a solid wooden base with wooden shavings on top (10 mm particle size, 20 cm deep). MM and MM+H treatments were constructed on a base of expanded metal mesh (10x50 mm grid). For the WS+H and MM+H treatment pens, two aluminium heat lamp reflectors (Brooder lamp reflector, Kerbl, Germany) with heat lamps (250 W, Infrared, General Electric, Budapest, Hungary) installed were suspended next to each other at one end of the pen at a height of 70 cm from the floor of the pen and a distance of 60 cm from the walls of the pen.

2.2.3 Behavioural measures

Behaviour recording

Play behaviours were recorded using continuous focal sampling of one individual per pen. The individual was chosen by a random selection of paint marking ID symbol, and each goat marked with this symbol in each pen became the focal individual (paint marking ID symbol selected was O). As per the observation of behaviour in Sutherland *et al.* (2019), two channels from each repetition (rep) were observed across two hours (10:30-11:30 and 13:30-14:30)

across two alternate days (a day being a 24 hour period) over the eight day recording period. Each channel was recorded across two different days in each of the groups (Figure 2).

Table 1. Ethogram of play behaviours recorded as frequencies per minute and using continuous focal sampling observations during a set sample period.

Behaviour	Description
Locomotor Play	Locomotion at a pace greater than a walk, including a trot (two-beat gait), canter (three-beat gait) or gallop (fast four-beat gait). This behaviour can include body twists, jumps, head movements and buck kicks. Behavioural event ends when the animal becomes fully stationary for at least 1 second.
Jump/Leap	Animal shifts its weight to its back legs and propels the body upwards with both front legs off the ground. Event concludes when the front feet land back on the ground.
Head Press	Animal presses head into any other part of another animal. The behaviour may include head butts, head rubbing and ramming and can be performed from a run. The behaviour ends when the head is no longer in contact with the other animal.
Head Movement	Animal jerks its head in a distinct head and neck movement. Behavioural event ends when the head is stationary for at least 1 second. Not to be mistaken for the shaking of the head and ears as a grooming behaviour.
Mount	Animal places one or both front legs onto the side, front, rear or head of another animal. Event concludes when the front feet land back on the ground.
Wall Play	Animal jumps up and rebounds against the wall with at least the front legs making contact with the wall. Event finishes when the front feet land back on the ground.

2.2.4 Reliability

Intra- and inter-observer reliability was tested based on the level of correlation within and between two trained observers. Reliability was tested through the recording of behaviour frequencies (number of behaviours performed per 1 minute) of one focal individual on a set 30-minute period for each treatment, in each rep. The behaviours recorded were the same as those used in the study (Table 1). Reliability correlations were calculated using the Pearson product-moment correlation coefficient function in Excel. The average intra-observer reliability was $r = 0.92$. The average inter-observer reliability was $r = 0.99$.

Table 2. Average correlation of all intra- and inter- reliability testing.

	Rep 1	Rep 2	Rep 3	Rep 4	Overall
Intra-observer					
Overall correlation	0.99	0.99	0.75	0.96	0.92
Minimum correlation	0.84	0.87	0.56	0.00	0.00
Maximum correlation	1.00	1.00	1.00	1.00	1.00
Inter-observer					
Overall correlation	0.99	1.00	0.99	0.98	0.99
Minimum correlation	0.91	0.94	0.96	0.70	0.70
Maximum correlation	1.00	1.00	1.00	1.00	1.00

2.2.5 Statistical Analysis

All data was summarized to give the total number of frequencies over the duration of the observation period, per rep, per treatment.

The data was analysed using Genstat20 (Genstat for Windows 20th Edition, VSN International, Hemel Hempstead, UK).

Means were compared between treatments using a 2-way ANOVA blocked by rep. Residual plots were inspected for evidence of departures from the residual assumptions of normality and constant variance.

The data were natural log transformed prior to analysis to stabilize the variance. One was added to all counts prior to transformation to deal with zero counts. Back-transformed means with 95% confidence intervals were calculated.

Fisher's unprotected least significant differences at the 5% level were used to compare pairs of means. Means without a letter in common were considered significantly different.

2.2.6 Animal ethics

Animal ethics consent was not required for Part 1 of this study as observation of animals performing natural behaviours in their natural habitat is not considered manipulation. All procedures involving animals in Sutherland *et al.* (2019) were approved by the AgResearch Ruakura Ethics Committee under the New Zealand Animal Welfare Act 1999 (Protocol N° 13,595).

2.2.7 Recording and equipment

All video recordings were analysed using Adobe Premiere Pro 2019 (Version 14.0, Adobe Systems Incorporated, CA, USA).

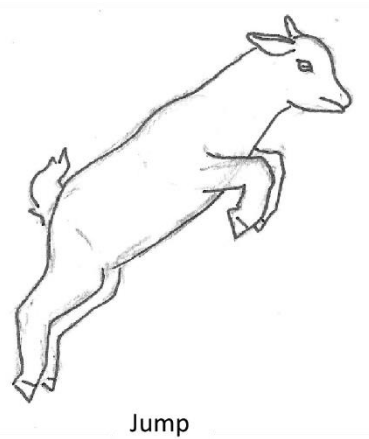
2.3 Results

2.3.1 Ethogram development

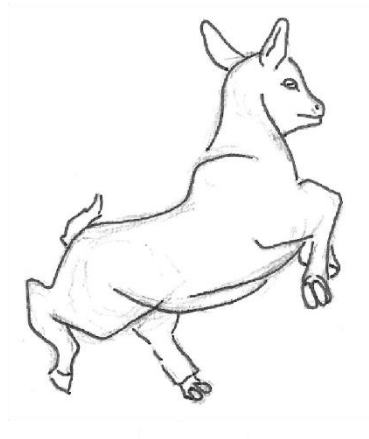
The final ethogram of play behaviours performed by domestic goat kids is presented in Table 3. Nineteen behaviours were identified and separated into three categories, these being locomotor play (4), social play (12) and object play (3). All four locomotor play behaviours were also identified in social play aspects. These behaviours were differentiated by their performance direction, this being either alone or towards that of another individual (Table 3).

