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Effect of weather condition on the activity of captive eland in outdoor enclosures

MASTER'S THESIS

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Declaration

I hereby declare that I have done this thesis entitled ‘’Effect of weather condition on the activity of captive eland in outdoor enclosures.” 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, 26.8. 2018

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MUHAMMAD SAID

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Abstract

Animals are often dependent upon weather condition for their well-being and nutrient requirement. Eland is significantly well adapted to harsh environment with much potentials economic value as domesticated livestock. However, there is a very limited information about the husbandry aspect of eland. The aim of this study was to determine the preferred weather condition for daily budget of this species to help the farmers to increase their production by optimizing the feeding and husbandry schedule. Fifty-two (52) animals were used which involve adult males and females, juveniles and calves. Animals were observed through a defined sampling technique (scan sampling technique) and identified by natural (horns, size) and artificial (coloured numbered ear tags) markings. Canon 10X30 IS Binoculars was used to identified distance animals. The weather condition was recorded by Kestrel 4500 device. The stored data was also uploaded to the PC, for analysis/storage with the optional Kestrel Interface and Communicator software. The behaviours of the studied animals which were recorded include: resting (RS), rumination(RM), eating outside the ban (EOB), eating inside the ban (EIB), nursing (NS), suckling (SK), mating (MT), fighting (FT), playing-fight(PFT), urination(UR), defecation (DF), and drinking water (DW). At beginning we waited for at least 15mins for habituation and then the animals were observed for 20mins and the activities observed were also recorded in the record sheet. Hence, in every hour, there was 20mins for the scanned of whole group of species which make a total of 40 mins for the observation and 20mins for resting before the subsequent circle of scan. A total of 204 observation session were recorded. The result shows that weather elements had positive effect on eating outside barn (EOB) and resting (RT), and negative effect on eating inside barn (EIB). In most cases, the effects were highly significant. In conclusion, relative humidity, temperature, wind chill and wind speed have been showed to pose adverse effects on captive Eland welfare, affecting the feeding activities which can result to poor growth and development.

Key words: weather elements, eland, observed behaviours.

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List of Abbreviations used in the thesis

BP	Barometric pressure
BR	Browsers
CS	Concentrate selectors
DF	Defecation
DW	Drinking water
DP	Dew point
EIB	Eating inside barn
EOB	Eating outside barn
FAC	Factor
FT	Fighting
GLMs	Generalized linear models
GR	Grass eaters
HI	Heat index
h	Hour
IM	Intermediate feeders
IUCN	International Union for Conservation of Nature
IPCC	International panel on Climate Change
MT	Mating
NRC	National Research Council
NS+SK	Combination of nursing suckling
NS	Nursing
PFT	Playing fight
RH	Relative humidity
RM	Rumination

RT	Resting
SK	Suckling
TP	Temperature
THI	Temperature-humidity index
UR	Urination
WB	Wet bulb temperature
WC	Wind chill
WS	Wind speed

1. Introduction and Literature Review

1.1. Introduction

Weather condition is one of the main factor that plays a very vital role in determining the success of agricultural production in the world. Animals are often dependent upon weather condition for their well-being and nutrient requirement. And of course, adverse effect of weather conditions can affect the performance or social well-being of the animals and can also cause production losses in general, particularly if experienced during critical stages of growth. Individual elements of weather can influence animals in certain ways.

Nevertheless, the combination of all-weather elements occurring instantaneously can have additive effects (Huey 1991; Fuller et al. 1999; Hetem et al. 2007). According to the study of Joshua et al. (2017), described that Arabian Oryx can change their daily activity pattern due to high ambient temperature.

Common eland has strong response to thermoregulation as cattle (Taylor 1970; Zahner et al. 2004; Kotrba et al. 2007). The study of Taylor (1969), shows that eland can live for a very long period without drinking water. Eland mostly often feed in the early morning and late evening, mostly when temperature is cool to avoid heat stress (Lewis 1978; Pappas 2002; Bothma et al. 2002; Thouless 2013). There are many studies on behavioural aspect of this species especially heat stress and thermoregulation (Owen-Smith 1998; Maloney et al. 2005). Therefore, the knowledge of animal behaviour with regards to response on climate change is extremely important as it is affected by evolution, physiology and development (Sih et al. 2010).

