CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Tropical Agrisciences

Mother–calves' interaction and suckling behaviour in captive common eland (*Taurotragus oryx*)

MASTER'S THESIS

Prague 2023

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Declaration

I hereby declare that I have done this thesis entitled 'Mother–calves interaction and suckling behaviour in captive common eland (*Taurotragus oryx*)' independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague …………..

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Madiha Arfan

Acknowledgements

I am deeply grateful to those who have supported me in completing this thesis. My sincere thanks go to my supervisor, Radim Kotrba, Ph.D., especially my co-supervisor doc. Francisco Ceacero Herrador, Ph.D.for their guidance and expertise, which proved invaluable in shaping this research.

I extend my appreciation to my family and friends especially, Ing Abubakr Sadiq, Kamran Javaid, and Ing. Divya for their support in completing my thesis.

Finally, I would like to thank myself for not going crazy during this period.

Lastly, I acknowledge the CZU for providing the resources essential for this research.

Abstract

The Common eland (*Taurotragus oryx*), a species of African spiral-horned antelopes, remains a popular game species, yet many aspects of its biology and behaviour remain unexplored. This research investigates the mother-calf bond in common elands, a crucial factor for calf survival and reproductive success. Despite its significance, this bond has received limited attention in research. Key factors influencing the mother-calf bond were examined, including age, weight, initiation, and termination dynamics of suckling, and affiliative social interactions. The study was conducted on captive common elands within a research facility. Data was collected through direct observations and video recordings. Data analysis was done by using IBM SPSS and generalized linear regression models. Results indicate that calf age negatively affects suckling duration, contrary to some previous findings. Calf weight is positively associated with nursing, likely due to increased nutritional needs. Initiation by the calf leads to more rigorous suckling, while social interactions such as licking, grooming, and head-butting impact suckling duration. Naso-anal contact (sniffing) before suckling contributes to mother-calf bonding and longer nursing sessions. This study enhances our understanding of common eland behaviour and provides insights for captive management and conservation efforts. By examining various factors influencing suckling behaviour, this research contributes to optimizing conditions for calf growth and development.

Keywords: *Taurotragus oryx*, Social interactions, Maternal behaviour, Weaning, Suckling, Lactation, Animal behaviour.

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1. Introduction

The Common eland (*Taurotragus oryx*) is a species of the monophyletic lineage of African spiral-horned antelopes, *Tragelaphinae*, which are large body-sized, gregarious, polygynous species that inhabit African woody savannah with rising popularity in ranching (Wallington et al. 2007). Despite being a popular game species, much of their biology and behaviour remains understudied (Kasiringua et al. 2019). More so, their welfare in game reserves is extremely important due to their sport, recreation, and meat production ability (Kasiringua et al. 2019). The farmers prefer to grow eland in captivity as their meat production is higher and the meat is darker in colour as compared to beef, the only drawback is their temperament which does not allow farmers to rear them easily (Simonova et. al. 2019). Eland's meat and leather are considered valuable by the hunters (Van Zyl 1962). FAO recommends domestication of eland due to quality production of meat and milk (Scherf 2000). Since then, research are being conducted for maximum utilization of meat production and educational purposes. So, most research are being conducted on different properties of eland like temperature regulation (Kotrba et al. 2007), organoleptic properties (Bureš et al. 2010) and meat quality (Bartoň et al. 2014).

One of the critical aspects of the common Eland's social structure is the mother-calf bond, which is an important factor in calf survival and future reproductive success. The mother-calf bond involves various behaviours, such as suckling, maternal care, bonding, play a crucial role in the development of the calf's social and survival skills. However, despite its importance, the mother-calf bond in common Elands has not received significant attention in research (Orihuela & Galina 2021). There are multiple factors which play their part in the development of the maternal bond including recognition of the offspring through various sensory receptors of smell, vision and hormonal impetus. Also, this bond requires a balance between its costs and benefits, which is acquired via the development of certain control mechanisms which change environmental stimuli received by the sensory receptors into neuroendocrine signals that influence gene expression, physiology and behaviour of the species (Harshman & Zera 2007).

In literature, we can find that elands show allosuckling behaviour. The term allosuckling explains to the nursing behaviour of mother elands towards non-filial offspring. This also linked closely to allonursing or allomothering, which involves nursing offspring from other mothers. Literature also suggests that young mammals suckling from multiple nursing females may benefit from immunological advantages because colostrum and milk provide important nutrients (Mota-Rojas et al. 2021). Thus, this happens mostly in barn born/kept animals. As in wild or in free-ranging conditions, allosuckling is uncommon due to the animals having more space and higher selection pressure (Glonekovà et al. 2016).

Holleman et al. (1971) found by radio-isotope tagging that a 4-month-old calf used to obtain 15 per cent of its milk supply from other females. The females threat and show aggression towards stranger calves to repel them from suckling attempts. Mothers also do this repulsion strategy in order to keep their own calves away who want or pursue milk at the wrong time. This threat display is also a part of hindrance towards the young males who try to make sexual approaches. This behavior is performed in multiple species in order to maintain a social dominance hierarchy, defensive strategies for harems and young ones.

Weaning is done mostly in connection with the infant behavior pattern of bunting in most ungulates. Bunting is assumed to indicate changes in both mother and infant. With the increase in the ability of infant to draw out milk, mother's production capacity may dwindle. The vigorous attempts of infants to suckle may end up in pain for mothers resulting in aggression towards the offspring and early withdrawal from nursing. Also, there are observations of aggressive actions among all ages of calves over food as the young ones fight for the mother's milk. Even if the production is in abundance, sibling rivalry is there and the abundant food supply leads to better growth and survival of infants with early maturation and capacity to reach early to an adult size close to their genetic maximum but their life expectancy would be lesser as they will be more playful and agile in fighting which would lead towards early deterioration as well (Geist 1971a, b).

The behavioral study in eland is important as it has a high status meat which benefits its owners therefore its domestication practices are increasing for its tasty meat (Ndibalema & Songorwa 2007). As domestication is increasing therefore, the need to study its behavioral needs is important in order to maintain eland's physical strength and reap as much benefits as possible. The research here is designed in order to distinctly observe the common eland's mother- calf interaction and their suckling behaviour in captivity. The research is also aimed to find out the termination and initiation of the suckling behaviour in eland, how does the factor of calves' age affect bout duration of suckling, which calf gender takes more milk, how do the calves position themselves while suckling as they age and what are the impacts of basic interactions like head butting, licking, sniffing, and grooming on the suckling mechanism of the calves. This information can be beneficial for cattle farmers and researchers seeking to optimize the conditions for calf growth and development.

2. Literature Review

2.1. Taxonomy

Spiral-horned antelopes belong to the subfamily *Bovinae* and their genus *Taurotragus* is a transitional group between deer antelopes and bovines (Furstenburg 2007). The Eland was categorized in its own group as the *Taurotragus* genus. However, based on various recent studies, including hybridization with the greater kudu (*Tragelaphus strepsiceros*) and the sitatunga (*T. speckii*), along with analysis of mitochondrial DNA, taxonomists have recently placed the Eland in the *Tragelaphus* genus (Pappas 2002).

Tragelaphus oryx is present in the southern savannah regions, and it is recognized to have three sub-species with different colour variations in their physical appearance (Lorenzen et al. 2010). New genetic research suggests that these sub-species are merely phenotypic differences, meaning they are only different in terms of physical appearance, and are not actually distinct sub-species of the Common Eland (Furstenburg 2007).

2.2. Characteristics of the genus

According to recent research, the Eland species is thought to have developed from a larger version of the kudu, which was wide spread approximately 1.3 million years ago. Elands are known for foraging on green foliage and can be found in various, often unstable habitats (Parrini et al. 2019). The Eland is widely distributed throughout Africa, with the giant or Lord Derby Eland residing in the Sahel region, spanning from the westernmost areas to Cameroon and southwestern Sudan (Gübert et al. 2022). The common Eland can be found across a vast area that includes eastern Sudan, Ethiopia, and Somalia, as well as the central eastern African savannahs and extending all the way down to the Common peninsula (Furstenburg 2007). The population of Elands experienced a significant decrease due to the rinderpest epidemic in 1896, causing them to become extinct in the former Transvaal, southwestern and northern Common regions, as well as the southern areas of Namibia, Botswana, and Zimbabwe (Kasiringua et al. 2019). Around 1910, a herd of Elands that originated from Mozambique made its way back into Kruger National Park near Letaba. Nowadays, Elands are being commercially farmed and exported to countries like Russia and the United States of America. This opening door for future conservation and commercial use of the species (Kuwornu et al. 2013). The population density and mortality rates of Elands can be influenced by various factors, such as food availability, predation, disease, and the presence of humans. When ranchers put up fences for their cattle, this can disturb the natural migration routes of Elands, leading to limited access to sufficient food resources (Furstenburg 2007).

In areas where there have been several seasons of below-average rainfall, it is common to see a rise in mortality rates among Elands due to drought-related conditions. Since Elands, particularly calves, are a crucial food source for many large predators, such as lions (latin), hyenas (latin), wild dogs (latin), and cheetahs (latin), their populations have been severely impacted in various parts of their original habitats due to overhunting and habitat destruction (Vymyslická et al. 2015). Although some populations of Elands may be vulnerable or endangered in certain areas, such as Uganda and Rwanda, they are still present in national parks and have a widespread distribution (Kasiringua et al. 2019). As a whole, the species is not currently endangered (Hoffmann 2016).

2.2.1. Taurotragus oryx

In earlier times, there were two primary species of Elands, consisting of nine subspecies. However, in accordance with the current systematics, there is now only one species of Eland, which comprises three subspecies: *T. o. oryx, T. o. livingstoni, and T. o. pattersonianus* (Furstenburg 2007). The common Eland is a type of monotocous species. These animals are considered tough, specially in low vegetation situations. This is usually because they can consume a wide variety of plants and can switch very easily while eating depending on all of the available sources of food. Mostly, during the very dry and cold months, they tend to look for food, while during the humid and rainy season, they tend to graze. The size of *Taurotragus oryx* is smaller compared to *T. derbianus* and its horns are shorter (less than twice the length of its head) and more tightly spiralled (Kubátová et al. 2020).

Figure 1. Adult common Eland bull in wild

Furthermore, the Eland's horn cores have a more prominent ridge on the front and are spaced wider apart. The Eland also has pointed ears that are narrow in shape, whereas the giant Eland has wide and rounded ears. Unlike the giant Eland, *T. oryx* does not have spotted cheeks and its coat color is generally consistent throughout the body. The giant Eland, on the other hand, has large white spots on each cheek and darker hair on the sides of its neck compared to the rest of its body (Hillman 1987).

Figure 2. Female eland with horns

Lastly, it's worth noting that the Eland's dewlap is confined to the throat area, while the dewlap of the giant Eland extends all the way down to the chin. The Eland is the second biggest antelope in Africa, and males are bigger than females (Furstenburg 2007). On average, male Elands have a shoulder height of 163 cm, although this can vary between 151 and 183 cm, while females have a shoulder height of 142 cm, which can range between 125 and 153 cm. The sample size is not specified (underwood 1981). On average, male Elands weigh between 500 to 600 kg, with a range of 450 to 942 kg. Females, on the other hand, weigh between 340 to 445 kg, with a range of 317 to 470 kg (Musa et al. 2021). The Eland's tail, which is tufted at the end, measures around 60 cm with a range of 54-75 cm (sample size not specified). Their fur ranges in colour from dark grey, brown to reddish brown, with males typically turning blue-grey as they get older (Rafferty 2010).