Table 3. Ethogram of total play behaviours observed being performed by domestic goat kids through live and video pilot observations

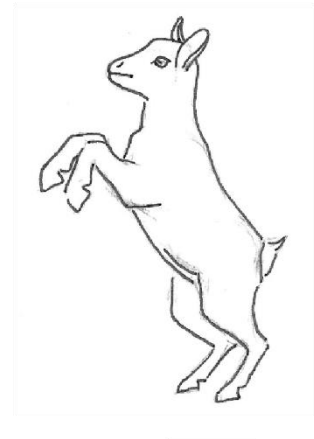
Behaviour Category	Behaviour	Description
Locomotor Play	Running	Locomotion at a trot (two-beat gait), canter (three-beat gait) or gallop (fast four-beat gait) with no apparent purpose/destination in either a forward or sideways direction. (Sutherland et al, 2014., Jensen et al, 1998)
	Frolic	Repeated, spontaneous locomotion including apparently random head shakes, body twists, leaps, jumps, bounds with propulsion from all four legs and/or buck kicks whilst airborne. Bout of behaviour stops when all animal becomes stationary.
	Leap	Animal shifts its weight to its back legs and propels the body upwards, front legs leave the ground first followed by back legs to land either front legs first or all four legs simultaneously. This behaviour appears to be a single jump with overexaggerated height and can include the twisting of the body whilst airborne and can be performed in a backwards or forwards direction. To be recorded as a leap this behaviour is distinctly one movement.
Social Play	Head Press	Animal lowers its head and presses its forehead into the side, front, rear or (most commonly) head of another animal. This position is held with varying weight shift forward and duration until the head contact is released. This behaviour can be performed from a stationary standing position, forward walking momentum, or sideways walking momentum and can appear to be a rubbing behaviour where the performing animal's head moves while maintaining contact with the other animal. This behaviour can include the twisting of the animals' head/s in order to lock horns if behaviour is performed head on; and forwards or sideways movement whilst performing can stop and restart within a single bout.
	Ram	Animal lowers its head and drives its forehead into the side, front, rear or head of another animal with continued momentum forward after contact that causes a change in direction of the targeted animal until the performing animal's momentum stops. This behaviour can be performed from either a stationary standing position, walking, jumping or running
	Social Running	Locomotion at a trot (two-beat gait), canter (three-beat gait) or gallop (fast four-beat gait) with the apparent purpose to either match or exceed the speed of another animal, or attract the attention of another animal, in either a forward or sideways direction.
	Social Jump	A jump behaviour (as specified above) that is directed against/onto/over/off or to attract the attention of another animal.
	Rear	Animal shifts weight to back legs and lifts the front legs and torso to then lower the front legs to the ground, usually directed towards another animal.
Object Play	Paw	Animal lifts either of its front legs, extends the leg forward towards, or to contact, another animal and draws leg back towards the body. This behaviour can occur repeatedly within a single bout. The bout is concluded when the foot is returned to the ground under full body weight.
	Substrate Play	Animal performs play behaviour directed towards or using the flooring substrate (usually sawdust) supplied as flooring in which the flooring substrate is purposely moved. This behaviour can include pawing at, jumping or leaping on the substrate.
	Wall Play	Animal performs a play behaviour using the walls of the pen to either jump against or press its front legs against before placing them back onto the ground. This behaviour does not include any investigatory behaviour where the animal uses its front legs to prop against the wall to identify objects on the wall, wall play must appear spontaneous and "purposeless".



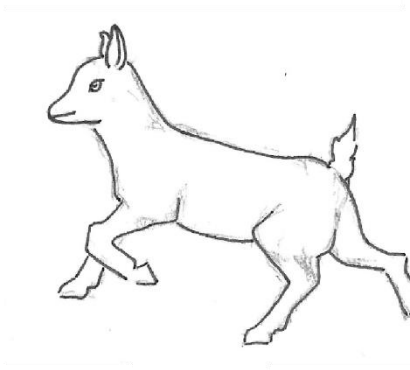
Jump



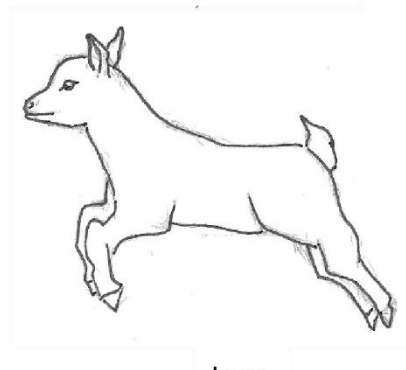
Frolic



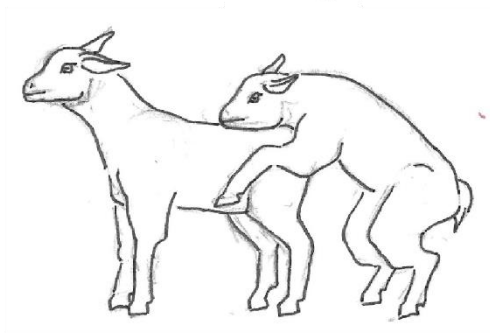
Rear



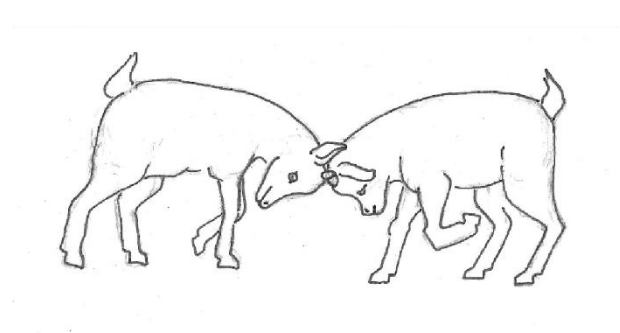
Running



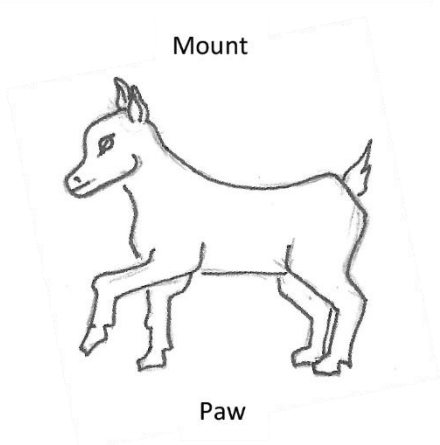
Leap



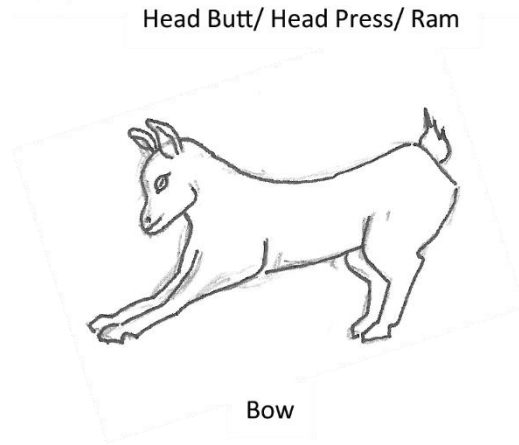
Mount



Head Butt/ Head Press/ Ram



Paw



Bow

Figure 4. Illustration of behaviours described in (Table 3).

2.3.2 Overall play frequency

The play behaviour performed with the highest frequency across all treatments was locomotor play ($x = 24.4\text{min}^{-1}$). This was followed by head press ($x = 16.1\text{min}^{-1}$) and jump/leap ($x = 12.8\text{min}^{-1}$). Wall play was performed at the lowest frequency ($x = 2.1\text{min}^{-1}$). Figure 4 shows that all behaviours were largely right skewed from the raw means and showed large variation in frequencies within the performing of one behaviour.