Several studies have described the possibilities for domesticating eland as livestock with high reproductive rate, apparently independent of drinking water and can be tamed easily. However, under natural farming conditions eland have proved inferior to cattle due to their spatial requirements and their social hierarchy. The common eland has been successfully, widely domesticated and bred easily (Posselt 1963; Thouless 2013). Recently, there is a very limited information about the husbandry aspect of eland, however, there is need to understand the preferred weather condition for daily budget of this species to help the farmers to increase their production by optimizing the feeding and husbandry schedule.

1.2. Literature review

1.2.1. Eland domestication

Common eland (*Taurotragus oryx*), is mostly found in protected areas and private reserves (East 1999) and has good temperament for being farmed because they are easily tamed and bred (Duncan & Monks 1992; Pappas 2002; Hoffman & Wiklund 2006; Hansen et al. 1985). Carruthers (2008), reported that eland are species with great farming potential. Eland is significantly well adapted to harsh environment with high potential and much commercial value as domesticated livestock (Posselt 1963). Eland can be domesticated to produce good quality meat, hide in large amount and high quality as well as milk with high protein content and less milkfat (Fahey 1999). Recently, the demand for domestication is increasing all the time compared to cattle (Kotrba & Scevlikova 2002).

The report of IUCN (2002), classified common eland as low risk and has potentiality to undergo domestication (Wirtu et al. 2004). The study of Thouless (2013), shows that common eland is widely domesticated in South Africa, Kenya, Zimbabwe, Russia and Ukraine, and they were successfully bred in temperate climate (Kotrba & Scevlikova 2002). Common eland is a source of meat and high rich nutritious milk (Pappas 2002). They can be used as alternative source of high quantity and quality meat as well as dairy (Hall 1975; Lightfoot & Posselt 1977).

Eland meat has already been reported as the best game meat in South Africa due to its higher fat content (Stevenson-Hamilton 1947) and from the health perspective, game meat may also be considered as an alternative to other red meats (Cordain et al. 2002; Radder & Le Roux 2005; Barton et al. 2014). Moreover, game meat has low level of intramuscular fat compared to other domestic red meat (Hoffman & Wiklund 2006). Fatty acid composition is considered as a tool which determines the nutritional values of meat (Jiménez-Colmenero et al. 2001; Hoffman 2007; Hoffman et al. 2007a, 2007b) and defines meat quality such as flavour and texture (Wood & Enser 1997). The amount of polyunsaturated fatty acids in game meat is higher than in meat from domesticated animals

(Crawford et al. 1970; Miller et al. 1986; Mostert & Hoffman 2007; Barton et al. 2014; Bure et al. 2014).

Table 1. Physical characteristics and chemical composition in musculus longissimus harbour from eland and cattle. Values are least square mean (LSM) and standard error of the mean (SEM). Borton et al. 2014.

Item	Eland $(n = 6)$ LSM	Cattle $(n = 6)$ LSM	SEM	p-value
Physical characteristics				
PH_{24}	5.71	5.55	0.03	0.010
Colour				
Lightness, L^*	36.3	41.0	1.51	0.050
Redness, a^*	11.6	12.9	0.65	0.200
Yellow, b^*	10.2	12.6	0.69	0.039
Drip loss(g/kg)	12.4	12.0	1.57	0.884
Chemical characteristics				
Dry matter	243.7	248.6	217	0.137
Protein	218.5	214.8	3.23	0.439
Crude fat	2.00	14.1	1.777	<0.001
Cholesterol	0.53	0.62	0.046	0.114
Total Collagen	2.85	3.66	0.175	0.009

There is no great difference between the two species on their dry matter and protein content, but the amount of fat content was found higher in cattle (Table 1). As an essential constituent of animal cellular membrane, cholesterol content is also higher numerically in cattle than in eland. The component of connective tissue (collagen) which paly a very vital role in toughness, was found higher in cattle than eland. Meat from cattle was consistently scored higher for sensory texture characteristics, juiciness, flavour, and overall acceptance. However, bulls of eland provided low-fat meat with a beneficial fatty acid composition from the human nutritional point of view, but with lower sensory scores, compared to bull beef.