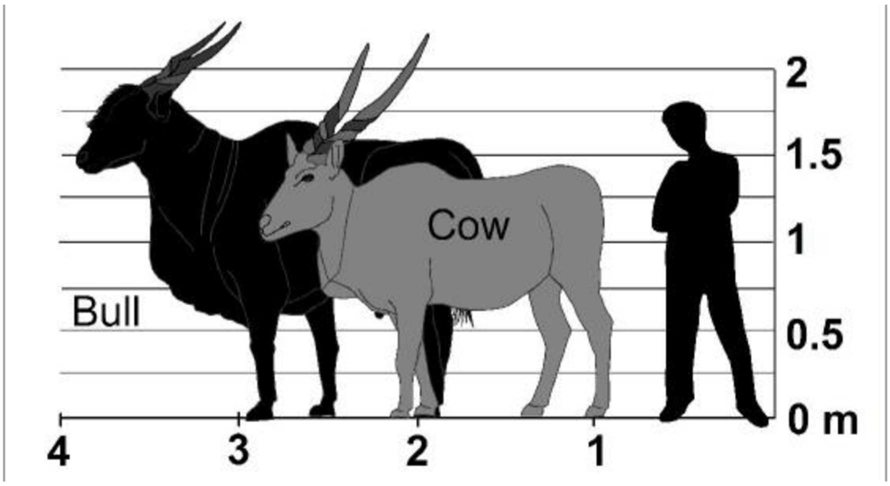

Figure 3. Eland in size comparison (Furstenburg 2007)

The Eland has a crest of hair that runs from the nape to a small hump on the withers. Male Elands have a particularly thick tuft of hair on their forehead. The Eland has a dewlap that is present in both males and females, but in males, it becomes more prominent over time, reaching a size that hangs down almost to their wrists.The Eland has several white stripes that run across its body, ranging from 2 to 15 in number. These stripes are more noticeable towards the front of the animal (Furstenburg 2007). The colour of the Eland's coat and the visibility of its stripes differ among subspecies and geographical locations. The southern population has a lighter coat and less noticeable stripes in comparison to the northern population (Simonova & Rystsova, 2019). A black spot is present on the upper part of the forelegs of all Elands, along with a dark stripe running down the back. The two *Taurotragus* species are characterized by having big pits above the eyes, noticeable flanges on the front part of the nose, and tooth rows that are located more towards the front. *Taurotragus oryx* has spiral-shaped horns in both males and females, but the horns of males are shorter, thicker, and have more tightly spiraled ridges. On average, male horns are 54 cm long, with a range of 43-67 cm (Furstenburg 2007). The female *T. oryx* has longer and thinner horns compared to males, with an average length of 60.5 cm (range, 51–69.6 cm). The Eland exhibits sexual dimorphism, with males being larger than females. Older males tend to develop a bluish-grey coat. Both male and female Elands have a dewlap, but it becomes more prominent in mature males and can extend down to their wrists. Adult male Elands also have a thick tuft of hair on their forehead that covers glandular skin (Simonova & Rystsova 2019).

2.3. Specifics about common Elands

New genetic research has revealed that the supposed sub-species are merely showing physical differences in appearance, and are only different in their color variations from the Common Eland, and are not actually legitimate sub-species (Kiley-Worthington M. 1978). Recent genetic studies have revealed that the differences between the various color variants of the Common Eland, sable antelope, and buffalo within local populations are significant, while the genomic difference among the three different Eland phenotypes is too minor to be regarded as subspecies (Bro-Jørgensen & Beeston 2015). The Common Eland of South Africa is the usual form and doesn't have stripes. However, in certain areas such as northern Botswana, Zimbabwe, and southern Mozambique, hybrids between the southern Common and Livingstone's Eland can have 1-5 vertical stripes on their body (Hellen 2010). Livingstone's Eland display 6 to 12 vertical white stripes that measure 9 to 12 mm wide on their sides. However, they do not have the noticeable dark brown marking on their front legs.

On the other hand, East African Eland have a rufous-fawn coloration, and their flanks feature 8 to 14 narrow stripes, which are only 4 to 8 mm wide. Additionally, they have a white chevron-shaped pattern located above their eyes on the forehead (Kasiringua et al. 2019). The Lord Derby Eland is characterized by 8 to 16 stripes that measure 4 to 8 mm wide. In regions where the ranges of the southern Common Eland and the East African Eland overlap, it is common to find hybrids of these two species. These hybrids share the same rufous coloration as the purebred East African Eland, but they lack stripes Brandlova et al. 2013. The Lord Derby's Eland exhibits a range of hues from rich terracotta to reddish-brown and chestnut. They also have 8 to 12 narrow stripes and a noticeable dark brown to black blaze that surrounds the lower half of their neck.

Additionally, they have a short black mane that stretches down their neck to the middle of their back. On the other hand, the East African Eland has a reddish hue and sports a distinctive black mane that runs down its spine and below its belly (Jeffery & Hanks 1981). The extensive translocations that have taken place in southern Africa are likely to have led to a dispersion of mixed phenotypes among Eland populations. In central east Africa, some Eland do not display stripes, which could be the result of hybridization that occurs when their ranges overlap (Bro-Jørgensen & Beeston 2015). Fully grown Common Eland cows weigh between 400 and 560 kg, and they have an average shoulder height of 150 cm. In contrast, adult bulls weigh between 650 and 940 kg, and they are taller, with a shoulder height ranging from 160 to 180 cm (Musa et al. 2021). In the Drakensberg Mountains of KwaZulu-Natal, Elands are relatively smaller in size, with male Elands weighing a maximum of 500 kg. This difference in size could be due to lower quality food and increased energy exertion required to move up and down the slopes of the mountains (Parrini et al. 2019).

2.4. Captivity

Elands are big, easily frightened animals that thrive in open-range environments. They require ample space to move around and run. Since they both graze and browse, it may be necessary to partition off trees that could be damaged. It's essential to provide enough shade and protection to ensure the well-being of all the animals (Rafferty 2010). It's important to ensure that the Elands don't get anxious when visitors observe them. The transportation of the animals to and from night or holding yards should also be taken into account (Furstenburg 2007). Although holding yards may be more confined, they still need to be spacious enough for the animals to escape if they feel threatened (Kasiringua et al. 2019).

Alternatively, it's important to think about allowing overnight access to the exhibit. Some key principles of exhibit design are: Ensure that the animals have enough space to move around comfortably without seeming confined. Make sure that all animals have sufficient protection from wind and rain, while avoiding any unwarranted aggression within the herd. Install water troughs made of concrete or cement, equipped with floats to maintain a consistent supply of drinking water. If feed troughs are utilized, they should be robust and firmly anchored in a location where animals can flee without sustaining injury. It's not advisable to use mesh feed racks since Eland horns could become ensnared in the mesh. The fences need to be sufficiently tall to prevent the animals from jumping over them or trying to do so, and strong enough to endure pressure from the herd pushing against them. Before moving the animals into the enclosures, all items that could cause them harm should be eliminated. It's essential to ensure that fresh feed and water are provided on a daily basis. In addition, the exhibit should incorporate grass tussocks, windbreaks, and behaviour-enriching elements like poles for horn rubbing (Furstenburg 2007).

2.4.1. General captivity systems

When designing holding enclosures for animals, it is important to ensure that they provide sufficient space and shelter without causing unnecessary conflict or fighting for territory among the animals. This is especially crucial for Elands, who are known to be skittish and may require access to exhibit areas or be confined to smaller holding enclosures for brief periods of time. Some general principles to consider when designing holding areas. The fences must be sturdy enough to prevent the strongest animal from escaping. The walls or sides of the fence must be tall enough to prevent jumping out and escaping. Objects that could potentially harm the animals must be removed from the enclosure prior to introducing Eland. Prior to introducing any animals, all enclosures should be examined, and all doors/gates and locks should be in good working order. Airflow must be maintained, so the sides of the holding enclosures should not be completely solid. If wooden posts are utilized, the gap should be no larger than 15 mm. A roof that offers shelter should be present over one-third of the enclosure. Any run-off water should be directed outside of the enclosure (Kasiringua et al. 2019).

Water troughs that are not securely anchored to the ground are not recommended as the Eland may move or overturn them, which could result in injuries or water spillage. Instead, it is advisable to use round cement troughs that are sunk into the ground and placed against the outer wall of the enclosure. It is also suggested that a part of the trough should extend outside the enclosure to make it easier to clean and refill with fresh water. Another option is to install a float system to ensure a continuous supply of fresh water (Furstenburg 2018).

2.5. Reproduction

Although Elands do not have a specific breeding season, peaks in calving occur due to variations in the quality of the dry season diet in different areas. In the Drakensberg region, the peaks occur between September and October, while in the Mpumalanga Highveld, they occur in November. Mating can occur throughout the year, but there is a slight peak from November to March. The gestation period is nine months, and calves are born throughout the year, with a peak in the summer. Cows typically give birth to their first calf when they are between 30-42 months old and can produce 10-13 calves in their lifespan of 14-18 years. Normally, elands give birth to only one calf, and twins are rare. Calves are not hidden and begin following their mother and the herd within four hours, forming a group with other calves. If a calf is lost, it has little chance of survival because cows do not act as surrogate mothers. Calves start feeding on vegetation at one month old and are weaned after four months. The eland reaches its adult body size at around five years old (Wirtu et al. 2009).

2.5.1. Gestation

For common Elands, the gestation period ranges from 260 to 284 days, while postpartum oestrus last up to a month. This allows few females to become pregnant right after giving birth. As a results the calving interval is approximately ten months which can also cause irregular timing of births within a year (Robeck et al. 2015). It was observed by Hillman (1987) that a captive common Eland cow gave birth to eight calves in a period of six years. (Skinner 1996) also studied birth intervals of common elands in two different habitats. His results showed that Elands in bush veldt have a much higher rate of calving than in high veldt. The study also indicate that the average rate of calving per year to be 83%. In southern African region, most common Elands gave birth between May and November, but (Hillman 1987) observed irregular birth timing throughout the year, which varies each year.

2.5.2. Birth and care for calf

The delivery process is categorized into three stages: prenatal, delivery, and postnatal stages. The signs of delivery are similar to those in cattle, including swelling, pelvic changes, enlarged sexual lips, smooth skin, weak spots, and the secretion of mucus from the sheath 2-3 days before delivery. The mammary gland enlarges during the same period. Females lose their appetite and have bowel movements and urination one day before calving. 3-6 hours before delivery, females become agitated and display erratic behaviour, using their horns and hooves to move the litter. 2-3 hours before delivery, females start making a distinct sound from the nasal cavity . The purpose is to communicate with its calf. The very first sound indicates the start of birth pains and contractions of uterine muscles. These are regulated by the nervous system. At this particular stage, the udder is filled with colostrum.

In the last stage of delivery the mother feels weak contractions followed with the discharge of foetal liquid. After this, the female starts eating the placenta quietly and completely followed with the licking of the area where the placenta and foetal liquid were located. This behaviour of eating placenta stimulates the mother's activity, increases secretion of colostrum, and also supports uterine involution. The female licks her calf after delivery. The licking starts from the hind legs and she proceeds towards the head, ears, mucus and foetal caul. The licking behaviour stimulates the calf and help in breathing, circulation of blood, and muscular tone. The mother's saliva provides additional benefit of better calf immune health. Licking initially starts from the anal area and this help the calf to eliminate waste. During licking, the smell is the first connection between the mother and the calf. Sometimes mother also makes specific nasal noises while licking. After a few minutes, the calf turns its head to point his ears toward the sounds followed by an attempts to stand up in a choppy posture (Underwood 1979).

