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Behaviour of animals in a mixed-species African savannah zoo exhibit related to expansion of the enclosure, visitor numbers and weather effects

Ethology

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Animal science

Acknowledgements

This thesis marks the end of my student life and five years at NMBU. It has been an interesting journey considering the pandemic.

First off, I'd like to thank Kristiansand Zoological Garden for giving me this unique opportunity to study these fascinating animals. It has been an experience that I will remember for the rest of my life.

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And I want to add how proud I am of myself for powering through and managing to write this thesis in my tiny house without water and bathroom facilities, despite of losing all I had written at one point, holding two jobs, while my car got messed up, sick horses, lambing and taking care of my tiny zoo at home. Well done me.

Abstract

Animal welfare in zoos has been in focus lately, especially in relation to visitor effects. Visitors have been observed to have either a positive, neutral, or negative effect on zoo animals, and studies have shown that this can depend on the species and the enclosure. I got the opportunity to study the animals in the African savannah exhibit at Kristiansand Zoological Garden in 2022 in relation to the expansion of the enclosure. The study subjects consisted of four zebra, two blesbok, eleven eland, three giraffes and nine ostriches. Kristiansand Zoological Garden wanted to know how behaviour of the animals in the savannah enclosure would be affected by the new space as well as if there was a visitor effect due to the enlarged exposure to visitors. I also wanted to see if there was a weather effect on the animal's behavior. I hypothesized that there would be an increase in the use of the new area as days went by since the opening of the area, as well as an increase in walking and standing behavior and less foraging in relation to higher visitor numbers. I also expected that there would be more standing with lower temperatures and higher wind speed, and more lying behavior with higher temperatures. The use of the new area increased as days went by for all species except for the ostriches, which used the new space the most at the beginning. Space use varied with the time of day and visitor number. The visitor numbers had no significant main effect on foraging, walking and standing behavior, but the animals were observed more with their heads down and lying down as visitor numbers increased. There was no increase in walking behavior in relation to visitor numbers except in the ostriches. There was variation in foraging between species in relation to temperature and in lying down in relation to temperature and wind speed. There was an increase in heads up and lying down in relation to days gone by since opening of the new area. Overall, there was significant variation between species and the behaviors observed in relation to the new area, visitor numbers and weather effects. The new area was well used as time went by, especially by the ostriches and eland. Although behaviour varied with the visitor numbers, most of the animals seemed to be well-habituated towards visitors and could be considered to have a neutral relationship with them.

Sammendrag

Dyrevelferd i dyrehager har vært mye i fokus for tiden, spesielt i relasjon til besøkseffekten. Besøkende har blitt observert til å ha enten en positiv, nøytral eller negativ effekt på dyr i dyrehager, og studier har vist at det er avhengig av art og innhegning. Jeg fikk muligheten til å studere dyrene i den Afrikanske savanneutstillingen i Kristiansand dyrepark i 2022 i relasjon til utvidelsen av innhegningen. Studie subjektene bestod av fire sebra, to blisbukker, elleve eland, tre sjiraffer og ni strutser. Kristiansand dyrehage ville vite hvordan atferden hos dyrene i savannen ble påvirket av det nye arealet, og om det var en besøkseffekt nå da det utvidete arealet øket dyrenes eksponering til besøkende. Jeg ønsket også å se om det var en væreffekt på dyrenes atferd. Mine hypoteser gikk ut på at det ville være en økning i bruken av det nye arealet ettersom tiden gikk fra åpning, så vel som en økning i gå- og stå atferd og mindre fôrsøk i relasjon til økt besøksantall. Jeg antok også det ville bli mer ståatferd ved lavere temperaturer og høyere vindstyrke, og mer liggeatferd ved høyere temperaturer. Bruken av det nye arealet økte med tiden for alle artene med unntak av strutsen som brukte arealet mest i begynnelsen. Arealbruk varierte med tid på døgnet og antall besøkende. Besøksantallet hadde ingen signifikant hovedeffekt på fôrsøk, gå- og ståatferd, men dyrene ble observert med hodene mer opp og mer liggeatferd i relasjon til økte besøksantall. Det var ingen økning i gåatferd i relasjon til besøksantall med unntak hos strutsen. The var en variasjon i fôrsøk mellom arter i relasjon til temperatur, og en relasjon mellom liggeatferd, temperatur og vindstyrke. The var en økning i hoder opp og liggeatferd i relasjon til dager som gikk siden åpningen av det nye arealet. Generelt var det en signifikant variasjon mellom artene og de observerte atferdene i relasjon til areal, besøksantall og væreffekter. The nye arealet ble mer brukt etter som dagene gikk, spesielt av struts og eland. Selv om atferdene varierte med besøksantall, virket de fleste dyrene til å være tilvennet de besøkende og kan bli ansett til å ha et nøytralt forhold til dem.

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1 Introduction

Kristiansand Zoological Garden is one of the most well-known zoos in Norway with over 100 different species ranging from sheep to tigers (Kristiansand dyrepark, 2023). An opportunity occurred when the zoo was looking for bachelor and master students for several different studies. One of these studies dealt with the expansion of the savannah enclosure, and how the inhabitants would make use of the new addition of space and if the animals were affected by the increased exposure to visitors. This seemed like a great opportunity to write a thesis about something completely different than what I am used to. As a Norwegian animal husbandry master student, I am used to farm animals such as cows, sheep, and pigs, but this gave me the opportunity to study zebra, blesbok, eland, giraffe, and ostriches.

Zoological gardens are popular tourist destinations, with over 10 000 zoos around the world (Gusset and Dick, 2011), and hundreds of millions of visitors each year (Hosey, 2010). Visitors allow zoos to meet conservation goals by providing education about wildlife and highlighting the need to reduce human treats on wildlife (Ballantyne et al., 2007). Since zoo animals have not undergone thousands of years of domestication like livestock and companion animal species, they are considered "wild" animals. While zoo animals can be considered to undergo natural selection in captivity, breeding is done with the goal of conservation. They are nevertheless regularly exposed to both familiar human caretakers and unfamiliar zoo visitors.

Kristiansand Zoological Garden is the largest zoo in Norway (Kristiansand dyrepark, 2023). They have a wide variety of both exotic animals as well as Norwegian animals. The park is divided into different biomes: Africa, Asia, Jungle, Nordic wilderness, and Norwegian farm animals. In each biome, there are animals of different species native to these biomes. In the African biome, there is a variety of enclosures as well as a petting zoo. One of the exhibits is the African savannah, in which this study was conducted, which contains an assorted mix of herbivores found in the South African savannah.

In 2022 the zoo started the expansion work on their savannah enclosure. One of my interests aligning with the parks interest was to gain knowledge about how the animals would use their new space, and if visitors had an influence on the animal's behavior. In addition to this, I also took note of weather conditions to see if there was an alteration in behavior in relation to it. I started by making a literature review of relevant information, in which to provide context to my observations. This made it possible for me to learn more about the species, how captive animals react to visitors, space use, and weather effects. This information is needed to further understand what was observed during the study period. I then spent the summer of 2022 in Kristiansand Zoological Garden making almost daily observations on the savannah enclosure and its inhabitants.

2 Literature review

2.1 Visitor effect

The presence of large numbers of visitors has led to questions about the "visitor effect" on the welfare of animals exhibited in zoos (Hosey, 2000). The visitor-animal relationships that occurs in a zoo setting can be characterized in three ways. 1. A negative relationship, where the animal is highly fearful of humans and shows avoidance. 2. A neutral relationship, in which interactions with humans have no consequences for the animal and can lead to habituation to humans. 3. A positive relationship, where the animal will potentially experience positive emotions associated with the interaction (Sherwen, 2019). As predicted by Hosey (2008) studies have indicated variable impacts of visitors on welfare outcomes, even when animals in different studies were confined in similar environments (Cole, 2018; Hosey, 2008; Maple, 2018; Maple, 2019).

Animals of all vertebrate species can experience a natural fear of humans, but this fear varies between species depending on the risk of predation by humans when living in the wild, whether humans could be seen as prey, and the number of generations that a population has lived in captivity. Features of the enclosure such as hiding places, ability to regulate distance from humans, and individual personality characteristics, affect the learning experience of each animal, and how they react to visitors. Early life experience with human caregivers is particularly influential in moderating fear of humans in animals born in captivity (Whitham, 2013). These factors can affect whether the visitor impact on zoo animals is positive (Bloomfield, 2015), neutral (Margulis, 2003; Sherwen 2014) or negative (Blaney, 2004; Davis 2005).

During the Covid pandemic, there was a possibility to observe how zoo animals behaved in a visitor free environment (Williams et al., 2021). Two popular species in zoos were studied during lockdown: Slender-tailed meerkats (*Suricata suricatta*) and little penguins (*Eudyptula minor*). In Adelaide Zoo, keepers introduced more enrichment options for their meerkats after observing less activity than normal in the absence of visitors (Eckert, 2020). A similar observation was done on little penguins in Singapore Zoo where zookeepers went for walks in the park with their penguins due to lack of stimulation from visitors (Fahey, 2020). Williams et al. (2021) observed that the meerkats in an UK based zoo used the zones closest to visitors less during the lock down, but there was no significant increase in out of sight behaviour (Williams et al., 2021). There was no significant behavioural change in the penguins with or without visitors. Williams et al. (2023) found that Psittaciformes and Proboscidea showed a more positive reaction towards visitors than first expected as well as that the Proboscidea also showed more neutral responses and no negative responses. It was uncovered that birds had a more neutral response to visitors, while amphibians were prone to negative responses (Williams et al., 2023).

In a study of penguins, whose enclosure was closed to the public on five random days, it was observed that there were fewer aggressive social interactions that occurred on the closed days when the penguins spent more time in the public viewing area. This was presumed to indicate fear in response to the presence of visitors during opening hours (Sherwen et al., 2015). A similar result was observed in a group of penguins in Melbourne Zoo Australia. By excluding visitors from the exhibit, the penguins spent more time in the viewing area, showed less aggressive behaviour and swam more (Sherwen et al., 2015). The same result occurred when visitor behavior was controlled in such a way that penguins were not exposed to loud noises or threatening displays from humans. Fewer penguins were vigilant and fewer retreated, and time spent in visitor viewing areas increased (Chiew et al., 2019; Saiyed et al., 2019).

Even though behavioural responses to visitors vary, or depend on the density of zoo visitors, animals can habituate to humans (Sherwen, 2019). Visitors can also work as a source of enrichment, and some zoo species engage in attention-seeking behaviour when visitors are around (Sherwen, 2019). Yeates and Main (2008) proposed that if visitors have a positive effect on the animals, there should be an increase in affiliative behaviours and animals should spend more time close to the visitors. In contrast, if visitors have a negative effect, the animals were predicted to avoid viewing areas, spend more time out of sight, and show an increase in vigilance (Hosey, 2013). The number of visitors might influence animal behaviour. Some species has shown an increased response to high and low number of visitors, but during intermediate levels of visitors, reduces their response (Krebs et al. 2023). In a walk-through enclosure of ring-tailed lemures (*Lemur catta*), the visitors had only an effect on the overall time budget with 3-8% while weather and time of day effects affected the overall budget with 10 – 37% of variation in each behavior. This result suggests that there was a visitor effect, but it were minimal when compared to time of day and weather effects (Goodenough et al., 2019).

Animals' physical environment also has an influence on the animals' responses to visitors. The design of the enclosure, such as size, type of barrier and other features, can affect whether and how animals' approach or avoid visitors. A result observed in different species is that giving the animals the opportunity to hide, and to control their own exposure to the visitors, can have a major impact on the animal's ability to cope in captivity (Morgan, 2007). For example, by giving polar bears (*Urus maritimus*) free access to their off–display area, there was a reduction in pacing and an increase in play, even though they were rarely recorded to enter the area (Ross, 2006). In a study conducted in Egypt on enclosure quality and reactive response to visitors of captive Soemmerring's Gazelle (*Nanger soemmerringii*), three groups of animals were divided into three different enclosures of different sizes and exposure to visitors. The animals in group 1 had a bare soil enclosure with a single wired fence which separated animals from visitors. Group 2 had a partially grassed area, which was easily observed from three sides through single wired fence. Group 3 was confined in a mostly grassed yard with mature trees which offered shade and partial concealment with double wired fence on both sides. The observers observed their different behaviours with such as freeze or running in response to visitors. The animals in group 1 showed more agonistic behaviour than Group 2, and Group 2 more so than Group 3 which was the animal group which showed the least reactive response. This showed that the group confined in the most concealed enclosure was the least reactive (Mansour, 2000). When it comes to managing the visitor effect, it is obvious that by giving animal's the choice to were to spend their time, and to be able to retreat from visitors, can reduce any stress associated with visitors (Choo et al., 2011; Fernandez et al., 2009; Hosey, 2005, Stoinski et al., 2012; Morgan and Tromborg, 2006). Therefore, enclosure design is of critical importance to allow the animals to be in control and avoid visitors if required.