1.2.2. Brief description of the species

After Giant eland (*Taurotragus derbianus*), command eland (*Taurotragus oryx*) is the second largest African antelope (Figure 1). Both male and female possess spiral horns that rise with a slight twist and back from the head to sharp point (Skinner & Chimimba 2005). The horn of the male is stronger and more distinct ridge than that of the female. According to Fahey (1999) their coat is tan, light-grey-brown or light-brown with a white vertical stripe and turn to bluish-grey on the neck and the shoulder with age and a short dark mane runs down back of the neck. They posse dewlap which is an adaptation to heat dissipation (Fahey 1999). Common eland has equitably small and pointed mouth and muzzle, small and narrow ear and long tail with black hair at tip (Kingdon 1997; Stuart & Stuart 1997). The studies of (East 1999; Pappas 2002), revealed that the common eland is mostly settle in savannah woodland of both Southern and Eastern Africa which include countries like Botswana, Angola, Kenya, Namibia, Congo, Malawi, South Africa, Rwanda, Uganda and Zambia. Most of the populations in the Southern part of Africa are those that have been reintroduced to the area. (Pappas 2002; Skinner & Chimimba 2005; IUCN 2008a). The male weight about 900 kg to 1000 kg with withers up to 180 cm and female weight up to 400 kg to 600 kg with withers up to 165 cm ear (kingdon 1997).

Figure 1. Common eland (cow) a typical description. (www.africaimagelibrary.com).

Figure 2. Common eland in captivity in the experimental farm at Lány, Czech Republic.

Source: www.ftz.czu.cz

The experimental farm at Lány was established in 2006 with 20 individuals of common elands which were conveyed from other institution. Breeding programme was started with five founders (1:4) born in Zoo Dvůr Králové. The farm-like environment is quit the same with cattle farm. There is a provision of barns with 2 paddocks of 1 hectare for the animals and the herd is divided in two smaller groups (Figure 2), which they can still interact with each other through the fence. The animals are kept on deep bedding inside the barns from December to March, while for the remaining months of the year elands have permanently access to paddocks and sheds.

1.2.3. Feeding behaviour and natural habitat

Common eland is highly adaptable species that can survive in a wide range of habitats. The study of (Stuart & Stuart 1997), described that common eland are found in flat, low-lying land to alpine moorland and from semi-desert area to relatively high rainfall. Common eland mostly occurrs in savanna woodland and alpine moorland (Grimshaw et al. 1995; Thouless 2013). They avoid settling in dense forest, complete desert as well as open grassland, but they can settle in grassland cover with good herbs (Estes 1991; Pappas 2002;

Thouless 2013). Common eland is not territorial but solitary and maintain inter- individual distance (Skinner & Chimimba 2005; Pappas 2002). During the wet season they can converge to form large group especially when the food remains available (Pappas 2002).

According to (Skinner & Chimimba 2005; IUCN 2016), Common eland are browsers. Therefore, they can move for very long distance primarily for searching food seasonally. The study of (Taylor 1970; IUCN 2008b), indicated that common elands are independent of water because they can live without water routinely, but they meet their need from water contained in the plants they eat. The report of (Pappas 2002), shows that population of eland can be reduced after several seasons of draught. They exhibit feeding in the early morning and late evening (figure 6), when temperature is cold and avoid heat stress (Lewis 1978; Pappas 2002; Bothma et al. 2002; Thouse 2013). Common eland spends more time in the shade (figure 2) with a sufficient food material during hot days and more time in sunny areas during windy days. However, they can eat anything available during each season—graze in summer and browse in winter (Skinner & Chimimba 2005; Pappas 2002). The Common eland prefer to eat flowering plant with high protein content (Pappas 2002). The report of (Owen-Smith 2002), explained that common eland need a high protein diet that comprises succulent leaves from a variety of flowering plants according to the fibre content and avoid dense wood forest. With regards to their body size, Common eland occupy large area per animal to which is range from 174 km² to 422 km² (Pappas 2002). Common eland requires a good quality of expensive food to supplement their diet in captivity (Pappas 2002). According to (Bothma et al. 2002), described that despite their commercial value, Common eland cannot ranch as simple as cattle. They primarily achieved their nutritional goal from browsing brush, shrubs, and low trees but also feed on grasses (Buys 1990).