Figure 4. Common eland mother eating placenta (Czech University of Life Sciences 2018)

The udder massage happens before the calf can stand up or suckle. While attempting to stand, the calf falls very often on its side, this gives an opportunity to the mother to lick both sides of her calf. The mother makes many sound signals during this whole process and each sound is different from the others. This causes imprinting which is very important for the calf to remember voice of its mother. In the presence of other females making similar sounds, the expectant mother will start making her sounds more often and more loudly to stand out from other females. After almost an hour, the calf is able stand and take first steps. At this stage the calf also responds to his mother's call by turning its head and begin its search for the udder. The process of finding the udder some times requires some effort from the calf as the mother does not usually help. However, its usually under 30 minutes (Hejcmanová et al. 2011).

2.6. Ethology

Elands are animals that live in social groups and can form herds with a large number of individuals ranging from 100 to 500. These antelopes are well adapted to their habitat and can coexist with other antelope species or zebras. The common Eland is a non-territorial, nomadic, and social antelope, and their social behaviour is influenced by communication, sexual behaviour, fighting behaviour, and social organization. The herd is led by a dominant male who claims the right to mate with all the females. The calves form a nursery group where they play, groom, and lick each other, forming strong bonds. As they grow older, subadult males become solitary (Hejcmanová et al. 2011).

2.6.1. Protective herd behaviour

Elands are migratory animals that do not exhibit territorial behaviour and move in small groups, covering several hundred kilometres per year in search of quality food. When kept in game ranches, they roam freely and adapt well to smaller environments, but require supplementary feeding. However, they should not be kept on land units smaller than 3,000 ha without supplements. Under favourable conditions such as grass plains, Elands can form very large herds of 300-1,000 animals consisting of satellite family groups of 15-50 animals. During the calving season, females form nursing groups that include yearling sub-adults. Adult bulls rejoin the family herds at the end of the season and stay until the start of the next calving season. Within the family herd, adult bulls maintain a strict dominance hierarchy. Young, non-breeding bulls form bachelor groups of 5-10 individuals, while adult bulls form small herds of 3-6 individuals outside of the mating season. Antipredator strategies vary widely among animals and include visual and acoustic signals, unique ways of escaping, and attacking predators in some cases. These behaviours can be categorized into acoustic and visual signals, defence behaviour, and attacking the predator (Bordes et al. 2018).

2.6.2. Herd feeding behaviour

There is variability in studies regarding the Eland's diet, with some classifying them as grazers, mixed feeders, or browsers. However, Parrini et al. (2019) research suggests that elands are strictly grass eaters, while Vymyslická et al. (2015) recorded a diet consisting of 94.3% browsing. Elands are active during cooler parts of the day, such as early morning and late evening, which is a common diurnal strategy among other animals like buffalo (latin), wildebeest (latin), impala (latin), mountain reedbuck (latin), and Swayne's Hartebeest (latin) (Deleporte & Cap 2014). During lactation, female Elands increase their foraging behaviour to compensate for higher energy losses. This behaviour is often accompanied by ruminating and lying down, which becomes more common during lactation. Conversely, foraging behaviour decreases during warmer seasons (Parrini et al. 2019).

2.7. Suckling

Suckling is a universal mammalian behaviour that plays a crucial role in the mother-offspring relationship Offspring may stimulate milk production by massaging the mother's udder with their nose or by butting, and the amount of butting can indicate hunger levels. The number of attempts and dismissed attempts of suckling can also predict the hunger of the infant (Hejcmanová et al. 2011).

Elands belong to the hider species, which means that the calf is hidden at a specific location after the birth and the mother goes after regular intervals to feed it. Cattle are another example of a hider species. On the contrary, calf that belongs to the follower species follow their mothers and are more mobile when they are young. Female elands mostly take care for their calves for a period of 4-6 months and milk and colostrum are essential sources of nutrients during this time along with hormones, vitamins and immune compounds required for the calves. This is critical during the first few weeks of their lives. The milk of the eland contains approximately 67.9 ± 22.7 g/kg of fat, 88.0±13.3 g/kg of protein and 50.0 ± 10.5g/kg of lactose. It is similar to bovine milk (Hejcmanová et al. 2011).

Lactation is a biological process whereby milk is produced and released for the offspring, and is a critical aspect of reproduction, species maintenance, and the survival of the offspring in many animal species. Lactation is initiated by hormones prior to giving birth. Suckling is a fundamental aspect of the social behaviour of mammals, and involves the relation between the mother and offspring, with the latter often massaging the udder for better milk release (Delaby et al. 2009).

There is a set of specific behaviors shown by some females of the eland species called Allo-nursing and allo-suckling in which non-filial offspring are nursed and fed due to death of animals because of some diseases and parasites. But it is not as simple as it seems because these species have inter-individual recognition, due to neurochemical signaling that plays pivotal role in the attachment of mother and calf within the first two hours after birth, to avoid any non-filial suckling. Sometimes though in allo-parental caring, the cost of raising a non-filial offspring is set aside to reap the benefits in the form of increased milk synthesis and the nutrient density of milk. Some benefits also occur at community level by efficient foraging and the cooperative detection of predators (Blauvelt 1956).

2.8. Weaning

Weaning refers to the gradual cessation of a young animal's dependence on its mother's milk for nutrition, leading to the offspring's independence. This process can create a conflict between the mother and her offspring. Typically, a young animal that has reached four times its birth weight will be weaned by its mother (Orihuela & Galina 2021). In addition, some animals are weaned before the next mating season. The weaning process can be influenced by various factors such as the offspring's behavior, immune system, and the weather. Every mother has her own unique weaning strategy that is adaptable to the specific environmental conditions (Wirtu et al. 2009).

For instance, in animals such as pinnipeds, elephants, deer, bighorn sheep, domestic sheep, and primates, weaning is dependent on specific environmental conditions. In carnivores, mothers may decrease the weaning age by sharing food with their offspring (Orihuela & Galina 2021). If offspring are weaned early, their mortality rate is higher. This can occur when the mother is unable to lactate or there is not enough food available. As a result, the growth rate of the offspring will be slower. On the other hand, if weaning occurs too late, the growth rate will also be slow. The best condition for maximum growth and survival of the offspring is when weaning takes place somewhere in the middle (Vymyslická et al. 2015).

2.9. Mother calf interaction

The bond between a mother and her young is extremely important for the offspring's social development as it relies completely on the mother during its early life. This bond between the mother and the calf has been studied extensively for many other species including humans, goats, sheep, horses and impalas. The main focus of the study was to know how the bond is formed and broken. Researchers have also studied the mechanisms involved in maternal bonding. The studies show that mammals use chemical sense primarily while vison and hearing come into play later on for mutual recognition. (Orihuela & Galina 2021).

In farm animals that live in natural settings, the connection between a mother and her calf can last beyond the time of weaning and even when another offspring is born. This has been observed in various studies conducted on agricultural species such as those (Hejcmanová et al. 2011). Typically, the bonding process begins immediately after the birth of the calf, during which the mother and calf become familiar with each other (Wirtu *et al*. 2009).

Figure 5. common Eland calf suckling (author)

The process of establishing a mother-young bond involves a range of social behaviors from both members, but typically identification occurs through the act of smelling the anal-genital area (Hejcmanová et al. 2011). The type and frequency of social behaviors may differ between captive and wild animals, but the first few weeks are crucial for developing a strong bond. According to (Mota-Rojas et al. 2022), female goats use the odors, saliva and colostrum to label their calves. This labelling helps the mothers to recognize their own offspring while rejecting other calves that may attempt to nurse or bond with them. This labelling usually occurs within first 24 hours of the calf's birth. This bond between mother and offspring is critical and it usually happens in a relatively short period, ranging within 10 to 30 minutes of contact. This bond is stable enough and enables the mother to distinguish her own calf from others. The research by (Hejcmanová et al.

2011) also support this finding. According to (Orihuela & Galina 2021), there are two types of offspring groups: hiders and followers. These groups are usually linked with different categories of ungulates. In the case of cows, their strategy can vary from either hiding or following and it depends on the ecological factors.

The female common Eland usually delivers her offspring alone, near to the herd in the wild. The mother builds a bond with her calf by licking it in the first few hours. This allows her to recognize its taste later on. The young calves also smells their mothers and this help them to recognize their mothers from other females. This recognition ability by smell is very typical among almost all ungulates. The mothers exclusively allow suckling to their own offspring and display aggressive behavior towards alien calves. Females also use distinguished sound signals to help in offspring recognition and this vocalization aids in developing the mother-calf bond. To recognise the mother, the first sucking is extremely important for the calf as this help the calf to recognize its mother's udder and milk taste. This requires enough time and repetition, specifically in the first few days. Eventually, by knowing the smell and the taste of milk, the calf learns to come to its mother for feeding after she calls for it (Underwood 1979).

It is considered that the process of creating a bond should be similar in captivity as it is in the wild however this is not always the case. The amount of available space for the animals is one of the critical factors. Too many animals in a small area can have a negative impact on this bond development. For instance, multiple calves can attempt to suckle from a female at once which can lead to confusion and ultimately aggression from the mother towards the calves (Mota-Rojas et al. 2021).

Frequent occurrences of the situations mentioned above can have negative effect on the calf as instead of focusing on suckling, the mother may become busy in defending herself against other calves. Also, with too many smells from other calves, the female can get confused failing to recognize the scent of her own calf. This may lead to allosucking which is not common in nature. The animal's quality of life, living space and access to high-quality food in sufficient quantity is also a significant factor to consider (Glonegová et al. 2016). Healthy animals with consistent supply of food may have a desire to care for additional calves. Another significant factor is social relatedness specially in captivity. This happens as animals in the wild aren't very closely related. Few animals are inclined to care for other calves that are related to them in some way (Simonova & Rystsova 2019).

Young animals begin to exhibit social behavior quite early, including actions such as mounting, chinning, flehmen (urine lapping), and aggression. Calves often imitate the behavior of adult animals, as shown in. Chinning, for instance, is when one calf places its chin against another calf's body. Calves use this action to chase away other calves or to put their chin against the dam's flank after being rejected during the weaning period. Male adults typically use chinning to prepare females for mating. Mounting occurs in similar situations, but with a higher level of excitement. Aggressive behavior, such as head lowering, tossing, nodding, and violent looping actions, develops in calves during the first few days of their lives. These actions are used to threaten other calves (Haberová & Brandlova 2012).

About a week after birth, calves begin to scrape and rub their horns against trees or the horns of other animals. This behavior is eventually modified into coordinated fights between calves and is considered a part of play behavior, alongside actions such as spontaneous running and jumping (Yosef et al. 2015). As, infants are susceptible to a harsh environment, shortly after birth, henceforth parents abilities to adjust their behaviour towards needs of the calves is primary requirement (Clutton-Brock 1991). Over the time, the type of parental care required by the calves is changed henceforth, multiple adaptations in the suckling behaviour become a crucial part of the reproductive strategy (Espmark 1969). But these changes might be influenced by the parent-offspring conflict regarding maintenance of the feed demand (Alonso-Alvarez´ & Velando 2012). As the feed is also affected by the mother's nutritional status during gestation and lactation (Auldist et al. 1998).

Lactation is the most energetically costly part of parenting in mammals and rightly so (Clutton-Brock, 1991). The arid environment offers adaptations for differences in suckling bout duration and frequency but lactation stages are defined physiologically as: colostrum, mid-, and late lactation (Kobeni et al. 2020), but these stages are not considered mostly in behavioural studies. Eland's suckling bouts are commonly characterised by the duration of suckling and decline in the frequency over time (Hejcmanová et al., 2011). Suckling is mostly initiated by mothers when calves are small and in need of more nutrition to grow while over the time the bout duration and frequency is terminated mostly by mothers towards the end of the lactation period with the increase in the age of calves.