2.2 Space use

Home range is described as the space used by animals in which they travel in search of food, mates, and care for their young (Burt, 1943) and the sizes vary between species, age, and sex (Hediger, 2013; Penzhorn, 1982; Sanderson, 1966). The higher the metabolic need the larger the home range. Carnivores, which require large portions of meat in their diets, have especially large home ranges (Gittleman and Harvey, 1982). For example, a polar bear's enclosure is one millionth of what its natural home range size would be (Clubb and Mason, 2003).

Space use involves a trade – off between accessing resources and the use of energy in accessing it (Fretwell and Lucas, 1969). In theory, an animal should occupy the smallest area possible which contains all the required resources (Harestad and Bunnel, 1979). Most captive animals are housed in enclosures which are considerable smaller than their natural home range. Limited space and finances are the two main restrictions on enclosure size. A study done on captivity effects on wide – ranging carnivores showed that species with a large home range had a higher stress level in captivity than other species (Clubb and Mason, 2003).

Exhibits that are too small can have a negative effect, especially in mixed – species enclosures where space used by different species overlaps which can lead to aggressive interactions (Andersen, 1992). A social hierarchy will be established in multi – species enclosures, whereby the species with the biggest body size is the most dominant one (Andersen, 1992). In such enclosures the most common interspecies behaviour is displacement, and aggressive attacks are rarely seen (Fisler, 1977; Sauer, 1969). A study conducted on a multi mixed species enclosure containing plains zebra (*Equus bruchelli*) and eland (*Taurotragus oryx*), revealed that the size of the exhibits had a direct effect on the amount of interspecific behaviour. The smaller the enclosure, the more competition was observed between the species (Andersen, 1992). Aggressive behaviour has been observed between different species, which mainly has been caused by a restriction in available resources (Andersen, 1992).

When given the opportunity, captive animals behaviour does not differ significantly from their wild ancestors (Boice, 1981). However, few exhibits provide captive animals with the right requirements as present in the wild, which leads to under stimulated conditions and thus a lack of species–specific behaviour. Under such conditions, the normal behavioural patterns can be replaced by abnormal behaviour patterns such as apathic or stereotyped behaviours (Dantzer, 1986). Abnormal and stereotypic behaviours are repetitive behaviours which seems to have no function (Mason, 1991). When it comes to the correlation between wellbeing and stereotypic behaviour, it is not as straightforward as it seems (Mason and Mendi, 1993). A stereotypy might not indicate that the animal is in poor wellbeing but can be a remnant from past experiences in different environments. However, a study conducted by Mason and Latham's (2004) showed that 68% environments causing stereotypies were connected to poor welfare (Mason and Latham, 2004).

2.3 Species of interest

2.3.1 Plains zebra (*Equus quagga*)

The plains (Burchell's) zebras (*Equus quagga*) are black and white striped, each with their unique pattern (Klingel, 2013). They have a brush-like mane like the Norwegian fjord horse (Estes, 1999). The stallions have an average weight of 250 kg and have a shoulder height between 127 – 140 cm. The mares have an average weight of 220 kg and are a bit shorter than the males (Estes, 1999).

The plains zebra are herd animals and live in small family groups consistent of one male and one or several females with their young (harem). These family groups can form bigger units, but each family group will continue to stay together. The stallion remains the dominant until his death or if he is unseated by another stallion. Should the stallion die, the remaining family group will stay together. The plains zebra is not territorial and tend to live in large areas together with other zebra families forming bigger units (Klingel, 2013). Stallions without harems usually live alone or in bachelor groups, and these groups roam widely while the family groups are more stationary and tend to occupy home ranges which has been observed to measure 9.4 km^2 (Penzhorn, 1982). However, the size and shape of a home range is not important if it contains all the necessities such as water – holes, sufficient grazing areas, shelter, and mineral licks (Penzhorn, 1982). Smuts (1975) found that the size of the home range was not based in the density of the herd, but rather a reaction to availability to resources in the habitat. In the wild, zebras have a regular grazing pattern, which starts by grazing close to their sleeping area and slowly progresses further away, interspersed with periods of rumination and resting, before they return to their sleeping spot in the late afternoon (Klingel, 1974; Penzhorn, 1982). The zebra mainly stands while resting, but resting while lying down does occur (Penzhorn, 1982).

An issue that has been seen in mixed–species enclosures is aggression from zebra stallions (*Equus quagga*, *Equus zebra*, *Equus grevyi*) towards other species' offspring (Pluháček and Bartoš, 2000). Pluháček and Bartoš suggested that among ungulates, captive plains zebras (*E. quagga*) were the most likely to engage in infanticide directed towards the offspring of other species. Walther (1965) noted that it is usually antelope's calves that fall victim to such attacks by zebra stallions. He believed that this behaviour arose from a defence instinct, and brown calves could resemble mid–sized predators which could trigger the behaviour. Klingel (1968) observed similar behaviour in wild zebra, where the zebra stallion chased hyenas away if they came too close to the family group. Zebra mares have also been observed doing the same behaviour, where a Thompson gazelle (*Eudorcas thomsonii*) calf was attacked and killed by the zebra mare.

In response to predator threats, the zebras change foraging area dependent on the predators hunting pattern. A study showed that a herd of zebras moved into woodlands during the night when lions were frequently observed hunting in the grasslands during the night (Funston et al., 2001). Comparing the night and day, lions shift towards a greater use of the grasslands during the night, whereas zebras increase their use of the woodland (Fischhoff et al., 2007). Zebras were less observed in patches where lions had been observed in the same patch on the same day. Fischhoff et al. (2007) observed that during a day and night, the zebras preferred the grassland, but the percentage of grassland use decreased from 83.8% in daytime, to 63.6% in the night. It was also evident that zebras changed their movement pattern depending on the time of day but kept to the same movement pattern in the woodlands (Fischhoff et al., 2007).

Different stereotypies have been observed in captive zebra. Coprophagy is a behaviour which is rarely seen in adult horses but seen in foals where it contributes to establishing the bacterial gut flora but can also be a sign of nutrient deficiency (Crowell-Davis et al., 1985). When seen in adults it is presumed to be motivated by nutrient deficiency. It is also presumed that coprophagy can occur if the animals are unable to feed continuously (Lowe, 2013). It can then be questioned whether this is considered a stereotypic behaviour or a dietary response. Head tossing has been observed in captive zebra. This is a behaviour often observed in horses which usually derives from lack in food and boredom (Thorne et al., 2005). It has been observed in horses that head tossing is not necessary an abnormal behaviour, but a way to keep away flies (Cook, 1992). Little research has been done on zebra in relation to oral stereotypies, but it has been observed in zoo conditions in the form of fence post licking (Lowe, 2013).

2.3.2 Blesbok (*Damaliscus pygargus phillipsi*)

The blesbok (*Damaliscus pygargus phillipsi*) is a small antelope with a size ranging from 85 – 100 cm and a weight up to 80 kg. Coat colour varies between a light brown to a darker brown with a distinct white bless on its forehead. Saddle and hindlegs are yellow – brown. There are other colour variations such as white and copper (Furstenburg, 2011). Both genders have horns with heavy grooves. The horns are thicker at the base with the rams, and slightly lighter in colour. The length is between 38 – 50 cm (Furstenburg, 2011).

The blesbok is a herd animal and forms groups up to 25 individuals. The herds have a loose structure, with an unstable membership. Adult males do defend females and young in harems year-round (Kingdon and Largen, 1997). Males are territorial and communicate dominance with a variety of postures and behaviours. Aggressive interaction can happen between males by clashing of horns which can be fatal. During the rut, most herds become smaller, with one mature ram. In lambing season, several ewes will band together in bigger nursery herds (Plessis, 1972). Single males tend to form bachelor herds. Similar to other animals present in the savannah, they are nomadic, migrating between pastures during different seasons. They tend to walk slower during winter season, when the food intake is low to conserve energy (Plessis, 1972). In captivity they still display a semi - nomadic behaviour if their enclosure is big enough (Kingdon and Largen, 1997).

During the mating season, adult rams establish small individual territories between 0.9 – 4.1 ha. (Furstenburg, 2011). The home ranges of territorial males have been shown to overlap with bachelor herds' home ranges, though the bachelor herds do not show territorial behaviour. Non territorial bachelor herds have been observed being chased out of an overlapping home range (Lynch, 1971). One territorial male and his herd was observed to have a home range area of 28 ha (Lynch, 1971). Several family groups of 20 – 120 animals have been recorded to roam over 150 – 400 ha of land but can sporadically migrate to other areas in search of alternative resources should the food source be depleted (Furstenburg, 2011). The herds tend to roam over the entire home range during the winter but stay in smaller areas during spring and early summer (Furstenburg, 2011).

No studies on abnormal behaviours in blesbok were found in the literature.

2.3.3 Common eland (*Taurotragus oryx*)

The Eland Antelope is the largest of all the African antelope species (Taylor, 1969). The common eland (*Taurotragus oryx)* has a mean shoulder height of 163 cm for males and 142 cm for females. Their body mass varies between 340 kg-445 kg for cows and 500-600kg for bulls (Estes et al., 1991). Their coat colour varies between a reddish brown to a darker grey-brown colour. As the bulls grow older, they tend to turn into a blue-grey colour (Hillman, 1974). Both genders have spiralled horns, but the females have longer thinner horns with an average of 60.5 cm, while the males have shorter thicker horns with an average length of 54 cm (Estes et al., 1991). The thicker shorter horns are more practical for the bulls during fights during the rut, when they butt heads and wrestle with their horns (Lundrigan, 1996).

The long slender horns found on the cows are mainly used for protection (Kiley-Worthington, 1978). The eland is calm and easily tamed and can be raised for dairy and meat production (Lightfoot and Posselt, 1977). Captive elands breed well, but there is a high mortality in calves due to lack of mothering skills (Hillman, 1979).

The common eland can be found in both small groups (Leuthold, 1977), but also in units with over 100 individuals (Shortridge, 1934) and they are rarely observed alone (Hillman, 1987). The size and composition of these groups tend to change regularly, and only females with nursing calves seemed to stick together permanently (Hillman, 1987). The males either stays alone or form smaller bachelor herds (Hillman, 1974). The males tend to move less that the nursing herds consistent of females and juveniles (Hillman, 1974).

Due to its large size, the eland requires a bigger area to fulfil its energy requirements compared to smaller species (Lewis, 1978). Their home range size between the sexes, and female – juvenile groups have been observed to have a year-round home range with a mean size of 222 km^2 while the males home ranges are measured to have a mean size between 41 km^2 and 63 km^2 (Hillman, 1974). There is no evidence that elands are territorial (Hillman, 1988). Parrini (2019) saw that the eland demonstrated clear shifts in foraging between the two seasons, moving from a diet high in grass during the wet season, to a diet almost exclusively consistent of browse (Parrini, 2019). The common eland is a mixed feeder, that shifts between grass – dominated diets and browse, but is considered to prefers browse (Hofmann, 1973). The selection of habitat and foraging opportunities is dependent on season whereby the eland tends to browse during the winter season, and graze during the rainy season when the grass is more abundant (Buys, 1990). The eland is not dependent on water and gets what it needs from its diet but will consume water if available (Skinner and Chimimba, 2005).