1.2.4. Morphology and physiology

All elands are herbivores, and according to their morphological feeding type, they are browsers(BR) (Grimshaw et al. 1995; Thouless 2013). Browsers are also called concentrate selectors (CS) which means that they are animals that prefer food sources that are highly digestible, high in starch, proteins and lipids. These are the animals that predominantly feed on woody and non-woody dicotyledonous plants. However, eland can eat anything available during each season—graze in summer and browse in winter (Skinner

& Chimimba 2005; Pappas 2002). On the other hand, grazers (GR) types of species are those feeding on plant material that is high in fibre. These species are characterized by highly developed fermentation system that allows cellulosic plant material to be digested. According to the study of (Estes 1991), elands are intermediate type of feeders which make them to adopt a wide range of habitats. The intermediate (IM) types of feeders feed on mixed diets and forages according to season and opportunity (Hofmann & Stewart 1972; Hofmann 1989). Most of the intermediate types are opportunistic feeders. Eland are adaptable to a wide variety of climatic conditions (Thouless 2013).

Feeding system varies among ruminants and can be influenced by distinct anatomical structures. For GR species, they have a wider, flat mouth with a short lip which maximizes the feed intake and sedges. On the other hand, BR have a deep mouth opening but narrow which ease the feed intake of feed. The reticulum-rumen varies in size according to the feeding type as well as response to diet and season. The GR species possess larger reticulum-rumen per unit of body weight than BR species. On the other hand, IM species possess relative size of reticulum-rumen which is adaptive to season: it is larger during summer when forages are available and smaller during winter season, when forages are very limited (Hofmann 1989). However, the rumen microbial population is affected by season and diet of the animals. Microbial population can reduce if for example the feed intake is low, but when food intake is high, there will be improvement of growth rate of microbes in the rumen or when there is an increasing level of forage in the diet (Gillespie & Flander 2009). According to Jarman (1974), ruminants select nutritious diets from different varieties of plant species that vary in concentrations of nutrients and toxins, and meet their nutritional requirements that vary with age, physiological state, and environmental conditions. Hence, ruminants possess a degree of nutritional intellect in the sense that they generally select feeds that meet nutritional needs and avoid feeds that cause toxicosis. There is still little reason to be convinced of that nutritional understanding occurs because animals can directly taste or smell either nutrients or toxins in foods. Taste, smell, and sight help animals identify and discriminate among foods, but these senses play somewhat different roles in food preferences and food selection.

1.2.5. Effect of climatic condition

Weather and climate which are also called environmental stressor (ambient temperature, humidity, thermal radiation, air speed, wind etc.) can directly and adversely affect animal daily budget or performance. Climate change is one of the threat to biodiversity in world (Bijlsma 2010). In Africa, weather is hot and dry from July to October when temperatures can reach up to 47 °C, and an average of 410 mm of precipitation occurs in a year and the relative humidity averages about 49 % (Şimşek et al. 2005). The report of (IPCC 2007), predicted that there will be increase in climatic factors such as inconsistence rainfall, ambient temperature, drought, flooding etc. Some studies have described that many species can show adoptive response within their life span by microevolution over few generations, phenotypic plasticity behaviour as well as physiology and morphology (Gienapp et al. 2007 & Fuller et al. 2010).