Mothers start to display characteristic interest in calves by sniffing and grooming and do not allow them to suckle until then, they also show interest in the birth fluids and membranes of other cows. While birthing cows sniff the ground before delivering the kid and after delivery they seem to be more interested in the membranes and after birth as compared to the calves (Siegel 1956). *Oryx* start to lick their newborn immediately after the birth as soon as five to seven minutes after parturition. They spend almost an hour licking their young one's post parturition. Some studies suggest that standing of calves during first 6 hours of life depends upon more licking from mothers while others put a question mark on this hypothesis (Laura et. al. 2021)

Figure 6. Grooming

The sucking motion of the newborns start even before they arise first time after birth (Kirchshofer 1963). Maternal grooming and orientation have facilitating effects on early nursing (Alexander & Williams 1964). Even if the animals are restricted from both grooming and orientation to aid their calves nursing attempts, the frequency of nursing is affected by age of lamb causing decline with age, number of siblings, birth weight and race (Blauvelt 1956).

When newborns are able to move a bit, they start nosing the ventral surfaces of the mother and poke their head between the limbs to reach out for teats (Kurt 1968). Calves first suckling attempts are termed as licking as well because at that time they cannot suck easily rather the simply lick whichever part of mother comes in the contact of their mouth

(Leuthold 1971). With age, calves are found to stop and do 'heading-off' to control the movement of the mother in order to get the feed. Also, bunting is done by striking the udder by the calf with its muzzle, to induce milk flow or 'let down'. It is done to move the resting mother in order to induce her to rise and nurse the calf (Hafez et al. 1962).

In initial stages of feeding, active mothers adjust their position to allow the offspring to reach towards their teats which is termed as maternal crouching. Reverse parallel one is the most common nursing position used by ungulate infants in which mother and young form an acute angle of their body axes (Blauvelt 1955). As the infants age, the angle of suckling is maintained at 90 degrees. Bigger infants suckle while resting on their carpal joints. There is also a characteristic of downward curving of the back and neck which directs the head upward to reach directly towards teat with correct orientation (Hafez et al. 1962).

Figure 7. Position 1 antiparallel

Figure 8. Position 2 vertical

Figure 9. Position 3 posterior

There is a practice in the ungulate infants to try to suckle from other adult females of their herd but it has been seen that those females chase them away. Only multiparous mothers seem to allow other young ones to suckle on them too occasionally as they also have established maternal-infant bonds with their own infants (Bubenik 1965).

Figure 10. Failed allo-suckle attempt.

Manski (1991) studied the mother-offspring connection of *Addax nasomaculatus* which is a North African native antelope. He observed that females were found restless during labor and found lying and standing multiple times. Lying was supposed to be the resting time. After delivery, amniotic sac and placenta was consumed by the mothers. The males in captivity were found to be highly aggressive towards newborn infants post birth during the first 3 days. Calves suckled while lying down for almost11–14 days and formed kindergarten groups with their peers. They suckled in standing position until 15 weeks of age and later on started sitting on their carpel joints while suckling. Calves were weaned off 29 weeks post-partum.

Licking has three types of behavioural complexes including first attempts of calves at suckling, grooming of the calves by the mother, and most importantly the feeding. Licking is also an integral part of calf's first movements and it leads to self-grooming as well. It abruptly grows in the start and suddenly disappears once the calf learns to find and suckle on the teats. Still, the licking by the calf can reappear if the female rejects his feeding advancements. It has been observed by multiple researchers on field that calves can also lick each other on the dewlap, mane, ears and tail but over the time, mutual grooming ceases as the calves become uneasy. Grooming is less frequent in adults and only occurs head on means its limited to the face and neck regions (Leuthold 1971).

3. Aims of thesis

The aim of thesis is to evaluate maternal behaviour in captive common Elands (*Taurotragus oryx)*.

- To examine whether age plays a significant role in influencing suckling duration among elands.
- To explore the potential relationship between the weight of the calf and its impact on suckling duration.
- To investigate the extent to which the initiation and termination of suckling sessions affect the overall suckling duration.
- To analyze the potential influence of affiliative social interactions such as grooming, sniffing, head butting, licking on the duration of suckling.

Hypothesis

- H_0 Age would influence the suckling duration
- H_0 Weight of calf would influence suckling duration
- H_0 Initiation and termination by mother and calf would influence the suckling duration.
- H_0 Affiliative social interaction would influence suckling duration.

Methodology

3.1. Observation in Lány

3.1.1. Research facility

The study was performed on the captive common Elands (*Taurotragus oryx)* which are largest antelope specie from the region of East Africa. These Elands were imported to Czech Republic in year 1972 and kept in a zoo. The animals came under the supervision of Czech University of Life Science (CULS), located in Prague – Czech Republic, in the year 2000. They were later moved to the new Common Eland Research Facility at Lány. The research facility is a captivity farm which was designated for experiments, observations, and research under Czech University of Life Sciences (CULS) in Prague, Czech Republic. The animals were brought up and bred under special care to increase the population. The total enclosed area of the farm is 2.5hc which include open pasture and enclosed stable. The open pasture was divided into two barns. One of the barn contained 5 mother females and their suckling calves with 10 females without calves and one male that has a nice body temperament. The rest of the animals were kept in the other barn. The study was performed on the suckling females and their calves and suckling was observed from April 2022 to July 2022. The division of the Farm is shown in pictures.

Figure 11. Lány farm (google maps)

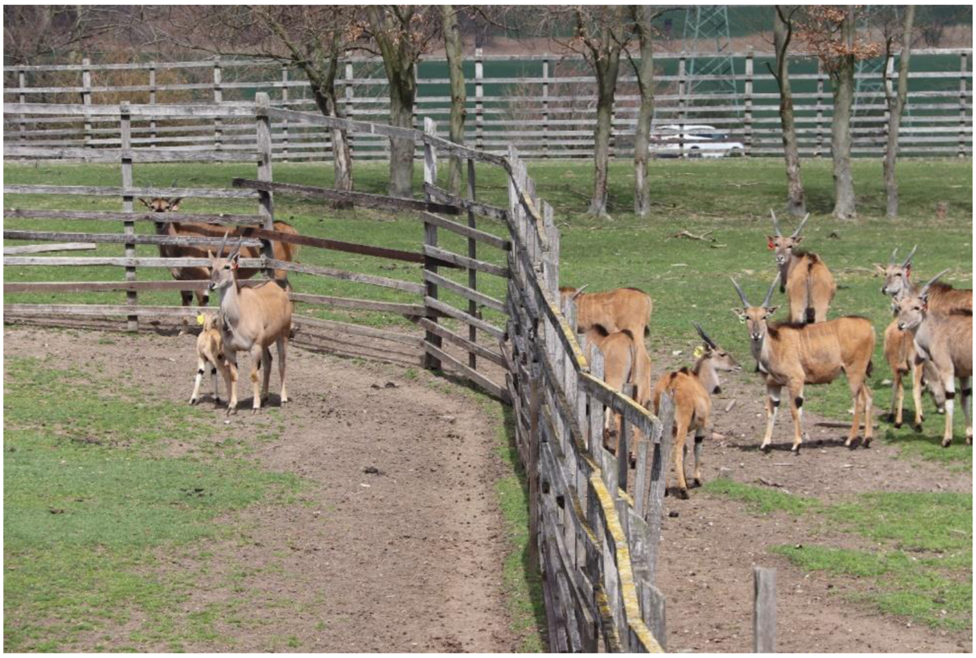

Figure 12. Common elands in Lány farm

The animals were in close contact with keeper, and they are daily fed with alfalfa hay and fodder concentrate because natural vegetation in pasture was not enough for them. Suckling was observed from April 2022 to July 2022.

3.1.2. Behavioural observation

Five calves were born and observed over the period of four month and the behavior was studied. The observations were recorded two times in a week from morning to evening. Direct observations were performed, and videos were recorded to evaluate the suckling behavior of Elands and other interactions such as vocalization, naso-anal contact, initiation, and termination of suckling and suckling bouts. The position of the calves while suckling was also observed to determine whether the calves were suckling from interior or posterior sides of their mother.

Figure 13. Herd of common Elands (author)

3.1.3. Data collection

As mentioned earlier, the observations were recorded in one of the barns of the farm. A place 100m away from the animals was selected. The observations were recorded from a platform which was 2 meters above the ground level. The choice of the place was based on the minimal distractions for the Elands. The mother calf interactions and suckling were observed with the help of Canon binoculars from and recorded with the help of a high zoom camera. The camera used for recording was Panasonic HC-VX1 model with 25mm wide lens and 24X optical zoom which can be extended upto 32x digitally. The camera used large MOS Sensor which made provide extreme clarity in the low light footages. The animals were monitored with the help of the binoculars and the recording were started instantly whenever some interaction or suckling were observed. A tripod was also used for the stability of the camera as tiny movements can produce a lot of noise in the zoomed videos. Additional data was collected in notebook in case the behaviour happened too quickly.

Figure 14. Type of camera used for data collection (author)

Figure 15. Observation point (author)

The data was obtained in the form of suckling videos of Elands. Apart from videos, data was also recorded by direct observations in the form of notes. The data was processed through “The Observer XT Software”. The required coding scheme was created to eliminate the excessive data and to summarize it meaningfully. The data obtained from the videos was in the raw form in the form of table. The present study was analyzed with the help of IBM SPSS, version 26 using the data sheet imported from an excel spread sheet. The dataset consists of numerical data points along with some categorical variables. Therefore, first and foremost after cleaning of the raw data, the exploration of the data was the first step in the direction of analysis and to do so descriptive statistics summary table was produced for all the quantitative variable be it continuous or discrete. Next, the frequency distribution table was constructed with the intention to have a better proportionate understanding of the qualitative variables involved in the study be it nominal or ordinal. At the same time all the numerical variables were visualized with the help of histograms which showed that none of these variables were normally distributed as they did not have a symmetric bell shape frequency curve. Thereafter, all the analysis was focused on non-parametric testing only to get appropriate and better results.

In this spirit, the chi square testing was employed to establish the association between the categorical variables present in the study. For all those variables which were quantitative the Mann-Whitney test was used to check how those behavioural characteristics changed when mother or calf initiated the suckling. Along with it the relationship between the different quantitative variables were examined and test to support the factor analysis. The other more complex part of the analysis was to reduce the number of variables by constituting a series of variables together resulting in a factor. This was obtained by running the principal component analysis and finding the most suitable combinations of the variables that explained the majority of variation present in the data.

Last but not the least, the modelling was performed with the help of generalized linear mixed regression models to understand which of these factors were mainly responsible for the initiation and termination of suckling by calf and mother respectively.

4. Results

This section comprises of all the results obtained to test and validate the research objectives. The tables and charts are displayed and segmented in sub sections as follows:

1. Descriptive Summary:

The results of the table-1.1 and 1.2 together summarize the descriptive statistics of all the sample data related to the present study. The output displayed by table-1.1 contains the descriptive statistics like mean, standard deviation, minimum and maximum value of all the continuous variables of interest along with their respective 95% confidence interval. Of all the numerical variables length of nursing, movement of the mother during suckling, mother tail wagging during suckling, mother tail wagging during last 10 second, length of interruptions, length of grooming and length of mother grazing during suckling have the unit of measurement as seconds and as continuous in nature while the variables number of interruptions, number of butting and number of failed allo sucking attempts are all discrete in nature.