The eland is prone to heat stress throughout all the seasons compared to other smaller antelope species, that are sensitive to heat stress only during summer in an African semi-arid environment (Shrestha et al., 2014). Heat stress can limit the activity time budget due to hyperthermia in areas where the temperatures increase above 40 C° (Shrestha et al., 2014).

No studies on abnormal behaviours in Eland were found, but it could be presumed that oral stereotypies and pacing could occur. Eland is a browser such as the giraffe which is prone to oral stereotypies (Lowe, 2013).

2.3.4 Giraffe (*Cervus camelopardalis*)

The giraffe *Cervus camelopardalis* is the tallest living terrestrial animal, with a mean height of 3.9-5.5m for males and 3.5-4.7m for females. Their weight is estimated between 970-1950kg for males and 450-1200kg for females (Dagg, 2014; Estes et al., 1991).

The giraffe roams the open grasslands in small herds of half a dozen members. According to Foster (1966), giraffes show no signs of being territorial. Game species tend to herd together which is presumed to be due to advantages for protection against predators, there have been no observations of giraffes' association with other ungulates (Foster, 1966).

In South Africa, 8 giraffe cows were observed to have an average home range of 206 km^2. However, in the same study the results showed seasonal movement, and fluctuation in home range. A larger home range is required during the winter for the animals to meet their energy requirements (Deacon and Smit, 2017). Another factor influencing home range for giraffe is the proximity to towns. Home range sizes for giraffes was not significantly correlated with vegetation type or local giraffe population density (Kjellander et al., 2004), but rather the proximity to human towns (Knüsel et al., 2019). According to Knüsel (2019), the home range of the Tarangire – Manyara giraffes were generally smaller than the home ranges of other giraffes in other parts of Africa. Another potential factor that drives these variations in home range size is the variation in rainfall. Measurements done on adult giraffes in Africa has shown a significant decrease in home range size with an increase of annual rainfall (Deacon and Smit, 2017).

Giraffes are diel active which means that they are active during both the day and night, though they tend to be more active during early mornings and late evenings in warmer climates. Midday is spent on resting and rumination (Dagg, 2014). Their diet consists of leaves, twigs, and fruits (Dagg, 2014). Female giraffes have been observed to spend more time foraging and feeding as well as walking, compared to male giraffes (Leuthold and Leuthold, 1978). On rare occasions, male giraffes were observed to lie down. Rumination time varied with season, with a concentration in early mornings and late afternoons during wet-season, and mid-afternoon during dry season. There was no significant difference in rumination time between the sexes (Ginnett and Demment, 1997).

Several abnormal behaviours have been observed in captive giraffe. Pacing in giraffes has been observed, but it was uncertain if it was an anticipatory behaviour before food or an abnormal behaviour (Bashaw et al., 2001; Lowe, 2013; Tarou et al., 2003). Oral stereotypies, such as licking inanimate objects like fence posts, bars and gates are a common stereotypy found in captive giraffe (Bashaw et al., 2001; Lowe, 2013; Tarou et al., 2003).

2.3.5 Ostrich (*Struthio camelus*)

Ostrich (*Struthio camelus*) is the largest living bird. Males can reach up to 2,8 meters and weigh 150 kg, while females are a bit smaller (Britannica, 2023). Due to its weight, the ostrich cannot fly. The female birds are brown – grey and have white – grey tail feathers and wing primaries. The males are mainly black with white tail feathers and wing primaries. The chicks resemble the female birds (Deeming, 1999).

In natural environments, ostriches are gregarious (Sauer, 1969) and lives in large groups of birds with a mixed age and gender. Ostriches are nomadic and can form groups from 5 up to 50 birds, and can travel over large areas, often in company with other grazing animals such as antelopes and zebras (Donegan, 2002). Even though they live in proximity to other species, ostriches tend to avoid contact with other animals (Sauer, 1969). In such cases, the encounters are usually neutral, whereby the ostrich ignored or tolerated the other animal species (Sauer, 1969). During the breeding season, the ostriches are observed alone or in pairs. The herds tend to be larger outside of the breeding season (Bertram, 2014). Single cocks might form bachelor herds (Sauer, 1969). The large herds do not seem to have any structural unit, but a hierarchy has been observed with a leading cock or a major hen (Sauer, 1966b).

Adult ostriches spent most of their day walking (60%) (Williams et al., 1993) and foraging (33%) (Bertram 2014) but tend to lie down and remain inactive during the night unless disturbed (Degen et al., 1989; Williams et al., 1993). A study revealed that ostriches show more feeding behaviour during the mornings, and more foraging behaviour during the afternoon (Cooper, 2009). Walking and pacing has been considered as a territorial indicator, which has also been observed in captivity (Cooper, 2009). In the wild, the ostrich tends to be a selective feeder, but can adapt its diets to the food available. The diets consist mostly of annual green grasses, forbs, leaves, and fruits, but also woody plants and succulents (Milton et al., 1994). Ostriches are considered omnivore, and has been observed to digested fragments of teeth, bone, and shells in addition to plant material. The reason behind this is thought to be a source for calcium (Milton, 1994). Ostriches cannot chew their food, but grinds their forage in the gizzard, where it is ground by several small pebbles, which requires them to consume stones (Milton and Dean, 1995).

In a report by Burger and Gochfeld (1998) from Kenya, male ostriches showed a shorter feeding period compared to females. There was also a correlation between time spent feeding vs group size. Solitary birds spent less time feeding than birds in groups. Vigilance and feeding were mutually exclusive. When the ostriches kept their head down, the ability to look around was lost. With increased group size, the rate of raised heads went down (Bertram, 1980). Males showed more vigilance than the females, presumed to be related to the possibility to find a mate or scout for predators or rivals (Betram 1980). Other observed behaviours in ostriches are maintenance activities such as dustbathing, stretching, and yawning (Sauer and Sauer, 1966).

In captive environments the ostrich spends 43% of the day walking, running, and fighting (Milton and Dean, 1995). Another time budget study showed that during summer, there was a significant difference in behaviours between genders (McKeegan and Deeming, 1997, Ross and Deeming, 1998). The males walked and paced more than the females, while feeding and foraging was more common in the females (McKeegan and Deeming, 1997). Time of day had little effect on the behaviours, apart from the feeding behaviour increasing right after food was presented (McKeegan and Deeming, 1997). Night behaviours seems to be similar to the ones in nature, even though some courtship behaviour was observed (Lambrechts et al., 1998). Not much is known about agnostic behaviour in captive conditions, though aggression has been observed from adolescent males towards females (Stewart, 1994), and from adults towards younger chicks (Bolwig, 1973).

The ostrich is tolerant when it comes to high temperatures, and they regulate this by increasing evaporation by increasing the rate and amplitude of respirating, referred to as panting. This means that ostriches exposed to higher temperatures release less water from respiration and are better adapted to dry areas than if they controlled their temperatures by sweating (Schmidt-Nielsen et al., 1969).

A behaviour disorder in ostriches is feather pecking. This behaviour can be observed, especially in chicks if there is restriction on feed availability (Deeming et al. 1996). Feather pecking is considered to be a compensation for nutritional deficiencies (Sambraus 1995). In a study done on adult birds, females where more prone to pecking and being pecked than males (Sambraus 1995). Once feather pecking and cannibalism have occurred, it is not easy to stop them, even though the conditions are improved (Deeming, 1999).

3 Goals, hypothesis, and predictions

The observations were conducted at the savannah enclosure in Kristiansand Zoological Garden, the species being zebra, blesbok, eland, giraffe, and ostrich. The aim of this study was to find out how the animals used their new space when they were given access to a larger area after expansion of the exhibit, as well as being exposed to more visitors. I also made observations on weather conditions to see if they affected behaviour.

I had three hypotheses. My first hypothesis regarded space use. The prediction was that there would be an increased use of the new area as time went by since the opening of the new area. The second hypothesis was about visitor numbers. It was predicted that there would be an increase in walking as well as head up and standing behaviour with increased visitor numbers, along with less foraging and lying behaviour with increased visitor number. The third hypothesis regarded weather effects. It was predicted that there would be an increase in lying behaviour with increased temperatures and more standing behaviour with a decrease in temperatures and increased wind speed (Table 1).

Table. 1 The hypotheses and predictions.

Element	**H1**	**H0**	**Prediction**
Hypothesis 1: Enclosure expansion	The animals will use their new enclosure area	The animals will not use their new enclosure area	The animals will be observed to spend more time in the new area as time goes by.
Hypothesis 2: Visitor number	The animals will be more alert and vigilant with more visitors	The animals will not be more vigilant with more visitors	The animals will walk and stand more with their heads up. There will be less lying and show less foraging behaviour when more visitors are present.
Hypothesis 3: Weather effects	The animals will change their behaviour in relation to the weather.	The animals will not alter their behaviour with changes in weather.	More lying behaviour will be observed during midday with higher temperatures. More standing during lower temperatures and bad weather.

4 Method

4.1 The enclosure

The first exhibition the visitors meet when visiting Kristiansand Zoological Garden is the savannah (Fig 1). The enclosure can be seen from the parking lot upon entering the zoo, and can be viewed from three directions, north, west, and south. During winter 2021, the savannah enclosure was closed off for renovation and expansion. It was later reopened in late June. The previous size of the enclosure was about 12 000 m^2 (Fig 1a), including both a smaller area behind the stables, and a smaller paddock in front of the stable. The stable is located in the southeast end of the enclosure. The new area is roughly 9 000m^2. The current size of the entire exhibit is approximately 21 000 m^2 including the island, and a fenced forest area. Before the expansion, the old enclosure consisted of two sand pits, a big fake tree, and a lagoon as well as a smaller area next to the stables with small bushes, not accessible to the giraffes. With the enlargement, an island and a fenced forested area was added, dividing the old part and the new. The island is inaccessible to the animals, and the forest is not available to the giraffes to prevent them eating the trees. Two enrichment stations where food was presented, one for browse and one for hay was located in the new area facing the parking lot together with a new sand pit. Along the fence between the new and the old area, there is a viewing platform used for presentations about the savannah animals, where a third enrichment station is located.

(a) (b)

Fig 1. Arial view of the African savannah exhibit. (a) Old area, which was bounded by fencing along the top and right side to prevent access to the treed area. The stable is visible in the lower right corner. The small area with pasture and trees in the bottom left was accessible to all animals except the giraffes. Viewing by visitors was from the left and along the path to the stables were there was a round sheltered observation pavilion. A lagoon flowed under that path. (b) The enlarged enclosure during the time when the new area at the top was under construction. It comprised the formerly treed area to the top and right of (a) and part of an adjacent parking lot. Some trees were left in the new area, which were shielded from the giraffes by fences that allowed other animals to pass through. Pictures taken from NIBIO gardskart.

4.2 Study subjects

The study subjects were a mixed group of African savannah animals. All the older animals were born and raised in other zoos while all the younger ones were born in Kristiansand Zoo. The adults came from several generations in captivity. There were four zebra mares, where the two oldest were 12 years old and the other two were 2 and 3 years old. The youngest was the daughter of one of the older mares. There were two blesbok, one 9-year-old bull and his daughter of one year old. There were four grown eland cows and six calves in the enclosure. The cows were 15 years of age while their calves were between 6 months old to little over a year. The youngest calf was still suckling during the observation period. There was a family group of giraffes, with a castrated bull of 18 years, and two cows of 15 and 10 years old. The youngest cow was the daughter of the oldest cow. Finally, there are eight ostriches in the enclosure. They comprised one breeding pair where the male was 9 years old, and the female was 4, and six yearling chicks which were hatched in 2021.

In general, all the species tolerate each other. However, the zebras could be aggressive, especially if there was a new-born even if it was of a different species.

4.3 Data collection

4.3.1 Sampling Technique

The observations were carried out during late June, throughout July until the beginning of August 2022. The observation times were random, ranging from 7 in the morning until 22 in the evening. The scans were conducted from 4 – 5 different observation points around the enclosure, depending on where in the exhibit the animals were located (Fig 2.).