1.2.5.1. Temperature

Temperature (TP) is one of the weather element that can affect grazing behaviour in ruminants. However, animals can shift their grazing periods by adjusting the total grazing period to avoid utmost expose to heat or cold. On the other hand, changes in barometric pressure (BP) as well as changes in resulting weather condition can also cause changes in animal activities. The amount, duration, and distribution of an animal's activities can be influenced strongly by ambient temperature during the day (Paola et al. 2015). Temperature stress is one of the phenomenon that has physical effect and cause economical losses to livestock production in both tropical and subtropical regions of the world. Temperature stress can make animals to undergo a series of metabolic and physiological changes (Berman 2005). These changes are necessary for the survival and adaptability of the animal to environment. Nutritional balance is also an important aspect in thermal stress which is deleterious to performance (Beede et al. 1983).

The study of Finch & Robertshaw (1979), shows that thermal sensitivity can help to maintain homeostasis. Incorporation of air temperature, solar radiation, wind speed, and relative humidity also partake an influence because ungulates as endotherms have very narrowed thermal roles which influence their social well-being or fitness (Porter & Kearney 2009). In addition, an integration of high air temperature and solar radiation, low wind speed (WS) and high vapour pressure beyond the thermal comfort of an ungulate pose a hazard because overindulgence of heat becomes more difficult (Schmid-Nielsen 1975; Owen-Smith 1998; Speakman & Król 2010). On the other hand, an integration of freezing temperature, snow and high wind speed enhance heat loss of ungulates. Eland can survive without drinking water in hot environment for a long-period of time (Taylor 1969; Posselt 1963). Eland can tolerate both excess heat and ambient temperature of about 38°C with an adequate provision of water and shelter (Ebedes & Van Rooyen 2002). Extreme climate condition can affect reproduction by altering the energy transfer between the environment and the animal (Gwazdauskas 1985). Eland can respond to thermoregulation as the cattle at ambient temperature (Kotrba et al. 2007).

These African antelopes have a maximum ability of tolerance limit to increasing temperature (Tewksbury et al. 2008) and are more sensitive to cold stress (Taylor & Lyman 1967). They notably rise their body temperature during the day-time (Talor 1970). According to Pappas (2002); Bothma et al. (2002); Skinner & Chimimba (2005), eland avoid heat during the day and seek for shade.

1.2.5.2. Wind speed

Cattle will search for shelter or microclimates that decrease the effects of inclement weather, mostly in strong winds and during substantial or persistent rain (Houseal & Olson 1995; Vandenheede et al. 1995; Redbo et al. 2001). Heat loss by eland can be influenced by high wind speed (Nelson 1995). Wind is identified to have a significant effect on heat loss from cattle (Webster 1974). Wind worsen the response to simulated rain in relation to both feed intake and feeding rate. However, exposure to wind alone do not significantly change behaviour or physiology, except for a minor reduction in feed consumption. But wind only on low air temperatures does not rise the metabolic heat production to the same level as experienced in wet conditions (Degen & Young 1993), also wind in combination with cold weather (Houseal & Olson 1995). Certainly, high wind speed together with low temperature has been revealed to rise lying times (Redbo et al. 2001). The incorporation of environmental stressor which include wind speed, solar radiation and ambient temperature affect the daily budget of common eland (Huey 1991; Fuller et al. 1999; Hetem et al. 2007).

1.2.5.3. Wind chill

Severe winter weather is characterized by low dry bulb temperature and high wind speed and it has been described by the wind chill factor (figure 3). This factor represents as air temperature without appreciable wind that would affect the same heat loss rate from exposed skin due to the actual combination of temperature and wind. However, wind chill factor is described as the cooling sensation due to the exposure to the wind temperature environment (Table 2). An excessive wind chill factor can be a health hazard, meanwhile excessive heat loss from the body may result in hypothermia (Wilson 1964). The usual temperature of a human body is 37°C. Heat is generated in the body via metabolic reaction. Therefore, if heat is withdrawn at a rate higher than it is generated, then hypothermia may occur. In the other hand, if heat is not withdrawn at an appropriate rate, it may result in hyperthermia/heat stroke. In a cold climate, the bodies create a thin film of heat to keep it warm. This heat film is swept away in windy conditions, thus creating the wind chill factor. This is shown in Figure 3. The comfort sensation depends on many other variable factors such as temperature, incoming and outgoing radiations, convection and wind velocity, conduction and humidity (Siple & Passel 1945). The wind chill factor is directly influenced by the phenomenon of heat transfer (Brauner & Shacham 1995; Steadman 1975). Heat transfer is a process of transfer of heat energy from one system to another. Generally, the rate of heat transfer is higher if there is a greater temperature difference between the systems.