Table 4. All play behaviours with total frequency of behaviours recorded, raw mean, minimum value and maximum values

	Locomotor play	Jump/Leap	Head Press	Head Movement	Mount	Wall Play	Total Behaviour
Total	390	204	258	65	76	33	1026
Mean	24.38	12.75	16.13	4.06	4.75	2.06	64.13
min	0	0	0	0	0	0	0
max	120	64	56	21	30	10	274

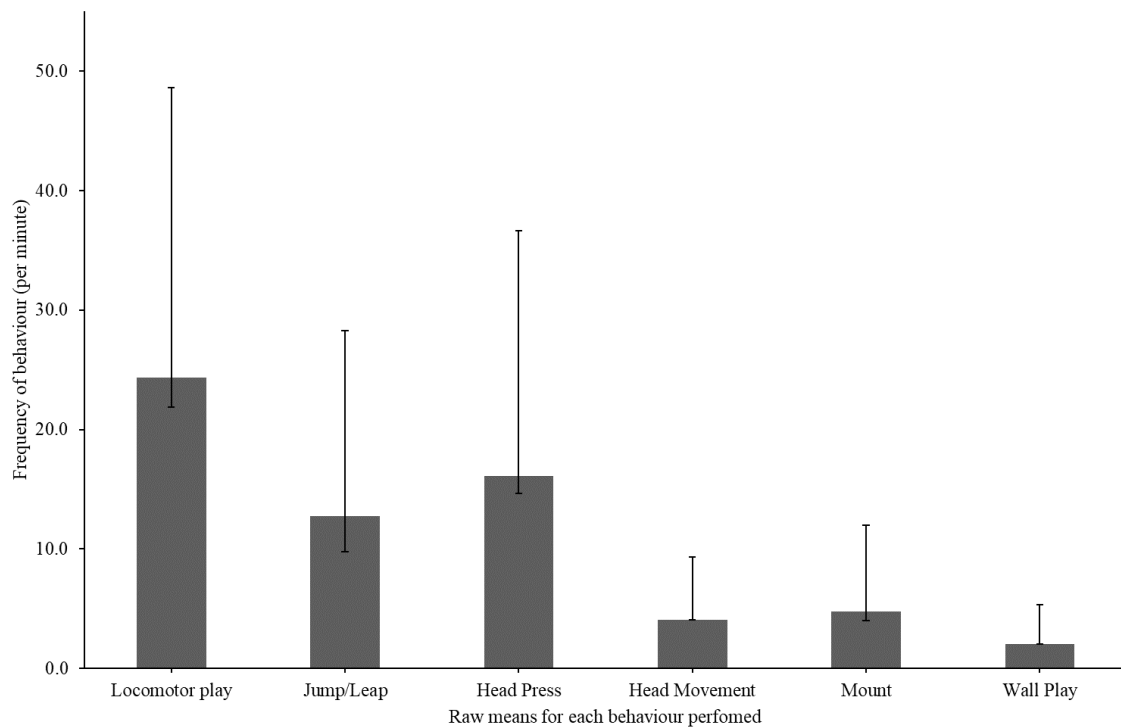


Figure 5. Raw means for each behaviour with upper and lower quartile range.

2.3.3 Treatment affect

Heat source

For the treatments including heat source, no significant affect was found on the total frequency of play behaviour performed by goat kids ($p = 0.352$; Table 5) as determined by a two-way ANOVA. There was no evidence that heat source influenced the performance of locomotor play, jump/leap, head press, head movement or wall play events. A significant difference was found between the means on the log scale of heat source treatments for the performance of mount ($p = 0.019$; Table 5). Log scale means were significantly different between Metal mesh with heat lamp (a) and Wood shavings with heat lamp (b), Metal mesh (b) and Wood shavings (b) (Table 5). It is worth noting that no mount behaviour was recorded for the treatment Metal mesh with heat lamp.

Flooring surface

For the different types of flooring surface, a significant affect was found on the total play behaviour performed by goat kids ($p = 0.041$). Means on the log scale were significantly different for the treatments of Metal mesh with heat lamp (a) and Wood shavings with heat lamp (b), as well as Wood shaving (b) for total frequency of play behaviour (Table 5). Significant differences between means were found for jump/leap ($p = 0.069$), head press ($p = 0.034$) and mount ($p = 0.008$) at the 5% level. No significant differences were found between the log scale means of locomotor play, head movement and mount at the 5% level.

Table 5. Back-transformed means of play behaviours with 95% confidence intervals. For each behaviour means with a letter in common are not statistically different ($\alpha < 0.05$). P-values were determined by 2-way ANOVA.

		Locomotor play		Jump/Leap		Head Press			
Metal mesh with heat lamp	1.7	a	(-0.5,14.5)	1.0	a	(-0.4,6.1)	1.6	a	(-0.4,10.0)
Wood shavings with heat lamp	26.5	a	(3.8,155.2)	10.6	ab	(2.3,40.5)	23.9	b	(5.0,103.3)
Metal mesh	8.4	a	(0.6,52.2)	6.7	ab	(1.2, 26.6)	4.4	ab	(0.3,21.7)
Wood shavings	14.5	a	(1.7,87.4)	12.6	b	(2.8, 47.4)	12.4	ab	(2.2,55.0)
p-value: heat source		0.677		0.213		0.938			
p-value: flooring surface		0.100		0.069		0.034			
		Head movement		Mount		Wall Play			
Metal mesh with heat lamp	0.4	a	(-0.6,3.7)	0.0	a	(-0.5,1.7)	0.821	a	(-0.3,3.5)
Wood shavings with heat lamp	2.4	a	(0.0,10.2)	3.5	b	(1.2,8.3)	1.991	a	(0.2,6.4)
Metal mesh	2.9	a	(0.2,11.7)	2.7	b	(0.8,6.7)	0.316	a	(-0.5,2.2)
Wood shavings	3.0	a	(0.2,12.3)	6.6	b	(2.7,14.8)	2.224	a	(0.3,6.9)
p-value: heat source		0.294		0.019		0.761			
p-value: flooring surface		0.403		0.008		0.115			
		Total behaviour							
Metal mesh with heat lamp	4.67	a	(0.2,25.8)						
Wood shavings with heat lamp	75.35	b	(15.1,360.3)						
Metal mesh	28.03	ab	(5.1,136.4)						
Wood shavings	56.49	b	(11.1,271.1)						
p-value: heat source		0.352							
p-value: flooring surface		0.041							

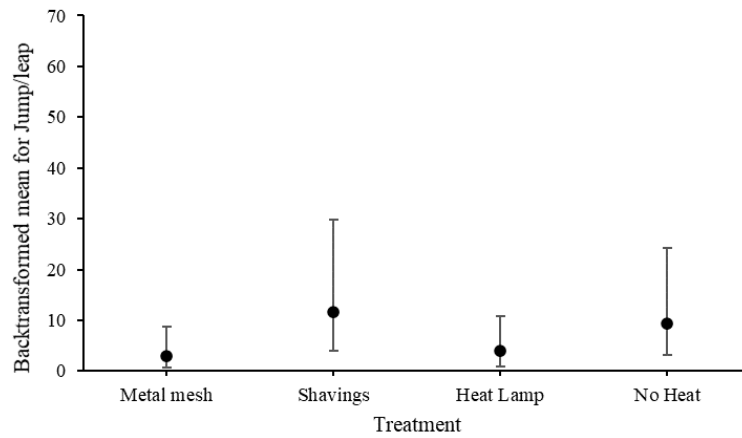


Figure 6. Back transformed means and confidence intervals for Jump/leap.