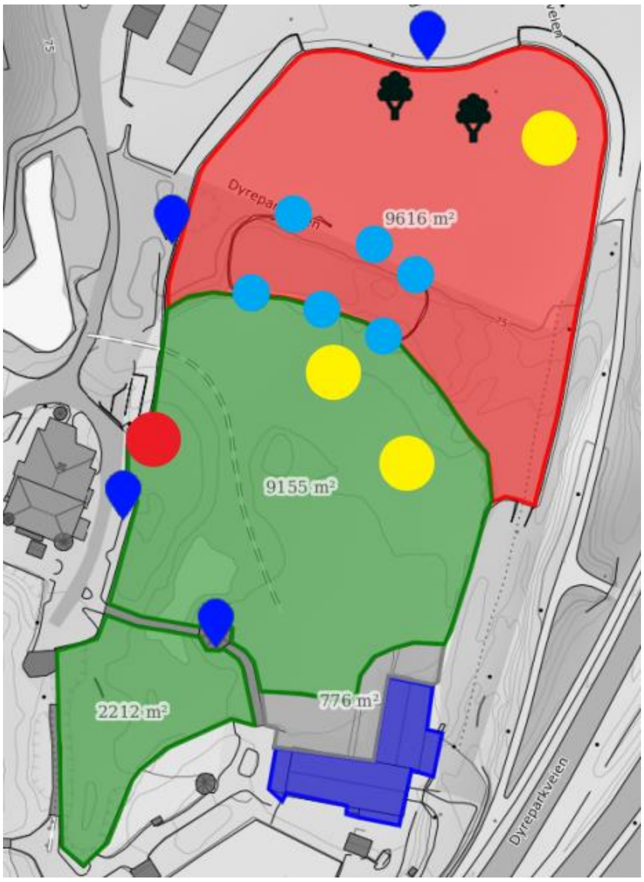


Fig 2. A schematic overview of the African savannah exhibit. Red area marks the new addition to the enclosure with three drinking stations (marked with blue dots), two enrichment stations (marked as black trees) and a sand pit (marked in yellow). The old area is marked in green with two sand pits (marked in yellow), and the animal presentation point (red dot). The stable is marked in blue, with the paddock area in front marked in grey. The observation points are marked with blue pointer marks. Pictures taken from NIBIO gardskart.

During each sampling session, the animals' location and behaviour was recorded with 1-0 sampling. This was done for each scan sampling. The scanning was conducted from right to left. Two scan samples were taken each session with 15 min between. Some deviations occurred. For simplicity and the opportunity to look back at each observation, they were recorded with a Samsung s10 light mobile phone and later reviewed and observed data were added to the data sheet. The temperature, wind and weather were recorded by using yr.no each day. The total number of visitors for each day was provided by the zoo. The ethogram for the behaviours that were recorded as mutually exclusive is shown below (Table 2). The behaviour that each observed animal was performing in each scan was recorded with a 1. All other behaviours for the scan of that animal were recorded as 0. In addition, it was recorded whether the animal's head was up (1) or down (0) in each scan (*Head up*). The location of the animal was noted as either in the new area (1) or the old area (0) in each scan (*New*).

Table 2. Definitions of mutually exclusive behaviours in the mixed group of African savannah animals

Behaviour	Definition
Out of sight (OS)	Behaviour cannot be seen and/ or determined from data collectors' location
Standing (SH)	Standing, either inactive or resting
Lying (LD)	Lying down, either with its legs tucked underneath the body, pr lying on the side, legs stretched out
Walking (W)	Movement from one location to another, not involving searching for food.
Grazing (F)	Activity related to the searching for, manipulation or consumption of food from grazing. Also includes pecking.
Browsing (B)	Activity related to the searching for, manipulation or consumption of food from browse and hanging food enrichments.
Drinking (D)	Drinking either from the lagoon or drinking stations.
Nursing (N)	Cow feeding calf from udder.
Suckling (S)	Calf suckling milk from mother's udder.
Grooming (A)	Includes self-grooming, scratching with a foot, and rubbing body against objects, or grooming another animal (allogrooming).
Rolling/dust bathing (R)	Rolling or moving around in dust, dry earth, or sand, with the likely goal of scratching and removing parasites from fur, feathers, or skin. For ostriches, dust bathing is performed to clean and fluff up the feathers.
Rubbing face against object (RF)	Rubbing face against any object such as a rock or tree. It can be related to grooming or marking.
Pawing/ground scratching (P)	Scraping foot or hoof against the ground.
Defecating/Urinating (DF)	Discharge of faeces or urine.
Sniffing another animal (SA)	Stretching neck towards another animal, bringing nose close, within approximately 1 meter from the other animal. Can include flehmen.
Alarm/Fear response (AV)	Standing stiffly, head up, ears erected.
Running (RP)	Fast movement from one location to another. Includes all types of running.
Aggressive behaviour (AG)	Biting, kicking and/or chasing
Play fighting (PF)	Head butting, pushing, or harmless biting, pecking, or kicking
Adult courtship (AC)	Species specific behaviour that results in mating and eventual reproduction
Stereotypy (L)	Repeatedly licking or chewing inanimate objects, pacing, spot pecking, or other abnormal repetitive behaviours.

4.4 Statistical analysis

All analyses were conducted using Rstudio 2022.12.0. R 4.2.2. All data were written down in Excel and then read into Rstudio. The data file contained all species.

The collected explanatory variables are shown in Table 3. Due to a big variation in observation times, they were divided into four groups of time of day. 0 for observations conducted between 07:00 – 09:00 (morning) which was before opening hours. 1 for observations between 09:00 – 14:00 (midday), 2 for 14:00 – 19:00 (afternoon), and 3 for 19:00 – 22:00 (evening) which was after regular opening hours.

Table 3. Variables with description.

Explanatory Variable	**Description**	**Additional information**
Date	Date of observation	Start date: 22.06.22 End date: 11.08.22
Day	Days elapsing from the opening of the new area.	1 – 32 days
Scan	Scan number within each day.	1 - 6
Time (Tod)	Time of day. Divided into four whereas group 0 was before opening hours and 3 after opening hours.	0= 07:00 – 09:00 1= 09:00 – 14:00 2= 14:00 19:00 3= 19:00 – 22:00
Animal	Unique animal code for each individual. Z= Zebra, B=Blesbok, E=Eland, G=Giraffe O=Ostrich	Z1, Z2, Z3, Z4, BB, BC, E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11, GB, GC, GU, OC, OH, OU1, OU2, OU3, OU4, OU5, OU6
Sex	Male or Female	0=male 1=female 2=Unknown
Age	Old or young	0=Young 1=Adult
Species	Unique species code for each species.	Z= Zebra B= Blesbok G= Giraffe E= Eland O= Ostrich
Weather	Weather conditions for each scan.	0=Sunny, no clouds 1=Partly clouded, sky is visible 2=Cloudy, no visible sky
Precipitation	Rain or no rain	0=No 1=Yes
Temperature	Hourly temperature in °C	Ranging from to 12 – 29 °C
Wind	Wind speed measured in meters/s for each hour	Ranging from 1m/s to 5 m/s
Visitors	Total number of visitors for each day. When scans were conducted before or after opening hours, the total of visitors was set to 1 (the observer, i.e., me).	2553 – 13 264 during opening hours. 1 before and after opening hours (Observer, i.e., me).
New area	Whether the animals were in the new area or the old area.	0=Old 1=New

There were insufficient numbers of animals of each sex and age in each species to evaluate these factors statistically. Not all the above explanatory variables were used for the final models. There were enough data to analyse H (*head up*), LD (*lying down*), SH (*standing*) and W (*walking*). The variables *grazing* and *browsing* were combined into a binary variable referred to as *foraging* (F). The variables *weather* and *precipitation* were combined into one single *weather2* variable since there were few occasions with rain, ranging from 0 sunny through 1, partly cloudy, 2, very cloudy, 3 raining.

Due to large variations in numbers for variable *visitors* (1– 13 264), and since the other continuous explanatory variables were within 0- 10, the explanatory variables *day*, *visitors, temperature*, *wind* and *weather2* were rescaled using the R scaling function.

Model used was generalized linear mixed model;

$$ModelName \ <- glmer\ (ResponseVariable \sim ExplanatoryVariable1 \\ + \ ExplanatoryVariable2 \ + \ ExplanatoryVariable3 \\ + \ (1|\ RepeatedLevel\ ), family = binomial, data \ = \ DataSet)$$

The test significance was set to alpha 0.05. Glmer is used for mixed models which include a random factor. In the models used, the ID of the animal was the random factor, shown as (1|Animal). This was because repeated observations of the same animal were not independent. The response values were 0 or 1 so the model was run with family=binomial. There were not enough data for all combinations of the explanatory variables to include them all in the same model so separate glmer models were used. Because species had a large effect on behaviour, it was included in all models, with attention focused on interactions of species with the other explanatory variables. The variance inflation factor (VIF) was run to measure the amount of multicollinearity between explanatory variables in the models. It showed high multicollinearity between some weather variables, so only *temperature* and *wind speed* were included in the final weather model. Model diagnostics were checked using the Dharma package and none was significant, indicating good fit of the final models. The estimates were tested against standard normal distribution (z-test) which has df infinity. All models were run with an ANOVA test to look at significance of the explanatory variables. The emmeans package was used to perform pairwise comparisons. P values for pairwise comparisons were adjusted using the Tukey method by default.

Three glmer models (Table 4) were run for each behavioural response variable *head up*, *lying down, standing*, *walking*, and *foraging* to determine associations between the explanatory variables and each behaviour. Associations of the response variable *new* (use of the new area) was then evaluated in three new models with different explanatory variables (Table 4) in the same way as the previous models. A scatter plot or bar graph was created for each significant result.

Table 4. Models 1 – 3 show interactions and main effects run with occurrence of the behaviours Head up, Lying down, Standing, Walking, and Foraging as response variables. Models 4 – 6 show interactions and main effects with presence in the new area as the response variable.

Model 1: *Dataset <- glmer (Behaviour ~ Day*Species + (1|Animal), family=binomial, data=allspecies1Sel1nona.scale)*
Model 2: *Dataset <- glmer (Behaviour ~ Visitor*Species + (1|Animal), family=binomial, data=allspecies1Sel1nona.scale)*
Model 3: *Dataset <- glmer (Behaviour ~ Time*Species + Temp*Species + Wind*Species + (1|Animal), family=binomial, data=allspecies1Sel1nona.scale)*
Model 4: *Dataset <- glmer (New ~ Species*Day + Day*Time + (1|Animal), family=binomial, data=allspecies1Sel1nona.scale)*
Model 5: *Dataset <- glmer (New ~ Species*Temp + Species*Wind + (1|Animal), family=binomial, data=allspecies1Sel1nona.scale)*
Model 6: *Dataset <- glmer (New ~ Species*Visitor + (1|Animal), family=binomial, data=allspecies1Sel1nona.scale)*

5 Results

5.1 Frequency of each behaviour

Twenty behaviours were chosen from the beginning of the study for observations (Fig. 3). Some were never observed, while others were rarely seen. The most common behaviours were head up, lying down, foraging, standing, and walking. The fewer common behaviours were running, alarm/fear response and stereotypy (abnormal behaviour). Adult courtship was only seen in the ostriches, nursing, suckling and play fighting were only observed in eland, and stereotypy was only seen in giraffes, in the form of repetitive licking. Rubbing body against object and ground scratching were never observed in the scans. The remaining behaviours grooming, rubbing face against object, defecating/urinating, sniffing another animal and aggressive behaviour were observed less than 8 times throughout the study. Due to many observations, head up, lying down, foraging, standing, and walking were analysed statistically.