Table 4-1: Continuous Descriptive Output

	N	**Minimum**	**Maximum**	**Mean**	**SD**
Length of nursing (secs)	83	9	680	309.08	134.86
Movement of the mother during suckling (secs)	83	0	37	5.28	6.97
Mother tail wagging during suckling (secs)	83	3	155	26.13	22.41
Mother tail wagging during last 10 sec (sec)	83	0	19	6.96	3.73
Number of interruptions	83	0	3	0.77	0.85
Length of interruptions (sec)	83	0	16	2.05	2.77
Length of grooming (sec)	83	0	25	1.30	3.23
Number of butting	83	2	190	89.65	42.77
Length of licking (sec)	83	0	24	2.12	4.04
Length of mother grazing during suckling (sec)	83	0	7	0.53	1.33
No of failed allos-uckling attempts	83	0	2	0.16	0.40

The results of the table-4.1 indicates that the mean length of nursing is 309.08 seconds with a standard deviation of 134.86 seconds along with the minimum and maximum value being 9 and 680 seconds respectively. Likewise, for the movement of the mother during suckling the mean value is around 5.28 seconds with a standard deviation of 6.97 seconds. The least movement of the mother during suckling is 0 second and the highest is 37 seconds. Similarly, the mean amount of time mother tail wagging during suckling happens is 26.13 seconds and 22.41 seconds is the standard deviations. The smallest time when mother tail wagging happens during suckling is 3 seconds and the maximum time is 155 seconds. Likewise, for mother tail wagging during last 10 seconds, the mean value and standard deviation is 6.96 seconds and 3.73 seconds respectively with the largest and the smallest time taken being 0 seconds and 19 seconds. Moreover, as far as the number of interruptions are concerned the mean value is 0.77 and the variation is about 0.85 interruptions along with at most 3 interruptions and at least 0 interruptions. However, the average length of interruptions is 2.05 seconds and variations in nearly 2.77 seconds with the maximum length of interruptions being 16 and the minimum being 0 seconds.

Similarly, the average length of grooming is 1.30 seconds and standard deviation is nearly 3.23 seconds with the maximum length of grooming being 25 and the minimum being 0 seconds respectively. Also, the average number of butting is 89.65 seconds with a standard deviation of 42.77 seconds and the maximum number of butting being 190 and the minimum number of butting being 2. Further, the average length of licking in seconds is 2.12 and the standard deviation is 4.04 second along with 0 and 24 being the minimum and maximum length of licking in seconds. In a similar manner, the mean length of mother grazing during suckling is 0.53 seconds with 1.33 seconds being the average variation. Also, the smallest and the largest value is 0 and 7 seconds respectively. For the number of failed allo sucking the mean value is 0.16 and standard deviation is 0.40 seconds with 0 minimum value and 2 maximum value respectively

Table 4-2: Categorical description of suckling initiation and termination

Mother	32.5%	Calf	67.5%				
Mother	72.3%	Calf	27.7%				

Yes	100.0%	No	0.0%				
Yes	100.0%	No	0.0%				
Yes	96.4%	No	3.6%				
Yes	42.2%	No	57.8%				
Perineal	26.5%	Anal	15.7%				
Yes	39.8%	No	60.2%				
Antiparallel	34.9%	Parallel	54.2%	Back	10.8%		
No	57.8%	Popping	28.9%	Peeing	9.6%	Both	3.6%

The results of the table 4.2 shows the frequency distribution for all the categorical variables present in the study in terms of percentages for mother and calf respectively. It is evident that among all those involved in the study, 32.5% times mothers are initiators and the remaining 67.5% are initiated by Calf. Also, with respect to terminator, the percentage of mother is 72.3% and that of Calf is 27.7%. It is seen that in 100% of the cases Calf tail wagging while head butting, butting and in 96.4% times sniffing happened except the 3.6% times. Similarly, the presence of licking is evident with a 42.2% and absent in the remaining 57.8%. In regards to the placement of licking 26.5% is Perineal and only 15.7% is Anal. Also, 39.8% is a yes to Regurgitation and remaining 60.2% is a no. As far as the position is considered, the majority percentage 54.2% is Paralel, next is 34.9% Antiparalel and the minority is Back with only 10.8%. Finally, 57.8% is a no to mother peeing/defecation with 28.9% times they were popping, 9.6% times they were peeing and only 3.6% times they were doing both.

Table 4-3: Correlational Analysis

		Mother W	BCS Averag	Calf Weight	age_calf(days)	length_nursin	Movement of	Mother Tail wagg	Mother Tail wa	number of interu	interuption no.	Grooming (secs)	number_butting	length_licking	Mother Grazing duration(sec) during suckling
BCS Average	Correlation Coefficient	-.495**													
	Sig. (2-tailed)	2,35E-05													
	N	66													
Calf Weight	Correlation Coefficient	0,112773	0,0393598												
	Sig. (2-tailed)	0,310073	0,7536937												
	N	83	66												
age_calf(days)	Correlation Coefficient	-0,21421	0,086365	.895**											
	Sig. (2-tailed)	0,051819	0,4904983	3,99235E-30											
	N	83	66	83											
length_nursing (secs)	Correlation Coefficient	0,147145	0,106375	-0,08903704	-.247*										
	Sig. (2-tailed)	0,184357	0,3952705	0,423446826	0,024191341										
	N	83	66	83	83										
Movement of Mother during suckling (secs)	Correlation Coefficient	0,009723	-0,14655	-.501**	-.438**	0,102286591									
	Sig. (2-tailed)	0,930481	0,2403207	1,42772E-06	3,52308E-05	0,357489591									
	N	83	66	83	83	83									
Mother Tail wagging during suckling (secs)	Correlation Coefficient	-.255*	-0,176207	0,09504681	0,119625861	0,180725187	0,075119468								
	Sig. (2-tailed)	0,01979	0,1569918	0,392704668	0,281395852	0,10204731	0,499709716								
	N	83	66	83	83	83	83								
Mother Tail wagging during last 10 sec of termination(sec)	Correlation Coefficient	-.304**	-0,175168	0,200453729	.329**	-0,1134996	0,134672813	.583**							
	Sig. (2-tailed)	0,005172	0,1594903	0,069214888	0,002421104	0,306944332	0,22480147	7,34737E-09							
	N	83	66	83	83	83	83	83							
number of interuptions	Correlation Coefficient	0,075324	0,1600394	-.286**	-.332**	0,196204739	.326**	0,009254001	-0,019443143						
	Sig. (2-tailed)	0,498541	0,1992764	0,008740859	0,002168559	0,075449187	0,002606977	0,93382678	0,861499602						
	N	83	66	83	83	83	83	83	83						
interuption no. secs	Correlation Coefficient	0,028072	0,1718784	-.248*	-.282**	0,178049932	.352**	0,095682883	-0,009794016	.945**					
	Sig. (2-tailed)	0,801103	0,1675985	0,024008201	0,00986363	0,107308841	0,001083297	0,389530548	0,92997474	3,83384E-41					
	N	83	66	83	83	83	83	83	83	83					
Grooming (secs)	Correlation Coefficient	-0,03551	0,0726611	-.360**	-.307**	0,142733153	0,110504269	-.270*	-.330**	-0,01112038	-0,054979671				
	Sig. (2-tailed)	0,749974	0,5620564	0,000827965	0,004826509	0,198009899	0,319967932	0,013684619	0,0022951	0,920520501	0,621542085				
	N	83	66	83	83	83	83	83	83	83	83				
number_butting	Correlation Coefficient	-0,08622	.266*	.230*	0,169644732	.757**	-0,069242163	0,215769823	0,123319327	0,071504413	0,089057869	-0,030149606			
	Sig. (2-tailed)	0,438329	0,0311507	0,036353271	0,125218077	1,25819E-16	0,533937626	0,050102505	0,266697575	0,520626624	0,423337921	0,786720356			
	N	83	66	83	83	83	83	83	83	83	83	83			
length_licking	Correlation Coefficient	.250*	-0,049183	-.611**	-.660**	.336**	.370**	-.278*	-.427**	.350**	.257*	.367**	-0,009264776		
	Sig. (2-tailed)	0,022376	0,6949358	8,2692E-10	1,13271E-11	0,001906505	0,000582317	0,01106712	5,70138E-05	0,001188432	0,01903675	0,000641413	0,933749907		
	N	83	66	83	83	83	83	83	83	83	83	83	83		
Mother Grazing duration(sec) during suckling	Correlation Coefficient	0,025048	0,0505648	-0,11267257	-0,105850894	-0,02036571	0,043104656	-0,083004317	-0,109903933	-0,066095656	-0,090547863	0,209353279	-0,073486325	0,056986025	
	Sig. (2-tailed)	0,822156	0,6868015	0,310505315	0,340893317	0,854997675	0,698810663	0,455651894	0,322620211	0,552727715	0,41559116	0,057501326	0,509104626	0,608853975	
	N	83	66	83	83	83	83	83	83	83	83	83	83	83	
No of failed allo suckling attempts	Correlation Coefficient	0,120334	0,0515366	-.320**	-.377**	0,023845544	.321**	-0,088740661	-0,132140175	.285**	.298**	0,199517228	-0,19394737	.225*	0,099516558
	Sig. (2-tailed)	0,278536	0,6811025	0,003156301	0,000446115	0,830563422	0,003126982	0,424997789	0,233721442	0,008943748	0,006190266	0,070552008	0,078939791	0,040598945	0,37072618
	N	83	66	83	83	83	83	83	83	83	83	83	83	83	83

The results of the above table-4.3 summarizes the correlations between the variables which helps us understand which variables are related to one another and so that it could later be used to support the principal component analysis. The Spearman Rank Correlation method is employed to compute the present correlations pairwise and their respective statistical significance are tested at 5% level of significance. The evident results displayed support that a negative relationship is present between BCS average and mother weight ($r = -0.495$). Likewise, the calf age is positively correlated with calf weight ($r = 0.895$). Next, the length of nursing is negatively related to the age of calf ($r = -0.247$). Further, the movement of mother during suckling is negatively correlated to calf weight ($r = -0.501$) and calf age ($r = -0.438$) respectively. Similarly, mother tail wagging during suckling is negatively related to mother weight ($r = -0.255$). Next, mother tail wagging during the last10 seconds of termination is also negatively related to mothers weight ($r = -0.304$) and positively related with calf age ($r = 0.329$) and mother tail wagging during suckling ($r = 0.583$) respectively. Further, number of interruptions is negatively related with calf weight ($r = 0.286$) and calf age ($r = 0.332$) along with positive relation with mother movement during suckling ($r = 0.326$). Also, grooming appears to be negatively related with calf weight ($r = -0.360$), calf age ($r = -0.307$), mother tail wagging during suckling ($r =-0.270$) and mother tail wagging during the last 10 seconds of termination ($r =-0.330$) respectively. Likewise, butting appears to be positively related to BSC average ($r= 0.266$), calf weight ($r = 0.230$) and length of nursing($r = 0.757$) respectively. Last but not the least, mother licking is seen to be correlated with all the other behavioural changes be it a positive relation or negative.

2. Chi-Square tests:

In this section, we discuss the association between the two categorical variables to have a better understanding about their relation with one another. This helps in establishing whether a particular dependent categorical variable is at all related to the other independent categorical variable. The results of the table 2.1 summarizes the cross tabulations for the two categorical variables and the table 2.2 states the chi–square value along with its corresponding p-value which decides the significance or insignificance of the hypothesis at hand. The Chi square test is the most appropriate to test association being two categorical variables.

Table 4-4: showing the proportion of various behaviour exhibited by mother and calf while nursing.