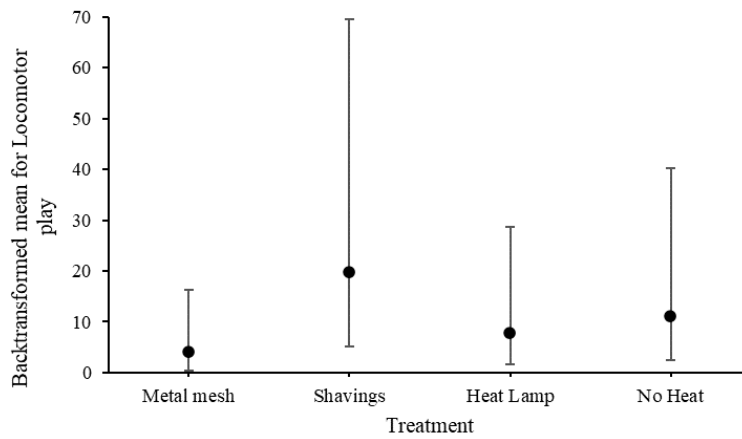


Figure 7. Back transformed means and confidence intervals for Locomotor play.

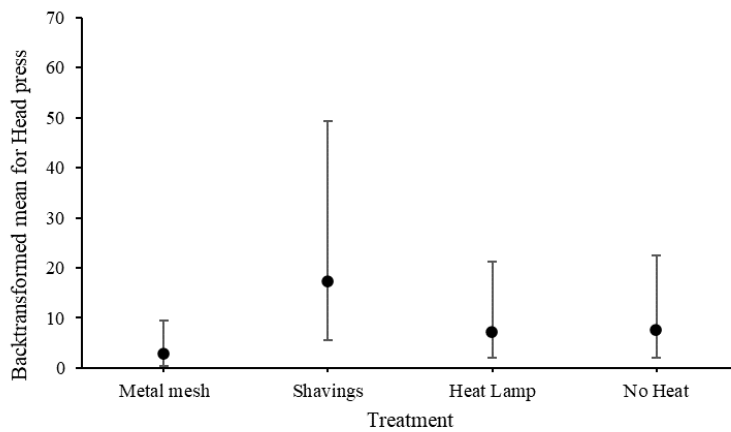


Figure 8. Back transformed means and confidence intervals for Head press.

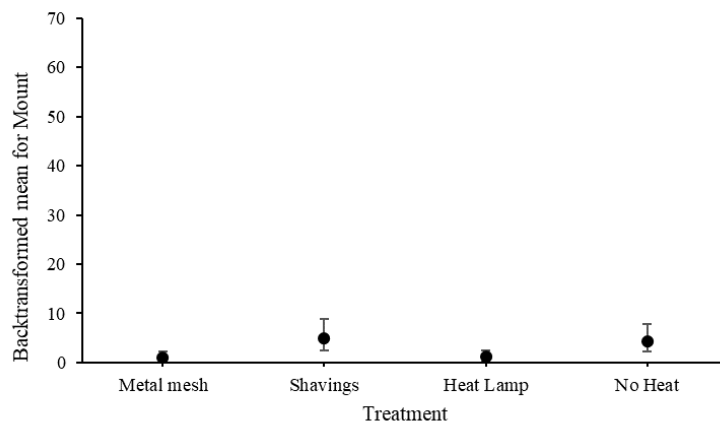


Figure 9. Back transformed means and confidence intervals for Mount.

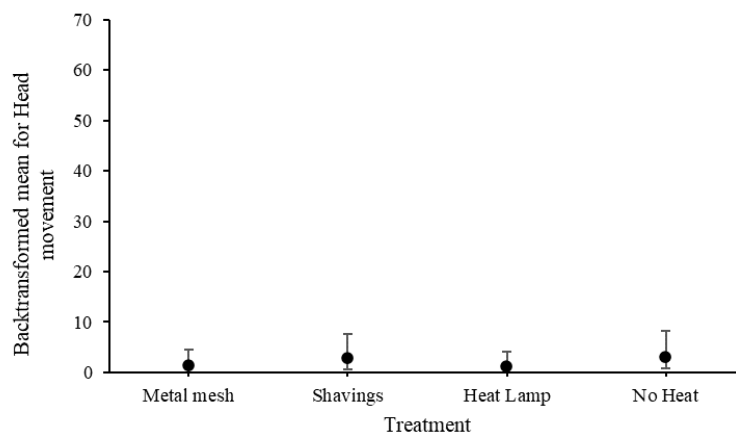


Figure 10. Back transformed means and confidence intervals for Head movement.

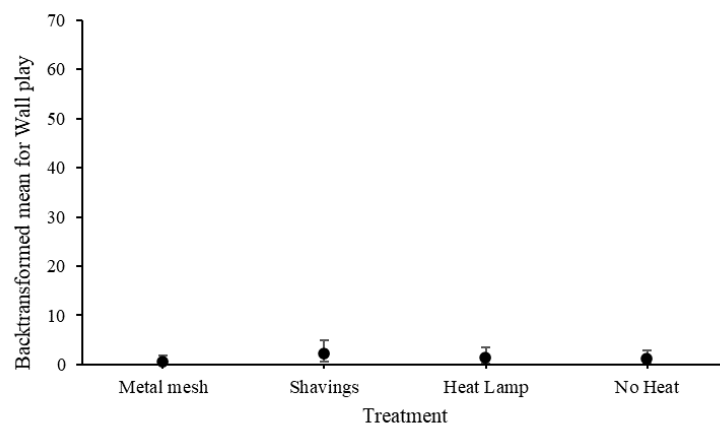


Figure 11. Back transformed means and confidence intervals for Wall play.

2.4 Discussion

2.4.1 Ungulate play (ethogram)

Current research on play behaviour in domestic goat kids appears to be limited. This was eluded to in Sutherland *et al.* (2019) where the need to develop an ethogram of play behaviours in domestic goat kids was suggested to further their research. Play behaviour ethograms have been developed for juveniles of other ungulate species including calves, pigs, sheep, and horses (Jensen *et al.*, 1998; McDonnell & Poulin, 2002; Chapagain *et al.*, 2014; Brown *et al.*, 2015). The ethogram developed for this study shows similarities in the play behaviour of domestic goat kids to that of other ungulate species.