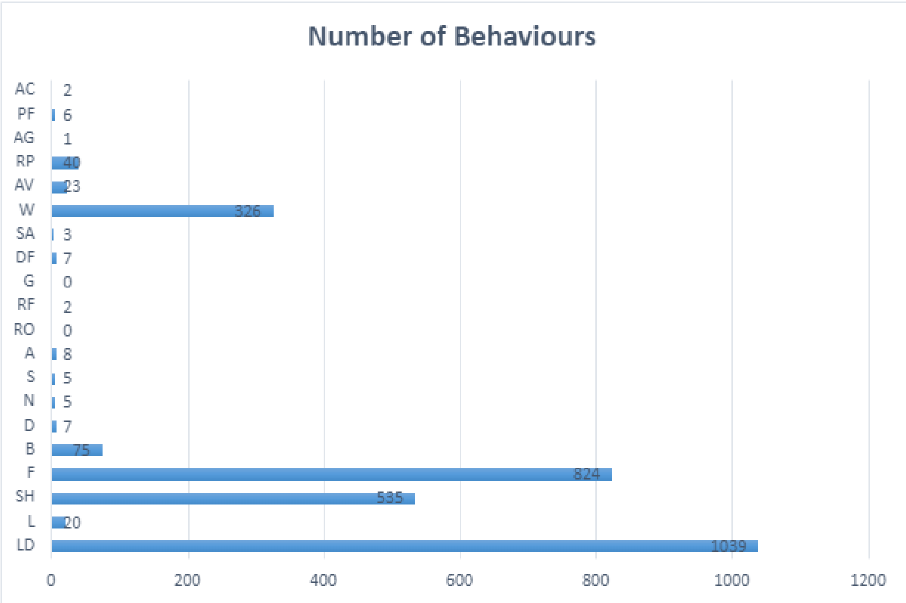


Fig. 3. The number of observations of each behaviour. For behaviour codes, see Table 2.

5.2 Factors affecting use of the new area

Days since opening of the new area was not significant for the use of the new area overall, but did vary between species (Fig. 4, Table 5). There was an increased use of the new area by all species except for the ostriches that were early to use the new area and used it less as days went by. There was also variation in use of the new area according to time of day, which varied across days since the animals had access to the new area (Fig. 4, Table 5).

(a) (b)

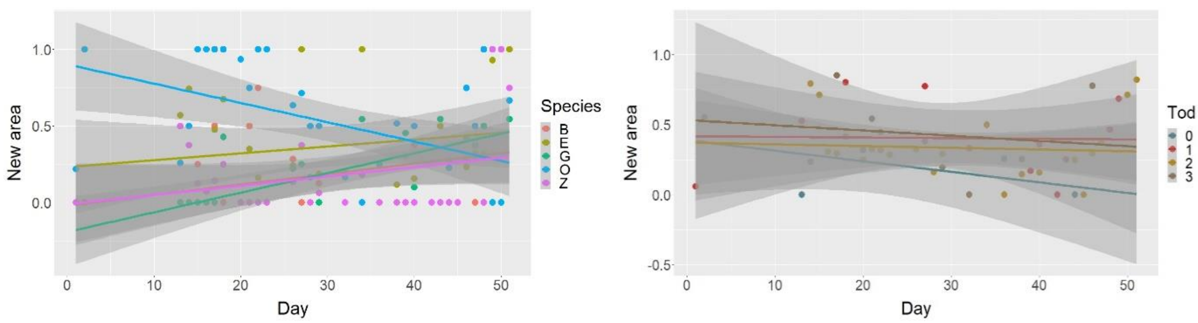


Fig. 4. Mean proportion of animals in the new savannah area according to days since opening of the new area according to (a) species (Z - zebra, B - blesbok, E - eland, G - giraffe, O - ostrich); (b) time of day (Tod: 0-morning, 1-midday, 2-afternoon, 3-evening), where each dot represents one scan of the savannah and grey shading shows the confidence interval by species (a) or time of day (b).

Table 5. Analysis of deviance showing how the explanatory variables in each statistical model affected use of the new area[1]

Statistical model	**Explanatory variable**	**Chi-squared statistic**	**Degrees of freedom**	**Probability**
1	Day	0.0	1	0.947
	Species	92.3	4	<0.001
	Time	36.0	3	<0.001
	Day*species	206.9	4	<0.001
	Day*time	13.8	3	0.003
2	Visitors	4.7	1	0.031
	Species	135.3	4	<0.001
	Visitors*species	58.0.	4	<0.001
3	Species	150.5	4	<0.001
	Temperature	1.2	1	0.279
	Wind	67.6	1	<0.001
	Temperature*species	15.5	4	0.004
	Wind*species	7.2	4	0.128

[1] Day - days since opening the new area; Species - zebra, blesbok, eland, giraffe, ostrich; Time - time of day (morning, midday, afternoon, evening); Visitors - total number of visitors on the day of observation; Temperature - C, Wind - m/s

Overall, there was lower use of the new area during mornings when the animals were fed breakfast before opening hours in the stable area, and most species were observed in the old area or were out of sight (in the stable area) during most mornings (Fig. 5). The blesboks were not observed in the new area during mornings but showed a steady increase with time of day. The elands used the new area most during midday and evening. The giraffes were not observed in the new area during morning or evening. Ostriches used the new area a lot throughout the day and was the species observed the most in the new area in the morning, afternoon, and evening. The zebras were not often observed in the new area in general.

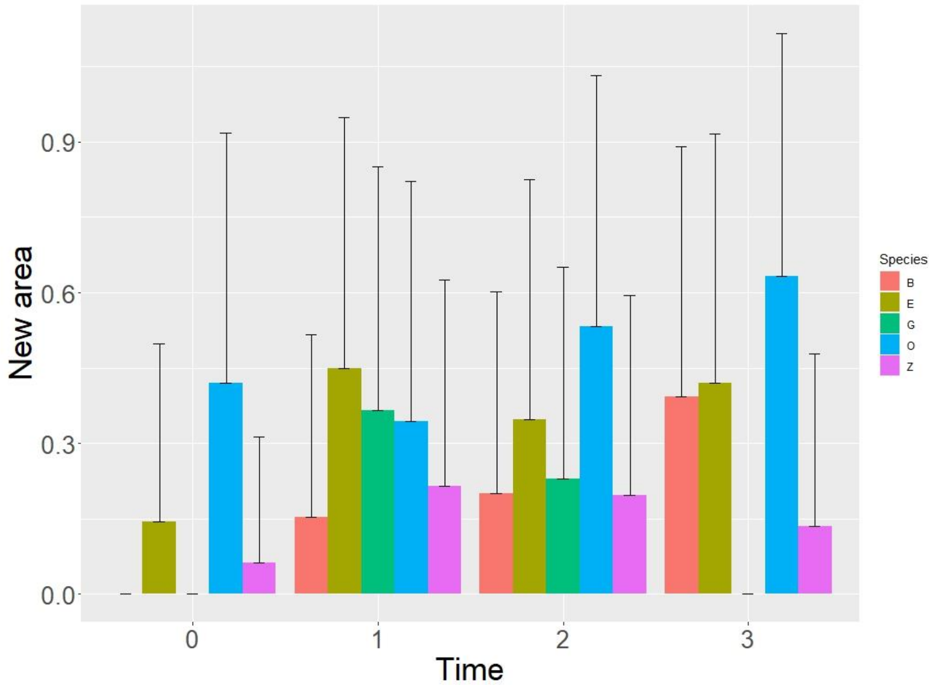


Fig. 5. Mean±SE proportion of animals in the new savannah area at different times of day (Tod: 0-morning, 1-midday, 2-afternoon, 3-evening) according to species (Z - zebra, B - blesbok, E - eland, G - giraffe, O - ostrich).

Use of the new area varied according to number of visitors overall, but this was influenced by the species (Fig. 6, Table 5). As the visitor numbers increased, the use of the new area decreased for all species except for the ostriches, that used the new area more in relation to higher visitor numbers. There is an interaction between species and temperature, and by looking at Fig. 5, it can be seen that most species spent less time in the new area with the increase of temperature, but ostriches used the new area more with increased temperature. Use of the new area was higher with increased wind speed, and this was similar for all species.

(a) (b)

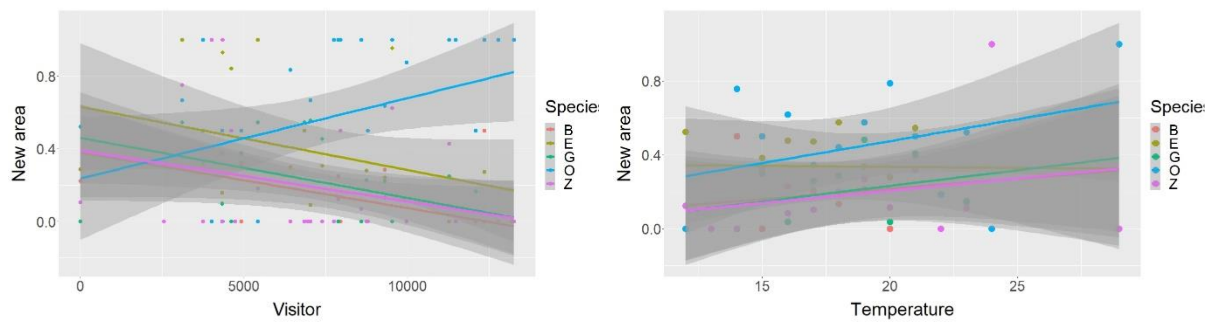


Fig. 6. Mean proportion of animals in the new savannah area according to (a) total daily number of visitors, and (b) increase in temperature (C), where colours show the different species (Z - zebra, B - blesbok, E - eland, G - giraffe, O - ostrich), each dot represents one scan of the savannah and grey shading shows the confidence interval by species.

5.2 Effects of days since opening the new area on behaviour

As days went by since opening of the new area, the animals were more likely to be observed with their heads up (Fig.7; Table 6). There were also differences between species in frequency of being observed with heads up. Giraffes were observed with their heads up the most often (90% of scans), followed by eland (69%) and ostrich (68%), then blesbok (55%) and zebra (37%). The interaction of day by species was not significant for head up.

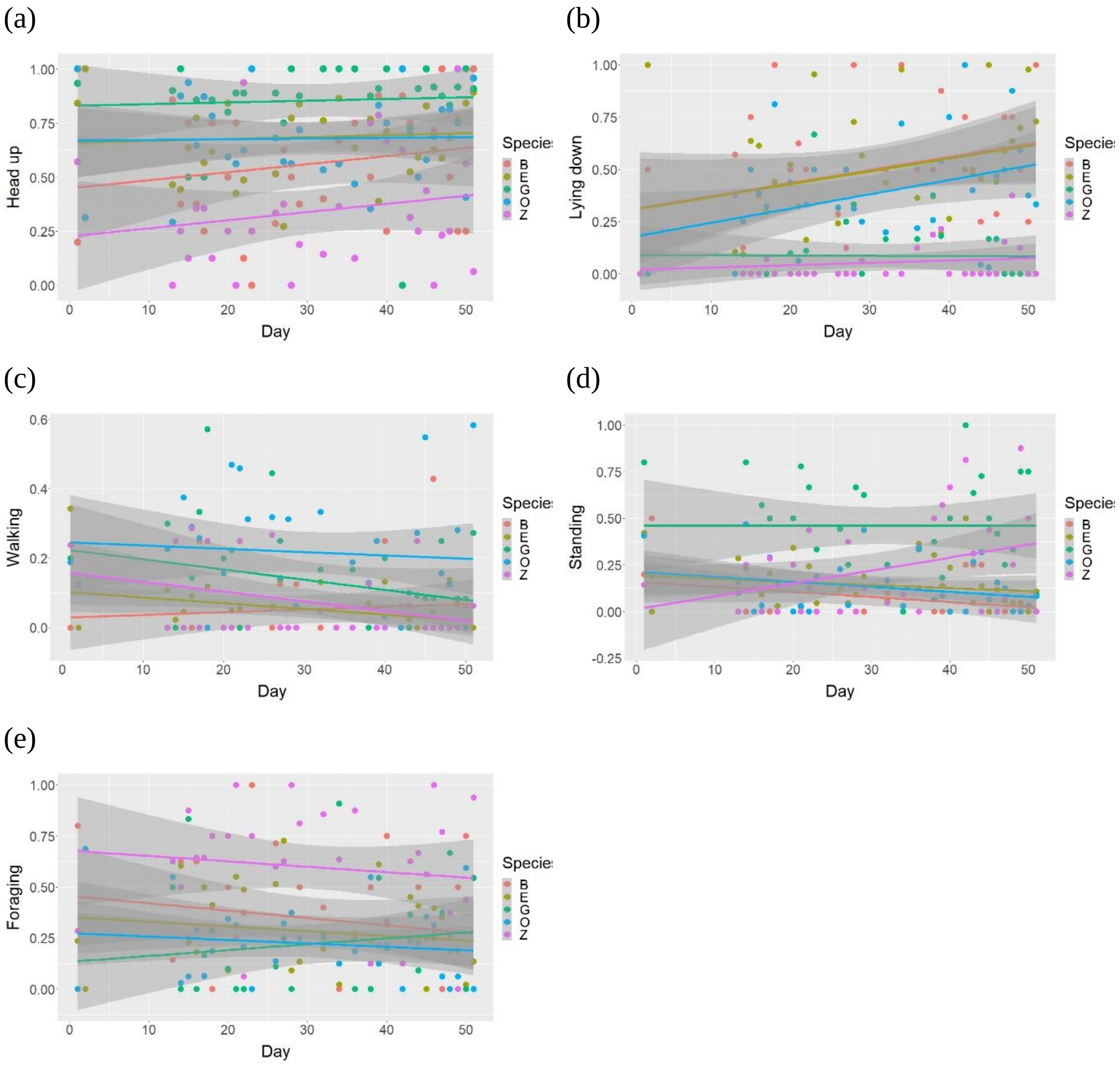


Fig. 7. Associations between mean proportion of animals performing different behaviours and days since opening of the new area of the African savannah exhibit. (a) head up, (b) lying down, (c) walking, (d) standing, (e) foraging. Each dot represents one scan of the savannah and grey shading shows the confidence interval by species (Z - zebra, B - blesbok, E - eland, G - giraffe, O - ostrich).