	Initiator				$\chi2(df)$	*p*
	Mother		calf			
	N	%	*N*	%		
Terminator					15.489(1)	<0.001
Mother	12	14.5	48	57.8		
Calf	15	18.1	8	9.6		
Licking					7.01(1)	<0.001
Yes	10	12	38	45.8		
No	17	20.5	18	21.7		
Place of licking					7.358(2)	0.025
No licking	10	12.0	38	45.8		
Anal	7	8.4	6	7.2		
Perineal	10	12.0	12	14.5		
Regurgitation					15.656(1)	<0.01
Yes	19	22.9	14	16.9		
No	8	9.6	42	50.6		
Position During suckling					5.862(2)	0.053
Antiparallel	14	16.9	15	18.1		
Parallel	12	14.5	33	39.8		
Back	1	1.2	8	9.6		
Mother urinating and defecating					13.233(3)	0.004
Non	9	10.8	39	47.0		
Defecating	14	16.9	10	12.0		
Urinating	2	2.4	6	7.2		
Both	2	2.4	1	1.2		

On the basis of the results of the cross tabulation between Initiator and Terminators it is evident that in total around 72.3% of mothers are terminator and only 27.7% of calf are terminators. Similarly, out of all, 32.5% are mothers and the remaining 67.5% are calf. Moreover, around 14.5% are mothers who are initiator as well as terminator at the same time while 9.6% of calf are both initiators and terminators. Approximately 57.8% of calf initiator and mother as terminator while in 18.1% of the times mothers act as the initiator and the calf are the terminators. The Chi-square value for this association test turns out to be 15.489 with a corresponding p-value of <0.001 making the results to be statistically significant. This is concluded by stating that there is some level of association present between who initiates and who terminates the suckling.

Also from the results of the cross tabulation between Initiator and licking it is evident that in total around 57.8% do not lick and 42.2% lick. Similarly, out of all, 32.5% are mothers and the remaining 67.5% are calf. Moreover, around 12.0% are mothers who are initiator and are not licking while 21.7% of calf are being both initiators and licking. Approximately 45.8% of them are calf initiator with not licking mothers and 20.5% of the times mothers act as the initiator and the calf are licking. The Chi-square value for this association test turns out to be 7.096 with a corresponding p-value of 0.008 making the results to be statistically significant. This is concluded by stating that there is association present between who initiates and who is licking at the time.

Next, from the results of the cross tabulation between Initiator and placement of licking it is evident that in total around 57.8% do not lick and 42.2% lick. Similarly, out of all, 32.5% are mothers and the remaining 67.5% are calf. Moreover, around 12.0% are mothers who are initiator and are not licking while 21.7% of calf are being both initiators and licking. Approximately 45.8% of them are calf initiator with not licking mothers and 20.5% of the times mothers act as the initiator and the calf are licking. The Chi-square value for this association test turns out to be 7.096 with a corresponding p-value of 0.008 making the results to be statistically significant. This is concluded by stating that there is association present between who initiates and who is licking at the time.

Based on the results of the cross tabulation between Initiator and Regurgitation it is evident that in total around 39.8% are Regurgitation and 60.2% no Regurgitation. Similarly, out of all, 32.5% are mothers and the remaining 67.5% are calf. Moreover, around 9.6% are mothers who are initiator and not Regurgitation while 16.9% of calf are both initiators and Regurgitation. Approximately 50.6% of calf initiator and not Regurgitation while in 22.9% of the times mothers act as the initiator and Regurgitation.

The Chi-square value for this association test turns out to be 15.656 with a corresponding p-value of <0.001 making the results to be statistically significant.

Likewise, from the results of the cross tabulation between Initiator and position during suckling it is evident that in total around 34.9% are antiparallel, 54.2% are parallel and only 10.8% are back position. Similarly, out of all, 32.5% are mothers and the remaining 67.5% are calf. Moreover, around 16.9% are mothers who are initiator and the position of suckling is antiparallel, 14.5% of mother are initiators and the position of suckling is parallel while only 1.2% of mothers are initiators and back is the position of suckling. Further, 18.1% of them are calf initiator with antiparallel sucking position, 39.8% of calf initiators are in parallel suckling position with the remaining 9.6% of the calf being in the back position during suckling. The Chi-square value for this association test turns out to be 5.862 with a corresponding p-value of 0.053 making the results to be statistically significant. This is concluded by stating that there is some association present between who initiates and the position during suckling.

Lastly, from the results of the cross tabulation between Initiator and mother peeing and defication it is evident that in total around 57.8% of the mothers did not pee and deficate, 16.9% of the mothers were popping, 9.65 of them were peeing and only 3.6% of them were doing both. Similarly, out of all, 32.5% are mothers and the remaining 67.5% are calf. Moreover, around 10.8% times mothers who are initiator did not pee and deficate, 16.9% of mother are initiators and were popping, 2.4% of mother are initiators and were peeing while 2.4% of mothers are initiators and doing both. Further, 47.0% of them are calf initiator with mother not peeing and deficating, 12.0% of calf initiators have mothers popping, nearly 7.25 of times mothers are peeing when calf initiates with the remaining 1.2% times calf being the initiator and mother doing both. The Chi-square value for this association test turns out to be 13.233 with a corresponding p-value of 0.004 making the results to be statistically significant. This is concluded by stating that there is some association present between who initiates and the peeing and defication done by mother.

3. Mann-Whitney U test:

In this section, the tests are performed to compare differences in the continuous response variables being length of nursing, movement of the mother during suckling, mother tail wagging during suckling, mother tail wagging during last 10 second, length of interruptions, length of grooming and length of mother grazing during suckling, number of interruptions, number of butting and number of failed allo sucking attempts with respect to the initiator being mother or calf. This helps in establishing whether a particular dependent continuous variable is at all affected by who the initiator is mother or calf. As all the continuous variables turned out to be non-normally distributed which is evident by visualization of the variables, therefore the most appropriate test under this situation to compare the difference is the non-parametric Mann Whitney U test. The results of the table 3.1 comprises of the test statistic and its corresponding p-value to decide the significance or insignificance of the hypothesis at hand. The considered level of significance under this situation is 5%.

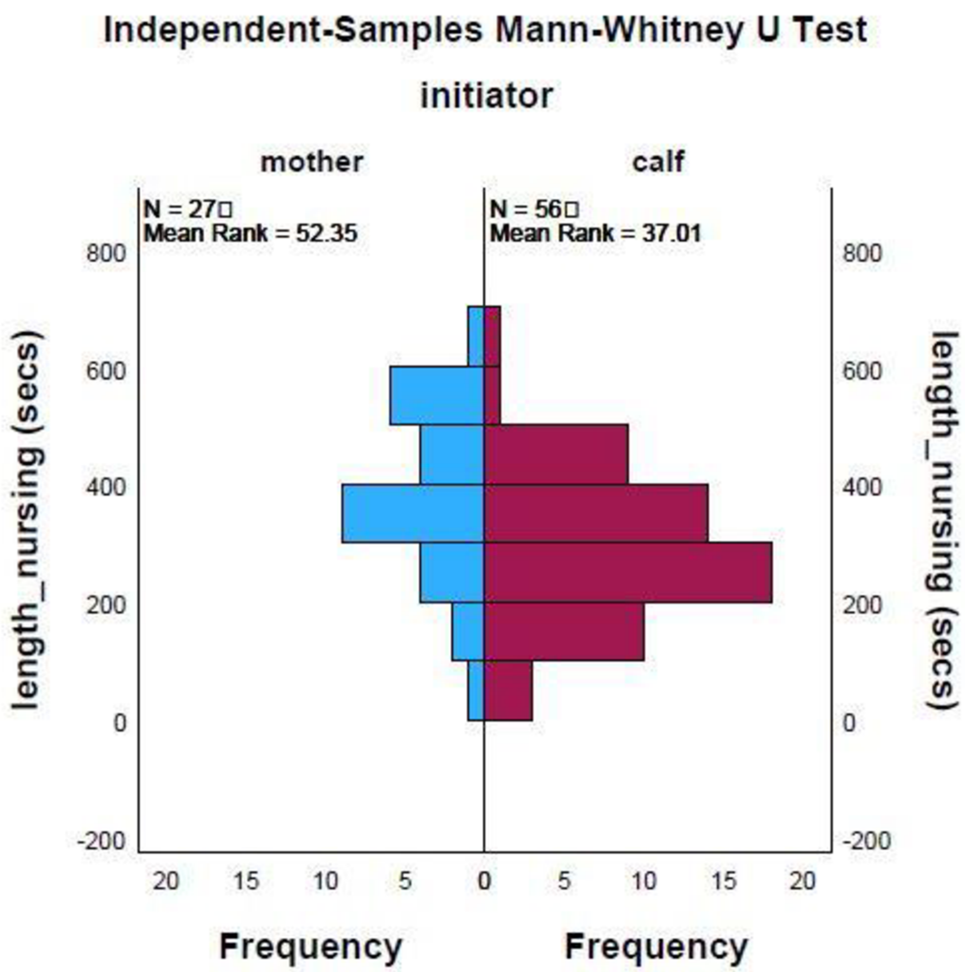

Figure 16. Association between initiation and nursing duration

Based on the Mann Whitney U test, to compare if the distribution of length of nursing is the same across both the categories of the initiator it is seen that the test statistic is U= 476.500 with corresponding p-value being 0.007, implying that the results are statistically significant. Hence, it is evident that the length of nursing is comparatively more when calf is the initiator rather than mother.

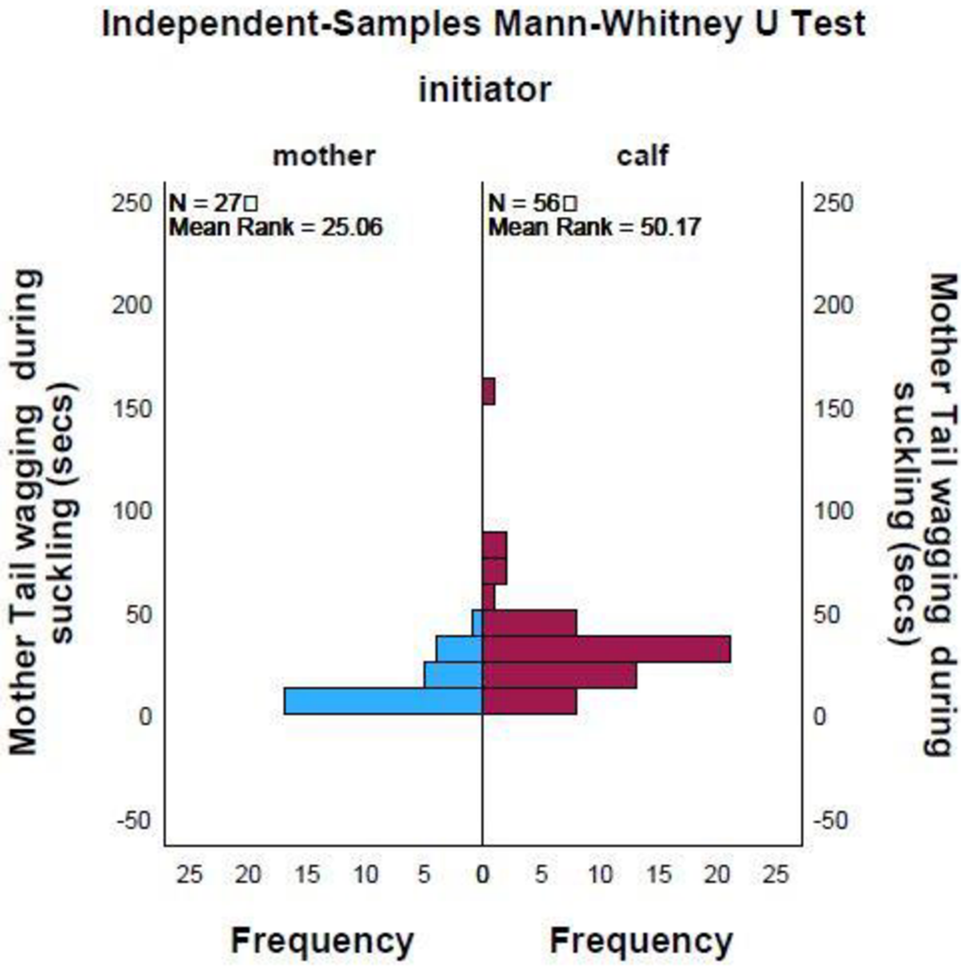

Figure 17. Association between tail wagging and initiation

Similarly, based on the Mann Whitney U test, to compare if the distribution of duration of mother tail wagging during suckling in seconds is the same across both the categories of the initiator it is seen that the test statistic is U= 1213.500 with corresponding p-value being <0.001, implying that the results are statistically significant. Hence, it is evident that the duration of mother tail wagging during suckling in seconds is comparatively more when calf is the initiator rather than mother.