Locomotor play behaviours described in Table 3 show similarities in structural description to those described in the studies of other ungulates. The behaviour of ‘gallop’ described by Jensen *et al.* (1998) in dairy calves, ‘running’ described by Brown *et al.* (2015) in piglets, ‘run’ described by Chapagain *et al.* (2014) in lambs and by McDonnell and Poulin (2002) in equid foals are all very similar in structural description to the ‘running’ behaviour of goat kids in Table 3. Behaviours similar to ‘leap’ and ‘jump’ are described in lambs (jump), piglets (pivot), calves (leap, jump and turn) and foals (jump and leap) (Jensen *et al.*, 1998; McDonnell & Poulin, 2002; Chapagain *et al.*, 2014; Brown *et al.*, 2015). Behaviours similar to ‘frolic’ in goat kids have been described in lambs (gambol), foals (frolic) and piglets (hop) (McDonnell & Poulin, 2002; Chapagain *et al.*, 2014; Brown *et al.*, 2015).

The relative similarities between the locomotor behaviours in the developed ethogram for goat kids (Table 3) and the behavioural descriptions of other ungulate species are unsurprising as locomotor play in ungulate species is the type of play most frequently recorded (Vilá, 1994; Dwyer, 2009; Théoret-Gosselin *et al.*, 2015; Yang *et al.*, 2018).

Social play behaviours described in Table 3 show some similarities in structural description to those in the studies of other ungulates. Behaviours similar to ‘head but’, ‘head press’ and ‘ram’ were identified in lambs (butt), piglets (nudge, push and non-harmful fighting), calves (frontal pushing) and foals (push)

(Jensen *et al.*, 1998; McDonnell & Poulin, 2002; Chapagain *et al.*, 2014; Brown *et al.*, 2015). Behaviours similar to ‘mount’ were found in lambs (mount), piglets (climb) and foals (mount) (McDonnell & Poulin, 2002; Chapagain *et al.*, 2014; Brown *et al.*, 2015). The behaviour of ‘head movement’ was similar to that of ‘head-shake’ described in dairy calves, however, this was categorised as a locomotor play as opposed to a social play behaviour in Table 3 (Jensen *et al.*, 1998). No form of isolated head movement was described in Chapagain *et al.* (2014), Brown *et al.* (2015) or McDonnell and Poulin (2002).

Social play behaviours across ungulate species appear to have both similarities and species dependent forms. Conflict behaviour, such as the ‘head press’, ‘head but’ and ‘ram’ behaviours described in Table 4, is evident in most hierarchical ungulate populations where aggressive graded signals are used to threaten and then initiate conflict behaviour in the defence of territory, juveniles or mating prospects (Vanpé *et al.*, 2009). Head to head collision is a common form of conflict behaviour in ungulate species such as goats, sheep and cattle and this is reflected in the patterns of social play behaviour recorded in these species (Blank & Yang, 2012). These species often have protuberances, in the form of horns or antlers, on their heads that aid in conflict and courtship behaviours (Dwyer, 2009; Vanpé *et al.*, 2009). Conflict behaviour in most ungulate species are aided by graded signals indicating intent and level of aggression that may be learned and ‘practiced’ by juveniles in the form of play (Reinhardt & Viktor, 1982). This supports the influence of adult related conflict behaviours on the conflict-like head play behaviours in the goat kid juveniles present in the current study. It is suggested that these play behaviours function both for motor skills and muscle development, as well as the learning of species recognition for future competition and/or co-operation (Jensen, 2011).

It may be that the differences in the social play behaviour structure of the goat kids from other ungulate species is related to species specific play signalling. Subtle signals are often used between con-specifics to indicate intent during agonistic behaviour, indicating whether intent is aggressive or in play (Burghardt, 2005). It may be that behaviours such as ‘paw’, ‘head movement’, ‘rear’ and ‘bow’, that appear to be performed by the goat kids, but not other ungulates, are associated with subtle signalling behaviours. Play signals can also be used to

communicate intent to play with another individual, therefore, many of the social play behaviours identified in goat kids may also involve aspects of play signalling (Burghardt, 2005).

The structural form of object play in ungulates has been found to vary across species. In goat kids object play is performed predominantly using the legs or hooves (Table 3), however, piglets have been observed to manipulate the objects with their mouth and teeth (Brown *et al.*, 2015; Yang *et al.*, 2018). Lambs have been observed performing object play with both their limbs (hooves and forelegs) and head (head and nose) (Chapagain *et al.*, 2014). McDonnell and Poulin (2002) observed a wide range of object play behaviours in foals that included the use of teeth, mouth, hooves, legs, and head to manipulate objects. The variation in structure of behaviours across species is likely due to physical differences and align with structural adaptations of each species. The preference of goat kids to manipulate objects with their limbs and hooves is likely due to structural adaptations that allow flexibility and control over these parts of the body that aid in predator avoidance such as running and climbing. Object play is performed with less frequency than other play behaviours in most juvenile ungulates and is considered less important to the development of juveniles than locomotor and social play behaviours (Blank & Yang, 2012; Bøe *et al.*, 2012). As ruminant ungulates, food resources are not difficult to find and the development of curiosity or searching behaviours may not be as important. The presence and structure of object play behaviours are also influenced by environment and availability of objects to manipulate.

Play behaviour ethograms can differ dramatically due to the subjective categorisation and context understood by the authors of each study. Observation and documentation of play behaviour is also subjective in experimental nature and, therefore, behaviours are likely to vary in categorisation and understanding across studies, as previously discussed (section 1.5). This could explain the similarities and differences between the structure and categorisation of other play behaviour ethograms to that of Table 3. McDonnell and Poulin (2002) identify that many of the behaviours documented cross over in categorisation including the behaviour of ‘to and from’ that is locomotor in structure but clearly directed around, or stimulated by, an object. This is similar to the addition of ‘social

running', 'social frolic', 'social jump' and 'social leap' described in Table 3. Chapagain *et al.* (2014) defined 'sniff object' and 'sniff pen mate' as play behaviours in lambs, however, sniffing behaviours in goat kids were considered exploratory behaviours and therefore did not fit the definition of play behaviour used in this study, excluding them from the ethogram in Table 3 and Table 1.

2.4.2 Frequency of play in juvenile domestic goats

Performance of locomotor play had the highest frequency across all treatments in goat kids (Table 4). This follows a similar pattern in the frequency of play in other ungulates. Gomendio (1988) found that Cuvier gazelles had high frequencies of locomotor play early in ontogeny. Vilá (1994) found locomotive play frequency to be high in vicuña and Blank and Yang (2012) found locomotor play to have the highest performed frequency in the goitered gazelle. Locomotor play frequencies have also been found to be high in juvenile predator species such as cheetah cubs (Caro, 1995).

Ungulate species are naturally prey animals where the greatest cause of mortality in neonates and juveniles is predation (Linnell *et al.*, 1995). This has been suggested as a motivating factor in the predominance of locomotor play performance in these species and could be suggested to be a similar innate motivating factor for the goat kids in the current study (Théoret-Gosselin *et al.*, 2015). Théoret-Gosselin *et al.* (2015) found that locomotor play frequency and development in neonatal mountain goats was a strong predictor of post-weaning survival into the summer months. Play behaviour in juveniles has also been positively linked to survival in both brown bear cubs and elephant calves (Fagen & Fagen, 2004; Webber & Lee, 2020).