Table 6 Analysis of deviance showing how the performance of each behaviour differed across days since opening the new area, species (zebra, blesbok, eland, giraffe, ostrich) and their interaction.

Response variable	**Explanatory variable**	**Chi-squared statistic**	**Degrees of freedom**	**Probability**
Head up	Day	7.46	1	0.006
	Species	199.0	4	<0.001
	Day*species	6.8	4	0.146
Lying down	Day	106.1	1	<0.001
	Species	214.4	4	<0.001
	Day*species	5.9	4	0.205
Walk	Day	20.2	1	<0.001
	Species	109.1	4	<0.001
	Day*species	15.3	4	0.004
Stand	Day	7.7	1	0.006
	Species	166.1	4	<0.001
	Day*species	38.1	4	<0.001
Forage	Day	9.8	1	0.002
	Species	159.2	4	<0.001
	Day*species	15.0	4	0.005

As days went by, the animals were also more likely to be observed lying down (Fig. 7; Table 6). There was a species difference, with the blesbok (48.8%) and eland 48.1%) lying down in almost half of the observations, ostriches 38.3%, giraffes 7.6% and the zebras 4.3%. The interaction between day and species was not significant.

Walking declined as days went by (Fig. 7; Table 6), and the species difference was also significant. Ostriches were observed to walk the most often (20.5%), then giraffes 13.4%, followed by zebra 4.3%, blesbok 4.8% and eland with 4.6%. There were differences between species in how they responded to increased days. There was less walking in all species except for blesbok.

Overall, animals were observed standing more as days went by since opening the new area (Fig. 7; Table 6). There was a difference between species in frequency of being observed standing, and there was also an interaction between day and species. For most of the species, there was less standing as days went by except for the zebras which were observed to stand more, while the giraffes were standing equally as much as time went by.

Days, species, and their interaction were all significant for frequency of being observed foraging (Fig. 7; Table 6). The animals were observed to forage less as time went by since opening the new area except for the giraffe which showed an increase.

5.4 Effects of number of visitors on behaviour

When the number of visitors was higher, fewer animals were observed with their heads up (Fig. 8; Table 7). There was no interaction between visitors and species.

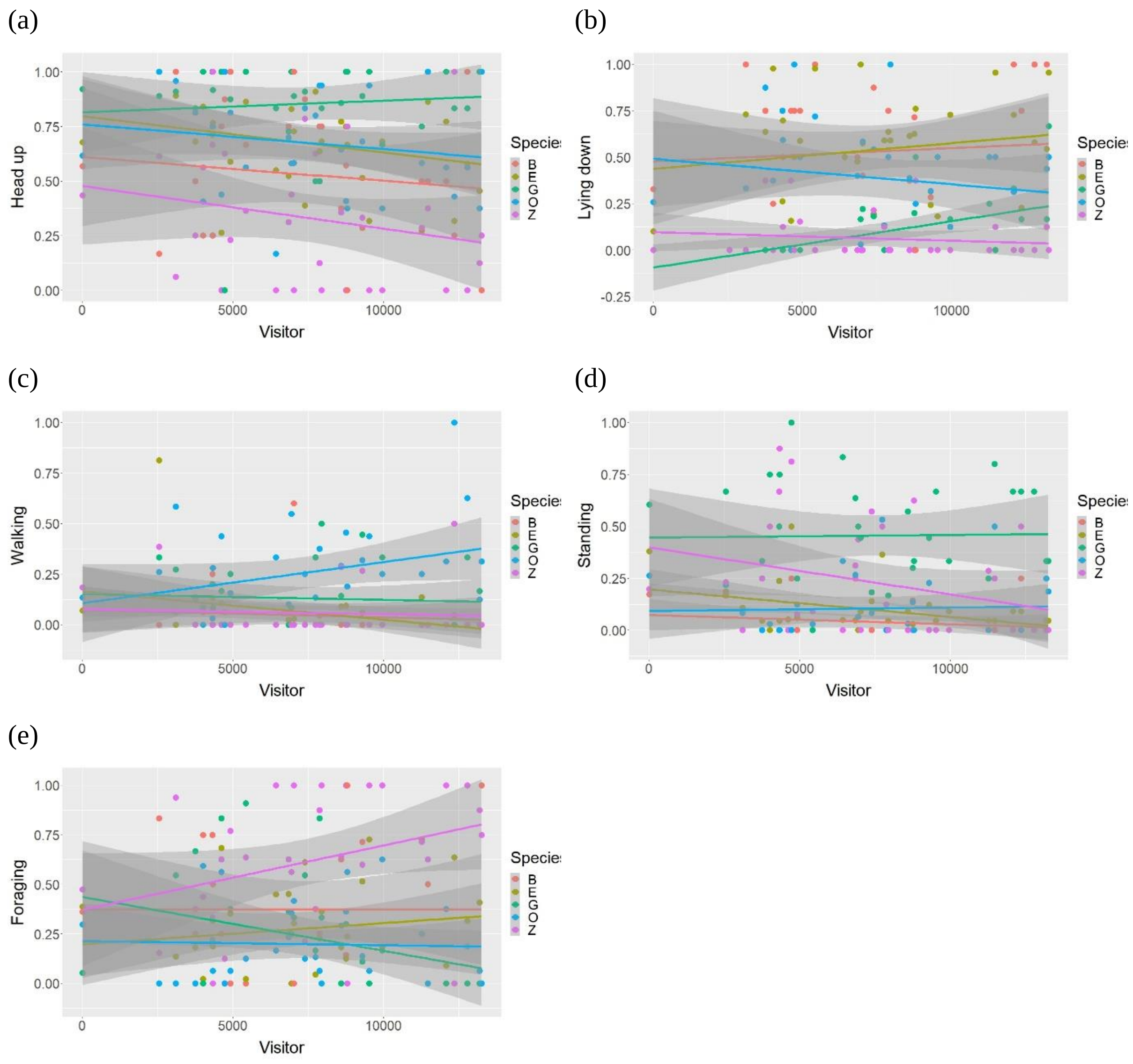


Fig. 8. Associations between mean proportion of animals performing different behaviours in the African savannah exhibit and number of zoo visitors. (a) head up, (b) lying down, (c) walking, (d) standing, (e) foraging. Each dot represents one scan of the savannah and grey shading shows the confidence interval by species (Z - zebra, B - blesbok, E - eland, G - giraffe, O - ostrich).

Table 7. Analysis of deviance showing how the performance of each behaviour was affected by the total number of visitors on the day of observation, species (zebra, blesbok, eland, giraffe, ostrich), and their interaction.

Response variable	**Explanatory variable**	**Chi-squared statistic**	**Degrees of freedom**	**Probability**
Head up	Visitors	9.1	1	0.003
	Species	198.0	4	<0.001
	Visitors*species	6.6	4	0.157
Lying down	Visitors	68.0	1	<0.001
	Species	191.1	4	<0.001
	Visitors*species	37.2	4	<0.001
Walk	Visitors	0.42	1	0.519
	Species	103.0	4	<0.001
	Visitors*species	39.3	4	<0.001
Stand	Visitors	78.0	1	<0.001
	Species	179.0	4	<0.001
	Visitors*species	31.2	4	<0.001
Forage	Visitors	0.02	1	0.9
	Species	151.0	4	<0.001
	Visitors*species	21.2	4	<0.001

Overall, there was more lying down when the number of visitors was higher (Fig. 8; Table 7). The blesboks, elands and ostriches lay the most with increasing numbers of visitors while the giraffes and zebras lying the least.

There is a difference in frequency of walking in association with increased visitor numbers, and an interaction between visitor number and species (Fig. 8; Table 7). Ostriches showed an increase in walking behaviour while the rest of the species showed a small decline.

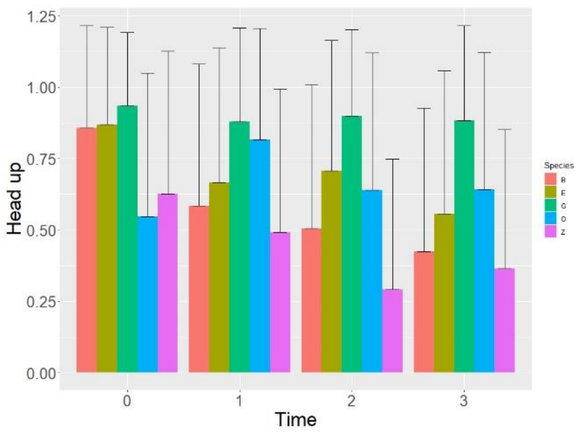
Standing was associated with the number of visitors, and specifically in interaction with species (Fig. 8, Table 7). For most species, visitor numbers did not seem to affect the amount of standing, but there was a decline in standing in the zebras.

Visitor number was not significant for foraging but there is an interaction between visitor number and species (Fig. 8, Table 7). With higher visitor numbers, giraffes foraged less. There was a slight increase in eland, and a steeper incline for zebras while the blesbok and ostriches did not change forage pattern in relation to visitor numbers.

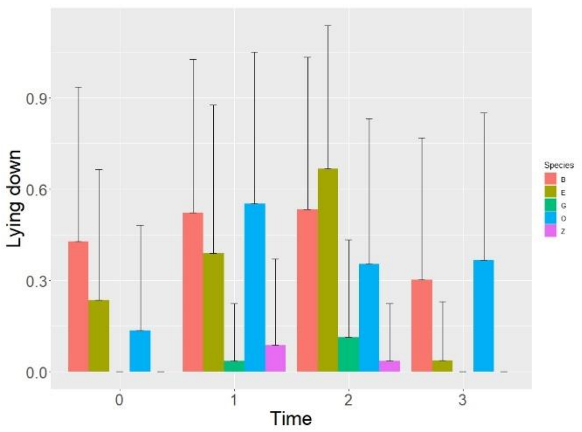
5.5 Effects of time of day and weather on behaviour

Fewer animals had their head up during the afternoon and evening than in the morning. The mean head up throughout the day varied with species (Fig. 9, Table 8). Blesboks were observed with their head up more during mornings and then head up decreases steadily to evening. The elands were observed with their head up the most during mornings but there is no big variation between midday and afternoon, and less observations for head up during evenings. The giraffes were generally holding their head up similarly for each time period with little variation. The ostriches were observed with their head up the most during midday, while morning, afternoon and evening were similar. Lastly, for the zebra, there was a decline of observations with head up, with the peak during mornings, down to afternoons, while during evenings they were observed with their head up more than during afternoons.