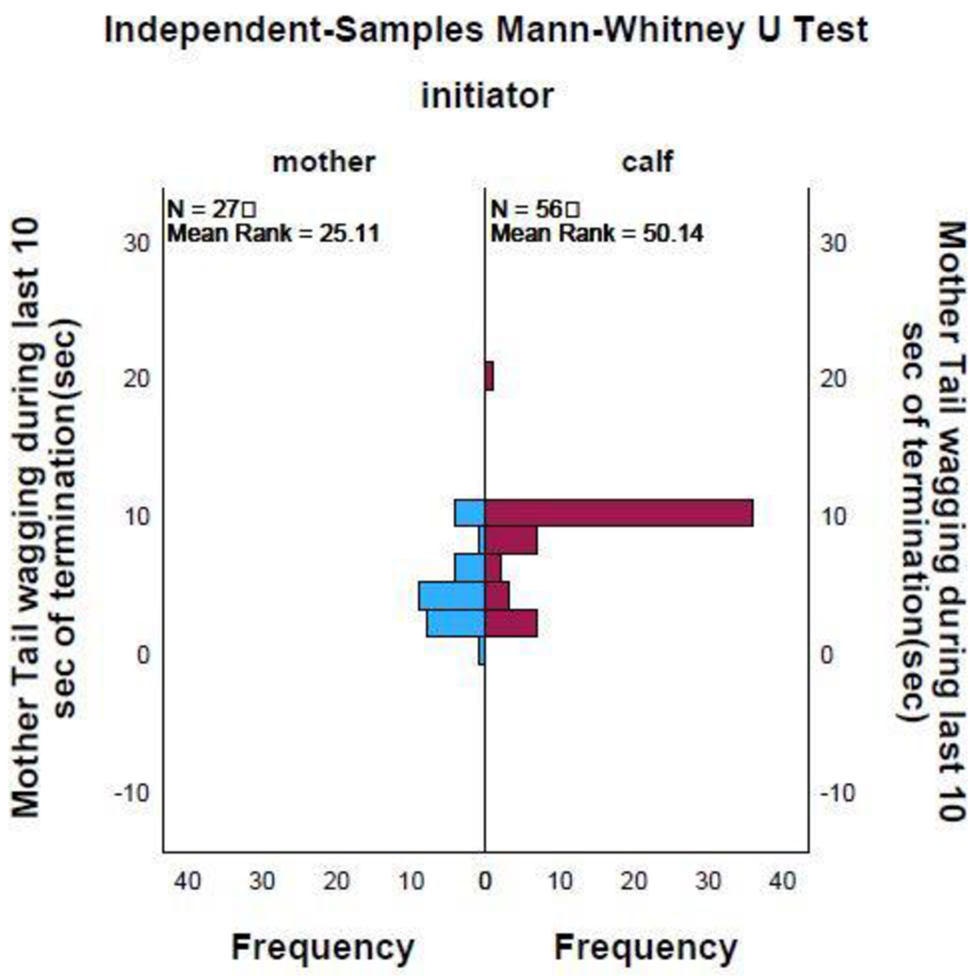

Figure 18. Association between tail wagging (last 10 sec of termination) and initiation

Again, based on the Mann Whitney U test, to compare if the distribution of duration of mother tail wagging during last 10 seconds of termination is the same across both the categories of the initiator it is seen that the test statistic is U= 1212.000 with corresponding p-value being <0.001, implying that the results are statistically significant. Hence, it is evident that the duration of mother tail wagging during last 10 seconds of termination is comparatively more when calf is the initiator rather than mother.

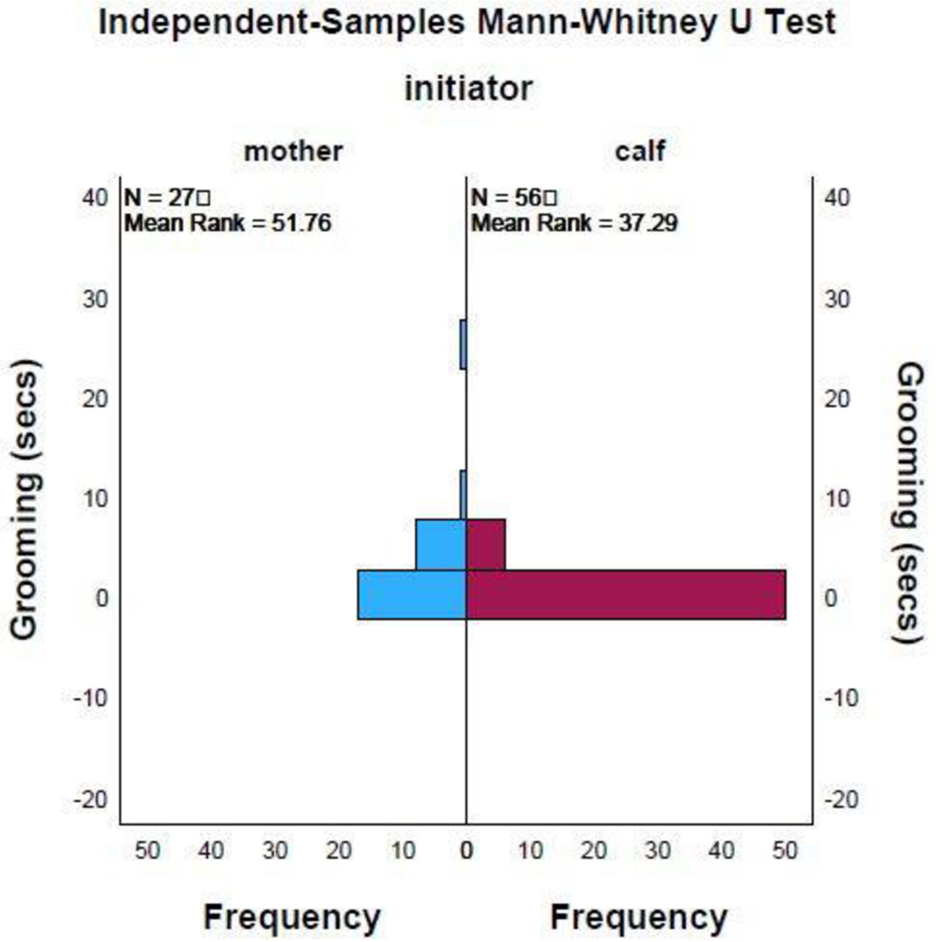

Figure 19. Association between grooming and intiation

Further, on the basis of the Mann Whitney U test, to compare if the distribution of grooming in seconds is the same across both the categories of the initiator it is seen that the test statistic is U= 492.500 with corresponding p-value being <0.002, implying that the results are statistically significant. Hence, it is evident that the duration of grooming in seconds is comparatively more when calf is the initiator rather than mother.

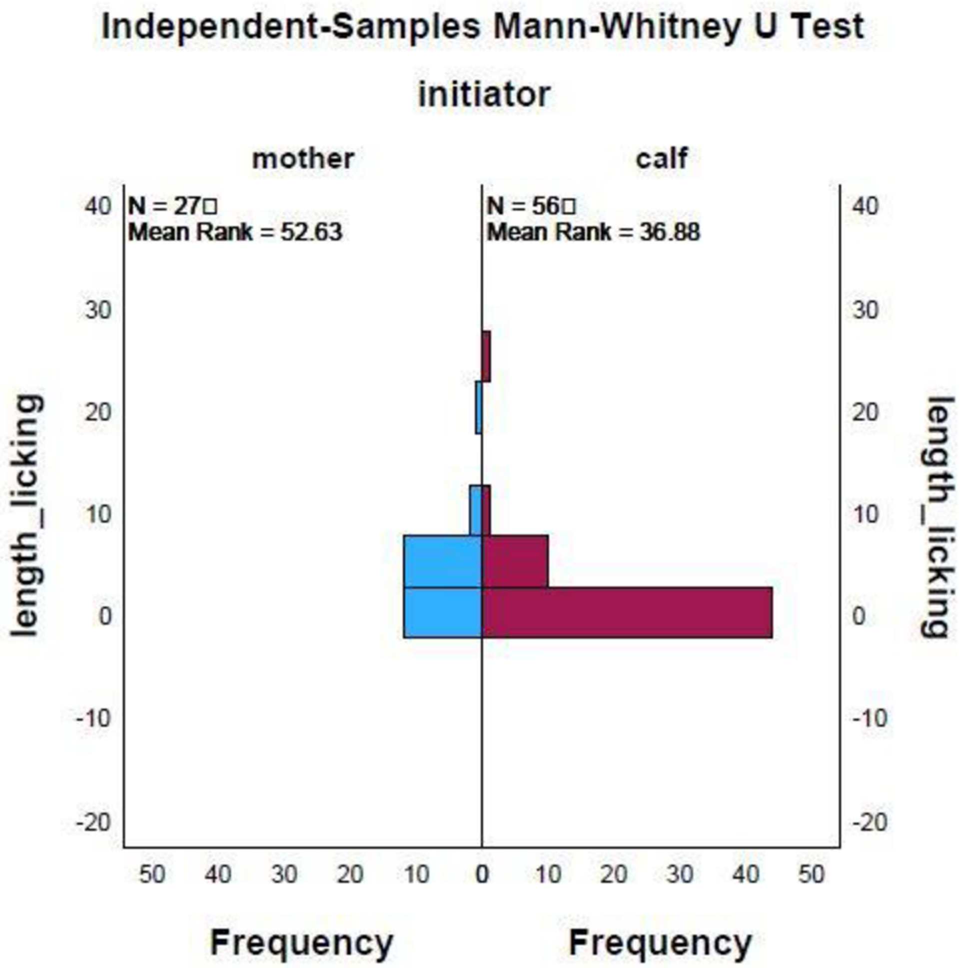

Figure 20. Association between licking and initiation

Also, based on the Mann Whitney U test, to compare if the distribution of length of licking in seconds is the same across both the categories of the initiator it is seen that the test statistic is U= 469.000 with corresponding p-value being <0.002, implying that the results are statistically significant. Hence, it is evident that the length of licking in seconds is comparatively more when calf is the initiator rather than mother.

4. Factor Analysis:

This section comprises of the results of the factor analysis performed on all the continuous and categorical variables of interest with the intention to of grouping the variables and forming factors explaining the behavior during suckling among mother and calf. As principal component analysis is a statistical technique that reduces a set of variables by extracting all their commonalities into a smaller number of factors. So, it is most suitable in this situation to find factors forming groups of common behavior during suckling.