In contrast to the findings of the current study, Chapagain *et al.* (2014) found social behaviour was performed at a higher frequency than locomotor behaviour in lambs. Hass and Jenni (1993) found that bighorn sheep lambs are attracted to other lambs, suggesting a 'safety in numbers' strategy when playing increased protection. This could indicate why social behaviour was more frequent than locomotor behaviour in Chapagain *et al.* (2014). Both these studies recorded behaviour in 'free range' animals as opposed to the penning of animal subjects

such as the goat kids in this study which could also influence the natural and preferred proximity of animals to each other.

Jensen *et al.* (1998) made note that although the predominant play performed was locomotor, the percentage of overall play behaviour performed in their study of penned dairy calves was low and occurred in short bouts starting and stopping within a short period. This is somewhat like the recordings of goat kid behaviour frequency where multiple, short bouts of play would occur in some recorded periods whilst in other recorded periods no play behaviour was recorded.

2.4.3 Influence of flooring surface on play behaviour frequency

The results of this study show that flooring surface had a significant effect on the performance of play behaviour in goat kids ($p=0.041$). Play behaviour was shown to be more frequent on Wood shavings than on the Metal mesh (Table 5). This finding supports the hypothesis that goat kids would play more frequently in treatments with flooring that has wood shavings (H2).

Sutherland *et al.* (2014) found that flooring surface had a significant influence on the lying behaviour of dairy calves. In their study of Friesian cross dairy calves, lying and walking behaviours were recorded significantly less often in pens with quarry stones used as flooring compared to those in pens with sawdust flooring (a similar product to wood shavings). Similar findings were also identified in Sutherland *et al.* (2019) where the running, walking and lying behaviours of goat kids were significantly less on metal mesh flooring than on wood shavings. It was suggested that the perceived comfort, higher compressibility and higher insulation properties of the sawdust and wood shaving treatments could be the reason for the animals preference (Sutherland *et al.*, 2014; Sutherland *et al.*, 2019). It is likely these suggestions correspond to the findings of the current study. The uneven surface of the metal mesh, similar to the quarry stones, could be perceived as uncomfortable for the goat kids both under foot and when lying. It may be that the uneven surface reduced play behaviour due to an attempt to reduce injury from falling on the harder surface.

It is possible that topping up the wood shavings for hygiene purposes during the study provided the goat kids with a novel stimulus that stimulated play behaviour. Environmental enrichment has been shown to stimulate play behaviour

in juvenile ungulate species (Jensen *et al.*, 1998; Nogueira *et al.*, 2011; Bøe *et al.*, 2012; Chapagain *et al.*, 2014). Nogueira *et al.* (2011) found that providing environmental enrichment, in the form of novel object stimuli, increased the occurrence of play in peccaries. Play motivation was also found to decrease after approximately five days of access to a novel stimuli further indicating the influence of an external environmental factor in the performance of play behaviour (Nogueira *et al.*, 2011). Bøe *et al.* (2012) also found that enrichment via a novel stimulus and access to an outside enclosure influenced frequency of active behaviour in goats. Goats have also been found to prefer elevated areas in natural environments (Zobel *et al.*, 2018). Investigating the influence of elevation and novel objects on play behaviour stimulation in goat kids could be an area of future research, particularly if it could enhance the positive affective state of animals housed in confinement.

2.4.4 Influence of heat supplementation on play behaviour frequency.

The results of this study show that a supplemental heat source did not have a significant effect on the performance of play behaviour in the goat kids. This finding was not in support of the predicted hypothesis that goat kid play would be more frequent in treatments with heat supplementation. Sutherland *et al.* (2019) found that goat kids showed a preference for a supplemental heat source, spending significantly more time under the heat lamps when provided the opportunity. It was therefore assumed this provided better environmental conditions which would promote an increase in play behaviour. This was not supported by the findings of this study and no significant difference was found between the treatments of heat lamp vs. no heat lamp. Suggestions for the lack of effect include the possibility that the temperature the heat lamps provided in heat supplemented treatments was not different enough from the no heat lamp treatments to influence play behaviour. It may be that providing a larger temperature difference (e.g. more lamps in the heat lamp treatments) could have a stronger effect on the frequency of play behaviour. Goat kids, like many juvenile ungulates, will huddle together to aid thermoregulation in cold conditions (Mellor & Stafford, 2004). It may be that

the goat kids in treatments with heat supplementation were aiding thermoregulation by lying under the lamp as opposed to using huddling behaviours. The significant difference in lying behaviours found in Sutherland *et al.* (2017) may then be unrelated to the frequency of play behaviour.

The goat kids in the current study were fed ad lib with no experimental manipulation of energy consumption among treatments. It may be that with restricted energy the goat kids would contribute more energy to thermoregulation and less energy to play behaviour indirectly providing a temperature treatment effect. In this situation the goat kids would play less frequently in treatments at lower temperatures, or treatments without the heat supplementation. Feed restrictions in dairy calves have been found to influence frequency of locomotor play behaviour up until five weeks of age (Krachun *et al.*, 2010). Investigating play behaviour in further detail with respect to the goat kids' perception of their environment could be an area of further research.

2.4.5 Other potential factors influencing play behaviour

Space allocation

For many captive animals space allocation can negatively influence play behaviour frequency. Jensen *et al.* (1998) found that space had a direct influence on locomotor play behaviour in penned dairy calves with calves in smaller pens playing significantly less than those in larger pens. The overall frequency of play behaviour in Jensen *et al.* (1998) was low compared to that of the current study which could imply that the goat kids had adequate space to perform more play behaviour. Another suggestion is that there could be a difference in play behaviour frequency across these species. It is worth identifying that the play behaviour was recorded in Jensen *et al.* (1998) as a percentage of active time budget as opposed to frequency per minute.

The goat kids in the current study were housed in 1.5 m x 3.5 m pens, five kids per pen. The Code of Welfare for goats in New Zealand requires the minimum standard of housing to allow grouped animals enough space to lie, stand and move around without interference from each other (Ministry for Primary Industries, 2018). Due to the small size of the goat kids at the time of the study, these minimum standards were likely met with excess. The large amount of play

recorded indicates adequate space to assess play behaviour if it is used as an indicator of welfare. The pen space provided in the current study was unlikely to have a negative influence on the amount of play behaviour performed by the goat kids.

Age

The current study was conducted over eight days and the potential influence of age on the play behaviour of the goat kids was not considered in experimental design, however, age and developmental period has been shown to influence the frequency and type of behaviour performed by juveniles (Gomendio, 1988; Newberry *et al.*, 1988; Caro, 1995; Richter *et al.*, 2016; Yang *et al.*, 2018). Gomendio (1988) found that age influenced the type of play performed in Cuvier gazelle calves. It was found that Cuvier gazelle calves had high frequencies of locomotor play during early ontogeny. These frequencies declined with age, followed by an increase in the frequencies of social play in the later months with all play behaviours declining after four months. Similar patterns of play behaviour decreasing with age have been found in cheetah cubs, mice, and piglets (Newberry *et al.*, 1988; Caro, 1995; Richter *et al.*, 2016; Yang *et al.*, 2018).