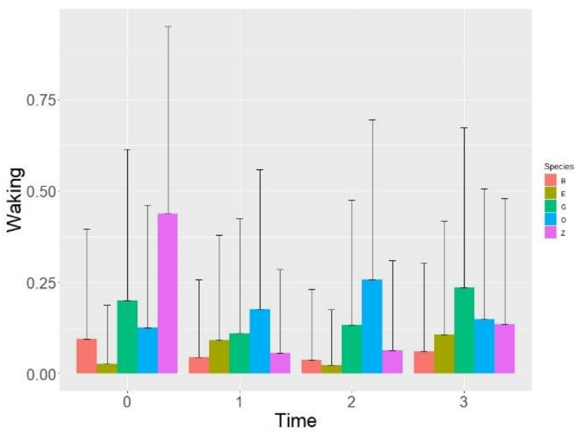
(a)



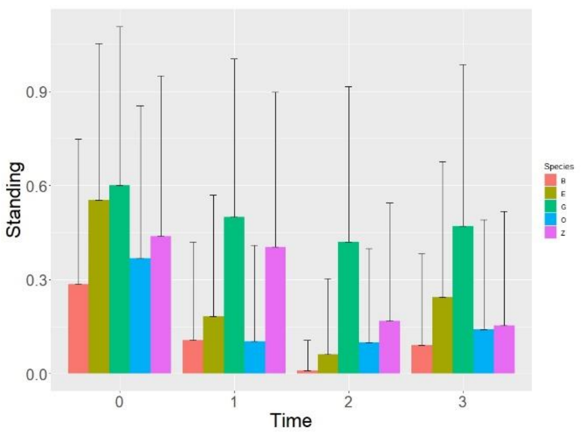
(b)



(c)



(d)



(e)

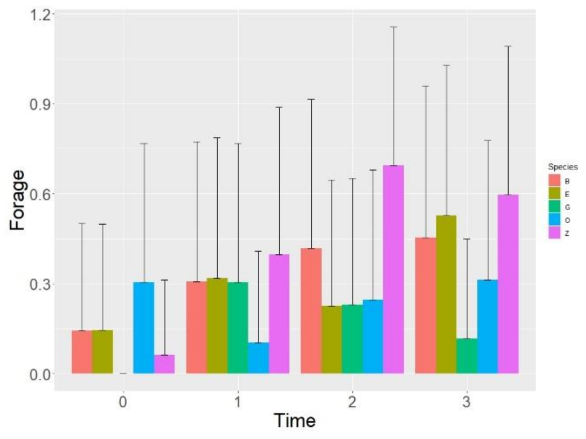


Fig. 9. Mean±SE proportion of scans of savannah animals performing different behaviours across time of day (0-morning, 1-midday, 2-afternoon, 3-evening). (a) head up, (b) lying down, (c) walking, (d) standing, (e) foraging.by species (Z – zebra, B – blesbok, E – eland, G – giraffe, O – ostrich).

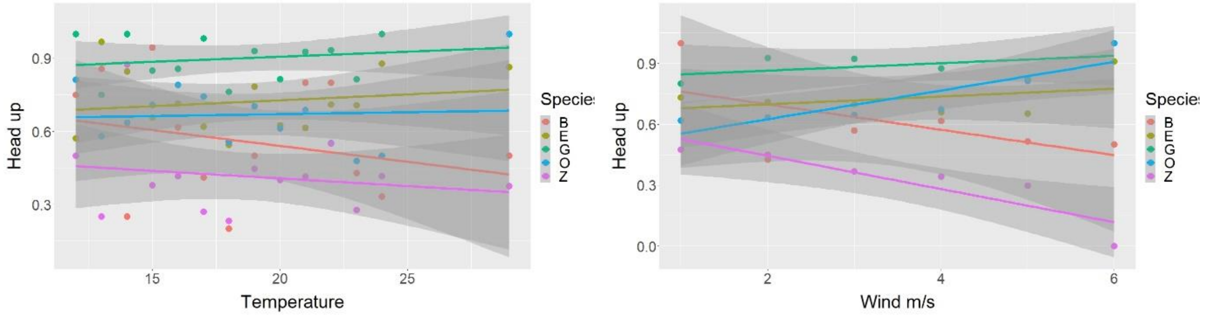
Table 8. Analysis of deviance showing how the performance of each behaviour was affected by the time of day (morning, midday, afternoon, evening), species (zebra, blesbok, eland, giraffe, ostrich), temperature (C), wind (m/s) and interactions with species

Response variable	**Explanatory variable**	**Chi-squared statistic**	**Degrees of freedom**	**Probability**
Head up	Time of day	18.9	3	<0.001
	Species	182.3	4	<0.001
	Temperature	0.4	1	0.510
	Wind	0.7	1	0.418
	Time*species	59.8	12	<0.001
	Temperature*species	11.1	4	0.025
	Wind*species	15.1	4	0.004
Lying down	Time of day	72.3	3	<0.001
	Species	185.4	4	<0.001
	Temperature	39.0	1	<0.001
	Wind	7.1	1	0.008
	Time*species	138.1	12	<0.001
	Temperature*species	76.1	4	<0.001
	Wind*species	12.0	4	0.02
Walk	Time of day	1.0	3	1.0
	Species	77.0	4	<0.001
	Temperature	0.1	1	0.8
	Wind	0.9	1	0.4

	Time*species	45.4	12	<0.001
	Temperature*species	8.0	4	0.1
	Wind*species	8.0	4	0.1
Stand	Time of day	92.3	3	<0.001
	Species	177.2	4	<0.001
	Temperature	4.0	1	0.1
	Wind	0.32	1	1.0
	Time*species	25.5	12	0.01
	Temperature*species	15.4	4	0.01
	Wind*species	1.7	4	0.8
Forage	Time of day	35.1	3	<0.001
	Species	127.0	4	<0.001
	Temperature	4.1	1	0.05
	Wind	0.05	1	1.0
	Time*species	82.4	12	<0.001
	Temperature*species	23.1	4	<0.001
	Wind*species	6.1	4	0.23

Temperature and wind speed did not affect heads up overall, but there were significant interactions with species. There was a slight increase in head up with increasing temperature for eland, giraffes and ostriches, and a decrease for blesbok and zebra (Fig. 10, Table 8). The results are similar for the wind speed, but there was a steeper incline or decline for the different species (Fig. 10, Table 8).

(a) (b)



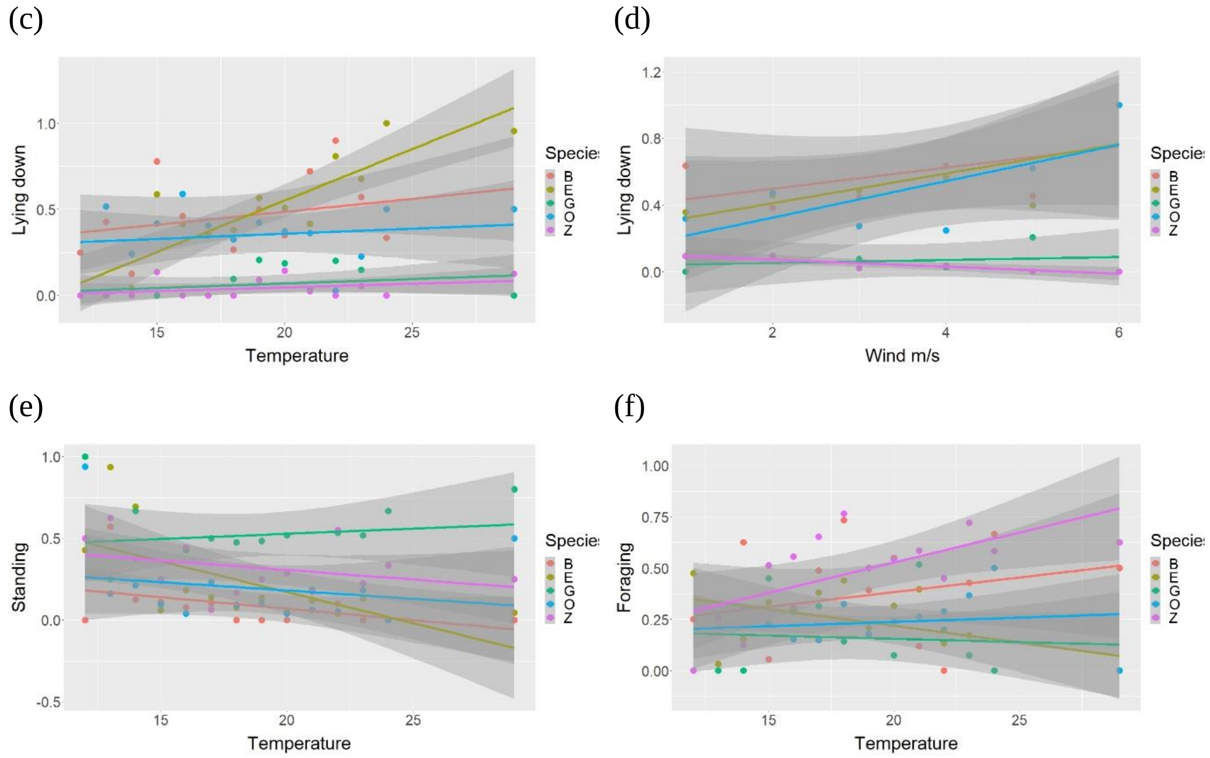


Fig. 10. Proportion of scans of savannah animals performing different behaviours according to temperature (C) and wind speed (m/s). (a) head up by temperature, (b) head up by wind speed, (c) lying down by temperature, (d) lying down by wind speed, (e) standing by temperature, (f) foraging by temperature, where colour denotes different species (Z - zebra, B - blesbok, E - eland, G - giraffe, O - ostrich), each dot represents one scan of the savannah per species, and grey shading shows the confidence interval by species.

There was a large variation in observations of lying down in each species for each time of day (Fig. 9, Table 8). The blesbok showed a slight increase in lying behaviour from mornings to afternoons, and a drop in observations during evenings. There is a similar trend in the eland with increased of lying from mornings to afternoons, and a big drop during evening. The giraffes are not observed lying at all for mornings and evenings but showed more lying behaviour during afternoons compared to middays. The ostriches had a varied pattern of lying. They were lying more during midday, followed by evening, afternoon, and morning. The zebra had a similar lying pattern to the giraffes. They were observed to lie mainly during midday and less during afternoons, but no observations of lying were seen during mornings and evenings. There was a correlation between high temperatures and time of day, with less lying down during evenings when the temperatures dropped.

Both temperature and wind speed were significant for lying down during the day but there was also an interaction between temperature and species, and between wind and species (Fig. 10, Table 8). In relation to temperature, all species had an increase in lying down with the increase of temperature. The giraffes and zebras did not have a big increase and were the species which were observed lying down the least. The eland had the steepest increase in lying down with the increase of temperatures. Blesbok, eland and ostrich showed an increase in lying down in relation to increased wind speed. The zebras had a slight decrease with increase in wind speed while the giraffes were almost the same. The giraffes were the species that was observed to be lying the least of all the species, surpassing the zebra, with only observations of the females lying down.

There was an interaction between time of day and species for walking (Fig. 9, Table 8). There was little variation in walking across time for each species apart from the zebras, that were observed to walk a lot during mornings, and very little during midday, afternoons, and evenings. Ostriches were also observed to walk more during afternoon than the rest of the day. Neither temperature nor wind speed affected the proportion of scans of walking in any species.

Time of day affected standing and there was an interaction between time of day and species (Fig. 9, Table 8). Most species were observed to stand more during mornings than the rest of the day except for giraffes, that showed a decrease in standing during afternoons, and zebras, that were observed standing mostly during mornings and midday but little during afternoons and evenings.

Temperature and wind did not influence standing overall, but there is an interaction between species and temperature (Fig. 10, Table 8). With increase in temperature, there was less standing by all species except for the giraffe, which had a slight incline.

There was an interaction between time of day and species for foraging (Fig. 9, Table 8). Observations of grazing and browsing (i.e., foraging) were low during mornings and non-existent for giraffes, but highest for ostriches. Foraging levels were similar for blesboks, elands and giraffes during midday and afternoons, but increased for both blesboks and elands during evenings and decreased for giraffes. The ostriches showed little foraging behaviour during midday but increases from afternoon to evening. The zebras had an increase from mornings to afternoons, with a slight decrease during evenings.