Table 4-4: Total Variance Explained

Component	Total	Initial Eigenvalues % of variance	Cumulative (%)	Extraction total	Sum of squared variance	Loading cumulative (%)
1	3.856	24.077	24.077	3.852	24.077	24.077
2	2.143	13.393	37.469	2.143	13.393	37.469
3	1.726	10.785	48.254	1.726	10.785	48.254
4	1.432	8.952	57.206	1.432	8.952	57.206
5	1.133	7.082	64.288	1.133	7.082	64.288
6	1.049	6.556	70.844	1.049	6.556	70.844
7	0.838	5.240	76.084			
8	0.793	4.958	81.042			
9	0.744	4.649	85.692			
10	0.585	3.659	89.351			
11	0.531	3.321	92.671			
12	0.462	2.888	95.559			
13	0.293	1.834	97.394			
14	0.267	1.670	99.063			
15	0.114	0.711	99.774			
16	0.036	0.226	100.00			

The tables 4-5 is the table of the total variance explained which is interpreted by understanding the initial eigen values and the rotation sums of squared loadings respectively. In terms of the eigen values the components which has it greater than 1 are selected thus the crucial components are the first six components. Although the most valuable component is the first component as it explains the maximum variability of each factor being 24.077% and the next is the second components explaining around 13.393% of the total variability present. Thereafter is the third component with 10.785% variability and fourth component with 8.952% respectively. The last two components fifth and sixth explains the least amount of variation of 7.082% and 6.556% each. Hence, it is seen that the first six components in total explains around 70.844% of the variability in the original variable

Table 4-5: Rotated Component Matrix

Variables	1	2	3	4	5	6
Movement of mother during suckling *(sec)*	0.328	0.521	0.288	-0.097	0.219	0.261
Mothers' tail wagging *(sec)*	-0.182	0.025	0.707	0.148	-0.100	0.035
Mother's tail wagging during last 10 sec of interruption *(sec)*	-0.320	0.008	0.764	-0.158	-0.078	0.154
Number of interruption	0.268	0.733	0.170	0.000	-0.012	-0.402
Interruption *(sec)*	0.162	0.860	0.065	-0.063	-0.157	-0.242
Grooming *(sec)*	0.215	0.002	-0.224	-0.034	0.705	0.005
Number of butting	-0.026	-0.025	0.317	0.802	-0.098	-0.168
Sniffing	0.202	-0.110	0.168	-0.040	0.042	0.773
Licking	0.909	0.170	-0.099	0.22	0.078	0.094
Length of licking	0.767	0.101	-0.084	0.300	0.125	-0.045
Placement of licking	0.900	0.087	-0.38	0.012	-0.073	0.079
Regurgitation	0.107	-0.167	-0.195	0.740	0.007	0.085
Mother Grazing during suckling	0.010	0.027	0.038	-0.047	0.863	0.026
Position during suckling	-0.689	-0.021	0.224	0.178	-0.079	-0.033
Mother urinating and defecating	0.000	0.449	-0.398	0.409	-0.162	0.374
Number of failed allo-suckling	-0.005	0.714	-0.262	-0.120	0.157	0.206

The next important table is the "Rotated component matrix" summarized in table 4-6 This explains which original variables are related to the new factors. Usually, we select those factors which are over 0.7. This provides information about each component as to which particular variables are part of it. This means that component 1 is related to licking, length of licking, placement of licking, and even suckling position. Likewise, the second component is made up of variables related to number of interruptions, timing of interruptions and number of failed allo suckling attempts. It is important to have the factors clearly defined for the proper interpretation of results in the following analysis. Next the component three constitutes of variables related to mother tail wagging during suckling and mother tail wagging during the last 10 seconds of suckling. Further the fourth component is made up of number of butting and regurgitation, the fifth component depends upon grooming and the last component six constitutes of variable related to sniffing.

5. Generalized Linear Mixed Models:

In this section we finally discuss the generalized linear mixed models, or binomial GLMMs, which are useful for modeling binary outcomes for repeated or clustered measures. The reason for choosing GLMM in this study is that the calf are treated as the subject and each observation as the repeated measure. Linear response for the duration f suckling, binary logistic regression for the terminator and the independent variables included in the model are age, weight and sex of the calf, parity of the mother, and the six previous "behavioural" factors named as the first six principal components. The models were solved by removing each time the less significant factor and the final models are retained and their results are discussed in detail.

Table 4-7: Showing how initiation of suckling affected FAC3_1, FAC4_1, calf weight and age

					% confident interval	
Model term	Coefficient	Std. Error	t	Sig.	Lower	upper
Intercept	319.645	25.8350	12.373	<0.001	268.211	371.078
FAC3_1	26.654	9.3719	2.844	0.006	7.996	45.312
FAC4_1	95.355	9.1328	10.441	<0.001	77.173	113.537
Calf Weight	2.505	0.7783	3.218	0.002	0.955	4.054
Age of calves (days)	-2.628	0.5796	-4.535	<0.001	-3.782	-1.474

The table 4-7 consists of the results related to the final model displayed after running many iteration of modelling done for the suckling duration with the independents variables being age, weight and sex of the calf, parity of the mother, and the six "behavioural" factors obtained as principal components in the factor analysis section. The fixed coefficients table led to some insightful interpretation about the suckling duration of the calf. The most significant one is that the suckling duration is negatively related to the age of the calf (get shorter as the calf grows). This means that the duration of suckling decreases by 2.628 seconds when the age of the calf increases by a day. Next important interpretation is that the duration of suckling is positively related to the weight of the calf. Similarly, the principal components three and four also have a positive impact on the duration of suckling. Hence, as a result of factor 3 more butting and mother regurgitating and not grazing makes longer suckling and as a result of factor 4 tail wagging and even sniffing increases duration of suckling.

Table 4-8: Showing how termination of suckling affected FAC1_1 and FAC3_1

					% confident interval	
Model term	Coefficient	Std. Error	t	Sig.	Lower	upper
Intercept	1.497	0.4453	3.362	0.001	0.611	2.383
FAC1_1	-0.846	0.3079	-2.746	0.007	-1.458	-0.233
FAC3_1	1.632	0.4358	3.745	<0.001	0.765	2.499

Likewise, the table 4-8 comprises of the results of the generalized linear mixed models for terminator with the independents variables age, weight and sex of the calf, parity of the mother, and the six "behavioural" factors obtained as principal components in the factor analysis section. The final iteration table showed that the only significant factors are the first and third principal components. The interpretation is that for factor one, the coefficient estimate is negative which means that termination by the mother decreases as factor 1 increases implying that if licking, length of licking, perineal licking and parallel position increases it results in a decreased termination by mother. However, the termination by the mother increases when the effect of the factor three increases meaning that if butting, regurgitation, and low grazing increases it increases the chances of termination of the mother.

5. Discussion

The variables including age, weight and sex of the calf, parity of the mother, and the six previous "behavioural" factors were monitored in this research for the evaluation of the four null hypothesis and the results generated depicted how multiple factors affect the suckling behaviour of the eland. The first hypothesis implies that age would affect the initiation and termination; and likewise, our research concluded that as the age of the calf progresses, the suckling behaviour declines which is not in line with the findings of Robbins et al. (1981) who said that with age the suckling behavior would increase but our results imitate the finding of Sarno and Franklin (1999); Cassinello (2001); Therrien et al. (2008) found that the suckling time declines as the weaning off period starts. For suckling duration, it is negatively related to the age of the calf as it gets shorter as the calf grows and Pavlo et al. (2023) also predicted that the suckling bout duration will decrease as the calf ages.

When we worked on the second hypothesis the results indicated that the low weight of the calf resulted in increased suckling in order to replenish the required amount of nutrition to grow specially when grazing was low therefore, suckling was linked positively to the weight. Likewise, Cameron (1998) implied that the more time spent suckling with milk intake helps in the more weight gain of the calves.

Third hypothesis implies that the initiation and termination of suckling would influence the suckling duration while we found it correct as If the mother acted as the initiator of the suckling behavior then suckling was less and when the calf acted as the initiator, the suckling behavior was more rigorous. Our findings are partly in accordance with the results of Pavlo et al. (2023) who predicted that the mother would initiate more suckling bouts at the beginning of the lactation period and will terminate more bouts towards the end of the lactation period. Rubin and Michelson (1994) and Wronski et al. (2006) found that the mothers generally decided how long the calves could nurse and they terminated the bouts more frequently and the calves would have longer bouts of suckling only if the mother allows them. But it is evident from our results that the length of nursing is comparatively more when calf is the initiator rather than the mother.

The social interactions including multiple factors would influence suckling duration in different ways. The licking behavior, length and position of the calf resulted in increased suckling as the mother recognized her own progeny in this way. The same results were observed by (LandeteCastillejos et al., 2000; Maniscalco et al., 2007; Zapata et al., 2009a,b) who found a positive relation between licking and proper position of the calf to the suckling duration. Also, more head butting by the calf, mother's regurgitating and less grazing makes longer suckling bouts because mother will not move to graze from her position and the calves will get ample time and opportunities to suckle without interruptions. Henceforth, if we talk about the factor of acting as the terminator of the suckling behavior, the termination by the mother increases with licking, length, perineal licking, and parallel position of the calf whereas it decreases with the head butting, regurgitation, and low grazing.

The sniffing increases the duration of the suckling behaviour as the naso–anal contact between the mother and calf before suckling plays an essential role in mother–calf recognition due to which the mothers allowed their own offspring to suckle more (Lent 1974; Wronski et al. 2006). This indicated that the naso–anal contact contributes to mother–offspring bonding which allows the calf to survive independently in the environment (Cowan 1974; Nowak et al. 2000).

Blauvelt (1956) found that even if the animals are restricted from both grooming and orientation to aid their calves nursing attempts, the frequency of nursing is affected by age of lamb causing decline with age, number of siblings, birth weight and race. We found that the duration of mother tail wagging during suckling is comparatively more when calf is the initiator rather than mother as the mother is trying to ward off the disturbance caused by the calf and the tail wagging behaviour increases vigorously in the same situation during the last ten seconds of termination. We also found that the grooming was more when the calf was the initiator of the suckling and same was the case with the licking behaviour.

6. Conclusions

Through examination of factors such as age, weight, initiation and termination dynamics, and social interactions, this study has provided valuable insights into the mechanisms governing calf behaviour during suckling. Current research explores how common Eland species exhibit parenting behaviours. Specifically, it focuses on how mothers and calves interact during the time when calves are nursing. The study findings highlight that the age of the calf affects how long they nurse. The research reveals a negative relationship between the calf's age and the suckling duration. Additionally, the study investigates how the weight of the calf influences nursing duration. Calves that are weaker and with low body mass tend to nurse for a longer time. This aligns with the general idea that a growing body requires more energy, hence more food.

This study also shows how the initiation and termination of the suckling influence the suckling duration. It has been observed that the suckling duration is more rigorous whenever calf is the initiator and significantly less otherwise. Moreover, the study also shows that the social interactions between the mother and the calf has a considerable impact on the suckling duration. The regurgitating mothers tend to move less thus resulting in longer suckling bouts and vice versa. With other interactions, it has been observed that with perineal and anal licking, licking length and parallel position of the calf, the mother tends to be the terminator whereas it decreases with head butting, mother’s regurgitation, and low grazing. Sniffing also plays an important role in the overall nursing behavior. The results shows that naso-anal sniffing before suckling plays an important role in mother calf recognition thus allowing the calf not only to suckle more but increases the mother-calf bonding which is essential for the independent survival of the calf.

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