A low level of play recorded in the first two weeks in piglets was suggested to be due to a high need for thermoregulation and energy conservation (Newberry *et al.*, 1988). Gomendio (1988) also identified a period of low total play behaviour performance in the first two weeks after birth, however, this coincided with a high frequency of locomotor play. In contrast to Newberry *et al.* (1988), Gomendio (1988) considered this an intentional reduction in overall conspicuous behaviour for predator avoidance. This period was labelled ‘the hiding phase’ due to the lack of conspicuous nature of locomotor play behaviour during a period of supposed ‘hiding’ in a prey species juvenile. The higher frequency of locomotor play during this phase suggested that locomotor play in the gazelles may have immediate benefits in endurance and strength to outweigh the cost of vulnerability. It was also suggested that this form of play may be a coping mechanism during a stressful period of development and also have long-term benefits in the learning of social and environmental context (Gomendio, 1988). The suggestions in this study support the view of play behaviour being flexible in purpose and time of benefit. Caro (1995) also suggested that the

increase in locomotor play during the first period of life coincided with a period of vulnerability where predator induced mortality was high. This then changed, as the cubs aged and were better equipped to defend themselves, into an increase in object and social play behaviour where exploration and family identification becomes more important to development (Caro, 1995).

The goat kids in the current study were approximately three days old which follows the pattern of other ungulate species where locomotor play was high in the first period of life, suggesting that goat kid play behaviour is likely influenced by age. The influence of age on play behaviour type, frequency and development in goat kids could be an area to further expand play behaviour research in dairy goats.

Sex

The goat kids in the current study were all female in sex, however, sex of individual animals and the sex ratio within groups have been shown to influence the performance of play in juvenile animals (Vieira *et al.*, 2005; Oliveira *et al.*, 2009; Nogueira *et al.*, 2011; Richter *et al.*, 2016). Hass and Jenni (1993) found that male bighorn sheep lambs played significantly more than females. The pattern of play behaviour performed by these lambs was similar to that of adult conflict and courtship behaviour which could suggest that male juveniles would benefit from motor pattern development of these behaviours later in life more so than females. Interestingly, gender preference of play partners was not found suggesting that female and male lambs could play both gender roles in behaviours similar to adult conflict and courtship. Newberry *et al.* (1988) found no significant differences between the play behaviour of male and female piglets, supporting the theory that play behaviour performance, purpose and influence varies across species.

The influence of sex and different sex ratios within a group on the play behaviour of goat kids could be an area where further research could be expanded.

Time of day

The time of day of recording of goat kids was consciously selected to align with feeding times. Time of day has been shown to influence the frequency of play behaviour, especially around feeding routines (Jensen *et al.*, 1998; Palagi *et*

al., 2004; Norscia & Palagi, 2011). Jensen *et al.* (1998) found that penned dairy calves played more frequently around scheduled feeding times. Norscia and Palagi (2011) found a similar pattern in marmosets with the highest frequency of play behaviour before feeding. Palagi *et al.* (2004) suggested that an increase in play around times of day related to high tension and stress, such as feeding times where competition is high, and play behaviour in juvenile chimpanzees could be a way to reduce injury from aggression and regulate stress levels. Due to the recording of goat play behaviour at approximately 30minutes after feeding when activity was observed to be high, time of day may have had an influence on the frequency of play behaviour and the results presented may not be an accurate representation of play behaviour performed across a 24hours period.

Species and individual variation

Variation in play behaviour frequency and structure has been found across and within species, as well as within individuals themselves (Smith, 1982; Clark & Ehlinger, 1987; Held & Špinka, 2011). As the current study used focal sampling of one individual animal per pen (n=16), there is potential for the recording of play behaviour to have been influenced by individual variation and by the behaviour of other individuals in the same pen. Richter *et al.* (2016) found significant differences between the play behaviour frequency of individual mice. Play behaviour in captive elephant calves have also shown high variation in performance between individuals (Webber & Lee, 2020). Suggested factors influencing the performance of play in these individuals include energy availability, partner availability, mood, temperament, distraction and potential risks (Webber & Lee, 2020). Extending the sample size of the current study could improve accuracy around the potential influences of individual variation on population assumptions around play behaviour in goat kids.

Differences in play behaviour structure between species are influenced by many factors including differences in biology, growth rates, environmental niche and energy requirements (Blueweiss *et al.*, 1978; Smith, 1982; Clark & Ehlinger, 1987; Carl & Robbins, 1988). Smaller sized ungulate species often develop faster than larger species creating a difference in development periods and influencing behaviour such as play (Blueweiss *et al.*, 1978). The goat kids in the current study were of the Saanen breed and caution should be shown when extrapolating

findings from the current study to other breeds of goat and/or other ungulate species.

Stress

Stress and pain have been shown to have a significant influence on the performance of play behaviour in many animal species (Newberry *et al.*, 1988; Blank & Yang, 2012; Mintline *et al.*, 2013; Nahallage *et al.*, 2016; Richter *et al.*, 2016; Yang *et al.*, 2018; Webber & Lee, 2020). Nahallage *et al.* (2016) found stone handling play behaviour in macaques was performed less in stressful situations. A study looking at the effect of pain relief on the play behaviours of dairy calves found that pain had a significant negative influence on the frequency of play behaviour in disbudded calves (Mintline *et al.*, 2013). Social isolation and weaning can also be major stressors to juvenile prey animals, influencing the performance of play behaviours (Newberry *et al.*, 1988; Vieira *et al.*, 2005; Reid *et al.*, 2017; Yang *et al.*, 2018). Newberry *et al.* (1988) found a decrease in play behaviour during weaning in piglets and Blank and Yang (2012) also found a decrease in play behaviour around weaning in goitered gazelles. Social isolation has been found to induce higher cortisol levels in horses than mild pain stimulants indicating that social isolation may be more likely to negatively impact play behaviour than mild pain (Reid *et al.*, 2017).