When foraging, the species varied in their response to increasing temperature (Fig. 10, Table 8) but not increasing wind speed (Table 8). Most of the species were observed to increase foraging with increased temperatures, except for giraffes and elands.

6 Discussion

The purpose of this thesis was to see if there was a change in use of the new area as days went by since the opening day, as well as behavioral changes in relation to visitor numbers and weather effects. It was predicted that there would be a steady increase in use of the new area, and a change in behavior for both visitor number and weather. It was expected that the animals would show more walking and standing behaviour with a higher visitor number.

6.1 Enclosure use

As predicted, the animals increased the use of the new area as the days went by (Fig. 4) except for the ostriches. They were quick to take the new area in use and were observed there on many occasions, especially during mornings. This could explain the decrease in use as time went by. The grass in the new area was not completely established when the new area was opened, which might explain why the grazing animals stayed more in the old area where the grass was more established. Perhaps the ostriches preferred the new area at that time because there were fewer other animals there.

There was a significant difference in the use of the new area in relation to time of day. Most of the animals did not use the new area in the mornings except for the ostrich. This is explained by that most of the animals except ostriches and the blesboks went inside for breakfast during early morning. However, as time progressed there was a slight increase in the use of the new area by the other species towards midday and then a decrease from afternoon to evening. According to Klingel (1974), the zebras tended to have a fixed resting place, and then graze their way around before grazing their way back to the sleeping spot (Klingel, 1974). This might explain why there is an increased use of the new area during midday and then less use as the day progresses. The stable was available to most species during the evening which can explain why elands, giraffes and zebras were not observed much in the new area in the evening. According to the zookeeper, the ostriches and blesboks preferred to forage outside, and the blesboks were never observed being inside during feeding in the mornings.

The blesboks and giraffes seemed to prefer the old area over the new. The lack of observations of the giraffe in the new area during mornings and evenings is probably due to the feeding stations inside. The giraffes were regularly out of sight which in general meant they were in the stables eating from food stations (Fig. 11). Animals tend to have small home ranges when resources are available close at hand (Harestad and Bunnel, 1979), which seems to be the case for the giraffes.

Fig 11. Feeding area in the giraffe stable, one for browse and one hay station. Photo by Ida Cecilie Ødegaard Jenssen.

Zebras walked the most during mornings and ostriches in the afternoon, while the rest of the species did not show any significant walking behaviour throughout the day. This might indicate that the animals in general were not bothered much by the public. According to observations done on ostriches, they spend most of the day walking and foraging, with preferable feeding during morning and afternoons (Bertram, 2014; Cooper, 2009) which fits with my observations (Fig 4).

The animals stood mostly during mornings and then almost equally for the rest of the day while giraffes stood a lot in general. Zebra stood mostly during morning and midday with a steady decrease as time went by. For the ruminants (blesboks, elands and giraffes), when they were observed standing, they were usually ruminating or had just finished grazing.

6.2 Visitor numbers

The eland and the giraffes were the only animals of the whole study group which came very close to the fence (if allowed, they could be petted) (Fig. 12). The reason behind this, on the giraffe’s behalf, is they got fed by hand by the zookeepers. The giraffes got fed by hand both behind the scenes in the stable and when learning tricks for treats. There is also reason to believe that some guests may have hand-fed them from the pavilion, which makes them associate humans with food. The older elands showed an interest in me when they were in their stable before they got released into the enclosure, which also may have been caused by being hand-fed by the zookeepers. I believed the eland group felt safer around people due to the relatively large number of individuals.

Fig 12. Picture showing the eland lying close to the pavilion sleeping or ruminating. Photo by Ida Cecilie Ødegaard Jenssen.

One thing that was noted, was that most days the animals paid no attention to the visitors, and it was on several occasions observed that the eland slept next to the pavilion, seeming unbothered with the guests leaning over to have a closer look (Fig. 11). However, during mornings with no visitors in the zoo, the animals seemed to notice the me, where the grownups showed a curious behaviour with ears pointed towards the observer, while the juveniles showed a more alert and avoiding behaviour, such as running away in the opposite direction. This can be seen with the explanatory variable *Visitor,* were the heads up decrease with the time of day, and number of visitors present, with the majority of heads-up during mornings (*Time of day*) when there is only one visitor present, me (Fig. 8). A similar result can be seen in (Fig. 4) where most heads were up during morning, than at midday and in the afternoon. However, the variables *forage,* and *head up* can be seen to be related to each other since most of the animals had their heads down while *foraging* (grazing). The majority of the study group were grazers, with the exception of the giraffes that are browsers and the occasional browsing by an eland. Therefore, the variable *head up* cannot be used as a certain indicator for alarm or fear response in this study. The head up observations have not been observed related to my observations of fear response and the ruminants (blesboks, elands and giraffes) were lying or standing with their heads up while ruminating, which in turn is a sign of relaxation rather than being stressed (Asres, 2014).

There was observed less foraging as time went by, but an increase in foraging was found in relation to more visitors with the exception for the giraffes, blesbok and ostriches. The increase of foraging when there are more visitors present is not what I predicted and could be an indicator that the animals are habituated to the visitors. The decline in foraging found in the giraffes and ostriches might be due to lack of food now that the other animals are grazers, and as time went by, the grass in the new area became more established.

As time went by, more lying down was observed. There was also an increase in lying down in relation to visitor numbers. Most of the study was conducted in July which is the major holiday month which shows that there was an increase in visitors throughout July, and an increase in lying down behaviour. This is not what I predicted and in relation to increased foraging indicate that the animals are habituated to the visitors. Neither the giraffes nor the zebra was observed to lie down a lot, and it was only the female giraffes, and usually the youngest zebra that showed this behaviour. Giraffes are observed to lie down on rare occasions (Ginnett and Demment, 1997), and this cannot be used as an indicator for disturbance from the public. The zebra was not observed to lie down a lot in general and tend to stand when they are resting (Penzhorn, 1982).

There was a decrease in walking, and nothing significant in relation to visitors whereas I predicted an increase in walking behaviour in relation to more visitors. Only the ostriches showed more walking behaviour, which is often seen in ostriches (Williams et al., 1993). The ostriches was not observed beeing alarmed, and the increased walking behaviour could be considered to be exploratory since they were the first of the species to make use of the new area.

The giraffes didn't change stand pattern for neither days gone by, nor visitors. Increase was found in standing for zebra for day but decreases with visitors. Decrease in standing was found for the rest of the animals for day, slight decrease in standing for eland and blesbok with visitors. No significant change in ostrich with visitor.

In relation to visitors, all animals except for ostrich used the new area less with more visitors. Ostriches can live in proximity to other species, but are observed to avoid contact, and this could be the reason why the ostriches chose to switch area when the other species moved (Sauer, 1969). Ostrich foraged the most in morning and evening while the rest preferred midday, afternoon, and evening.

6.3 Weather effects

With higher temperatures, more foraging was observed in most of the species. Only the eland foraged less with higher temperatures. Eland is prone to heat stress and might prefer to lie down during hight temperatures to avoid overheating (Shrestha et al., 2014). There was a decrease in foraging when windy for all the species except for giraffes. The increase in wind speed might be correlated with bad weather which could cause the animals to stand seeking shelter from the weather.

Lying down increased with temperature, especially in eland. With nicer weather comes warmer temperatures and more visitors. The increase in visitors did not seem to bother the animals significantly. Lying down increased also with wind except for zebra which did not lie down in general. Only female giraffes were observed to lie down. Most animals stood less with increased temperatures except for giraffes. This shows that during bad weather such as low temperatures and precipitation the animals preferred to stand still and were observed under trees to avoid the wet and chill. The days when there was high temperatures and rain (which is not divided in this thesis due to few days with proper rain), the animals seemed to prefer to lie outside in the rain as a mean to cool down. In relation to higher temperatures, all animals used the new area more except for eland which seemed to prefer to lie in the old area.

The weather effects were most significant for the eland which showed a visible change in behaviour in relation to increased temperatures. For all the species, there were an increase in foraging except for the eland, which also showed more lying down than the others with the increase in temperature. Elands are as mentioned earlier, prone to heat stress which these results underlines (Shrestha et al., 2014). For the rest of the species, lying down during midday and afternoons which tend to be the peak in temperatures.

For the weather effects, there is a reason to believe that these factors are interrelated with time of day and visitor effect. The afternoons tend to get warmer than the mornings, which also can have an impact on visitors. While the behavioural result from the cooler days might be caused due to raining which might have meant fewer visitors. However, from feedback form the zoo, most visitors arrived in the morning and stayed until closing time in the evening which might make time of day irrelevant. As mentioned in the introduction, the savannah enclosure is the first enclosure the visitors encounter when arriving which might give the impression that the peak in visitors surrounding the enclosure would be around opening time (Tod 1).

6.4 Limitations and future research

In this study, I used 1-0 scans, with video recordings to be able to rewatch the behaviours. To get more observations on behavioural events, it would be necessary to observe the animals longer per scan.

In future research where an exhibit expansion is planned, it would be best to collect data before the new area is opened for comparison with behaviour after the new area is opened. This was not possible in the current time-limited Master study because the animals were confined in a small area around the stables for several months while the exhibit was modified. The weather is also different in winter than summer, so a comparison before and after would be confounded by a difference in weather. Since there were no data on visitor effects or space use before the expansion of the savannah enclosure, there is no way to find out if there was a change in behaviour with the increase of the enclosure size and more exposure to the public compared to that in the old enclosure. In this study the total visitor number was used, and the model used for visitor numbers did not include time of day for lack of hourly visitor numbers. I did get hourly data for visitors for the month of July, but these data were strongly correlated with the total number of visitors, which suggests that visitors arrived and stayed for most of the day. Therefore, I used only the total number of visitors. For later studies, I would suggest counting visitors surrounding the enclosure to get more accurate visitors number to the enclosure. This could be done by making an approximate grouping with for example 0-10 people. 10 – 20 and so on.

Due to large distances and difficulties in distinguishing some individuals, especially from a distance, it was not possible to analyse difference in behaviour between individuals. Also, there were not enough animals of different ages and sexes within each species to investigate possible differences due to age and sex. For more accurate space use data, more thorough research would be needed where the study subjects wear GPS collars to obtain precise location data. Ruminating, which was not included in this study, could be a possible behaviour to study to be able to distinguish just standing and lying down and rumination. It was not possible at the time to observe rumination due to distance. This could be solved by either having the observer in the enclosure, by the use of binoculars or when the island opens for visitors, which would bring the observer closer to the animals.

There were some observations of out of sight behaviour especially during feeding time in the morning. This was not considered in this thesis, it could be argued that all the scan results should have been divided by the total number of scans present (i.e., not out of sight) before analysis. This would be done so to control the difference in number of sightings for each animal. However, in general most species stayed together as a group, and species was included in all the models to account for large differences between species.

The current results are exploratory and descriptive in the absence of replicated groups. Due to differences between studies at difference zoos (enclosure size, resource distribution, species, ages, sexes, weather conditions, background experience, etc.), it is difficult to compare the current results with those from other studies. Large data sets are needed from many zoos to find general trends, such as studies done on elephants (Greco et al., 2016) and carnivores (Clubb and Mason, 2007).

For further analysis, area (old vs new) *species could be added to the behaviour models used in this thesis. With this model (needing more data) it could be possible to evaluate three-way interactions of species x area x day. Other interesting variables to do a three-way interaction model on could be time of day, visitor effect, temperature, and wind.

7 Conclusions

Overall, there was a significant variation between the species and behaviors. As I predicted, there was an increase in use of the new area by most of the species as time went by since opening except for the ostriches. For the visitor number I predicted that the animals would show more walking and standing behaviour and less foraging and lying behaviour with increased visitor numbers. The result showed the opposite, with an increase in both lying and foraging behaviour in relation to visitor number. For the weather, the results were consistent with my predictions and there was a weather effect on the animal’s behaviour with an increase in lying behaviour with increased temperature and more standing with lower temperatures. For later studies, these results can be used as a background for more in-depth analysis of behaviour in relation to area use, visitor numbers and weather effects.

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