In contrast some species of primate have been found to increase play behaviour around stressful situations such as feeding times (Palagi *et al.*, 2004; Norscia & Palagi, 2011). Yang *et al.* (2018) found that an increase in object play behaviour was positively correlated with a decrease in cortisol levels after weaning in piglets when novel stimuli were presented supporting suggestions that play behaviour may mitigate stress. The predominant finding in research on ungulates suggests play behaviour is performed in environments with minimal stressors (Gomendio, 1988; Newberry *et al.*, 1988; Burghardt, 2005; Mintline *et al.*, 2013; Sutherland *et al.*, 2014). The goat kids in the current study were not subject to pain or stress inducing treatments, therefore pain and stress factors were not considered direct influences on their play behaviour. Further research is needed for us to understand the relationship between stress and the performance of play behaviour in goat kids if it is to be used as a measure of welfare/positive affective state

2.4.6 Animal welfare

Play behaviour has been considered a good indicator of positive affective state, which implies good welfare for many animal species in commercial environments including production, entertainment and research areas (Fraser & Duncan, 1998; Palagi *et al.*, 2004; Carrasco *et al.*, 2009; Oliveira *et al.*, 2009; Battini *et al.*, 2014; Richter *et al.*, 2016; Bateson, 2017). Nogueira *et al.* (2011) found that environmental stimulation enhanced play behaviour and overall activity in peccaries suggesting that play behaviour could be a positive indicator of the quality of their environment. Carrasco *et al.* (2009) found positive reinforcement training and unstructured play periods were effective at reducing aggression and fear while increasing relaxation and spontaneous play in captive gorillas. The findings of this study indicate that play behaviour could be used as indicator of welfare in domestic goat kids.

Play behaviour in animals has been linked to positive affective states and shown to decrease when an animal is in uncomfortable environments (Newberry *et al.*, 1988; Fraser & Duncan, 1998; Carrasco *et al.*, 2009; Mintline *et al.*, 2013). Sutherland *et al.* (2019) suggested that an increase in activity on wood shaving flooring may indicate a more positive affective state in the goat kids and a better welfare friendly environment. The findings of the current study support this suggestion by showing that goat kids perform play behaviour significantly more frequently on the wood shavings than on the metal mesh.

Locomotor play performance was not significantly different across the flooring surface treatments. As locomotor play is the most frequent type of play in ungulates and often the earliest performed, this form of play behaviour is likely to be performed at the first opportunity, even when welfare conditions are not ideal. This has been found in other animal species where play has been suggested as a coping mechanism for environment depletion or high stress environments (Palagi *et al.*, 2004; Webber & Lee, 2020). Palagi *et al.* (2004) found play behaviour in chimpanzees increased around high stress time periods and was associated with a reduction in aggression and tension in juveniles. This differs from research suggesting that play is only performed in high quality environments. Webber and Lee (2020) found that captive elephant calves played more than those in the wild.

It was suggested that play in elephants may not be a good indicator of welfare and that although captive contexts may provide some short-term needs, other social and physical needs are unlikely to be met in the same way as in the wild. Webber and Lee (2020) also suggested that an increase in play in captive animals could indicate a removal of other natural behaviour and act as a coping mechanism to an inadequate environment rather than an expression of a positive affective state.

It could then be suggested that complexity of play behaviour in goat kids could be an indicator of enhanced levels of welfare, where the presence of behaviours other than locomotor such as social and object play, are an indication of a more positive welfare environment that exceeds minimum standards.

2.4.7 Limitations of this study

Due to the use of video recordings from a previous study there were many limitations to this study. The first of these being the camera position used to record each pen. Being positioned above the pens, the camera used to record the animals provided a single dimensional bird's-eye view of the behaviours performed causing difficulty in identifying and isolating different behaviours. Although many alterations were made to the ethogram used, there was some subjectivity in the recordings of behaviour. This was minimised by reliability testing (section 2.2.4). The camera position also caused the heat lamps to block areas of the pen restricting behavioural recordings when the focal animal moved under the lamp.

Another limitation provided by the reuse of videos from a previous study was the camera quality and consistency. The recordings had occasional pixilation in areas of the screen that restricted ability to identify behaviours when the animal was blurred by the pixilation.

Behavioural recording was completed over two 30 min periods in a 24 h day. This would have limited the number of potential behaviour frequencies recorded and could have been an inaccurate representation of the frequency of behaviour performed across a 24 h day.

The experiment was designed to record simplistic behaviours, and not specifically for the recording of more complex play behaviours. The pens used were set spaces and could have restricted play behaviour ability to the confines of the pen.

The sample size of the current study is relatively small. Although 80 goat kids were used in the previous study, only 16 of these were used for focal sampling. This could increase the number of type II errors evident in the data questioning the robustness of the results. A larger sample size may have strengthened the significance of the results.

Only female goat kids were used in the current study. As sex differences in play has previously been identified, this could have influenced the results of this study (section 2.2.2). Further research investigating the effect of sex on play behaviours in goat kids is warranted.

Chapter 3: Conclusions and recommendations

3.1 Conclusions

The current global commercial market for goat products has been increasing, and with it an increase in concern for animal welfare and an increased demand for research. The current study focussed on investigating a gap in commercial goat research that includes goat kid play and its implications for welfare.

The current study developed the first known ethogram for goat kid play that showed patterns of play behaviour that were similar to most other species of ungulate including aspects of locomotor, social and object play.

The type of play behaviour performed in the highest frequency was locomotor play. Locomotor play is often the first and most frequently performed type of play found in juvenile ungulates during development.

Flooring surface was found to have a significant effect on the frequency of play behaviour in goat kids. The goat kids in the metal mesh treatments played significantly less than the goat kids in the Wood shaving treatments. This finding supports H2, where a higher frequency of play behaviour on the wood shavings was predicted. This finding also supports H3, where play behaviour was predicted to be higher in frequency in more optimum conditions. Wood shavings were assumed to be a more optimum condition than metal mesh due to the flooring preference findings in Sutherland *et al.* (2019).

As supplemental heat source was not found to have a significant effect on the frequency of play behaviour in goat kids. There was no significant difference between the frequency of behaviour performed in the heat lamp and no heat lamp treatments. This finding does not support H1, where play behaviour was predicted to be higher in the treatments with heat supplementation. Suggested reasons for this finding include the possibility that the temperature difference provided by the use of supplemental lamps was not extreme enough for between treatment comparison or that heat supplementation may not influence play behaviour if energy needs are met.

The results of this study indicate that play behaviour in goat kids could be an indicator of good welfare in support of H4. It is also suggested that complexity of play behaviour in goat kids, including the performance of social and object play behaviours, could be an indicator of enhanced levels of welfare exceeding set minimum standards. Further research is needed investigating play behaviour in goat kids.

3.2 Future research

The area of goat kid play behaviour in research is limited. Research around this area could aid in the development of both efficiency for commercial goat businesses and concerns for the welfare of the animals involved.

Areas for future research include:

- The potential influence of environment on play behaviour in goat kids. This could involve the manipulation of play pens or arenas to include areas of elevation and/or novel stimulus to promote play behaviours.
- The importance of thermoregulation for goat kids and its influence on play behaviour. This could include feed restrictions and investigations into how energy variability influences frequency of play behaviour.
- The potential influence of sex on play behaviour in goat kids. This could include groups with varied sex ratios and investigations into partner preferences.
- The potential influence of age on play behaviour in goat kids. This could be a similar study on the play behaviour frequency of goat kids over a longer period of time to investigate how development, frequency and type of play behaviour changes over time.

- The potential influence of compromised welfare on play behaviour in goat kids. This could include the possible effects of pain or stress on play behaviour in goat kids.
- Investigation into the variation of play behaviour between species of domestic goat kids as well as individual variation of play behaviour.

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