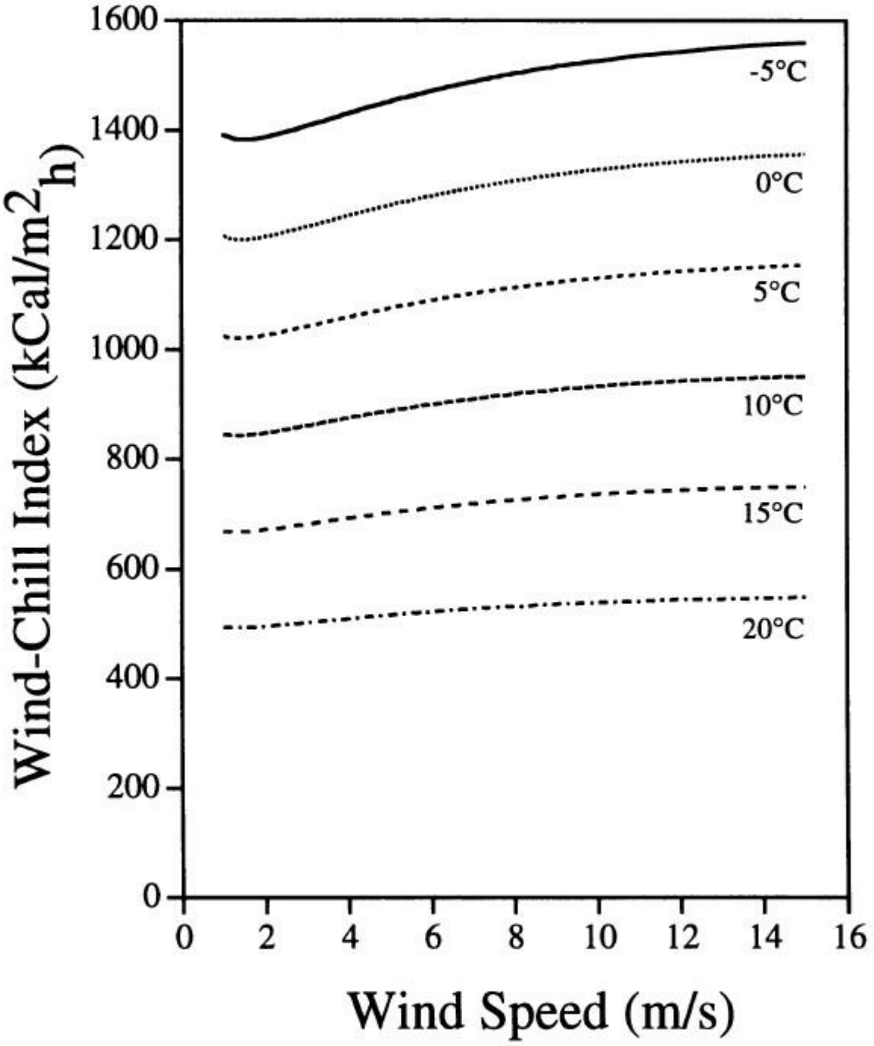

Figure 3. Wind chill index (kCal/m^2) variability with wind speed (m/s) for various facial temperatures ranging from -5 °C to 20 °C (Osczevski 2000).

Table 2. Discomfort descriptor with wind chill Index value showing the associated discomfort descriptor with various values of wind chill Index. Osczevski (2000).

Discomfort descriptor	Wind chill index (kCal/m^2h)
Cold	800
Very Cold	1000
Bitterly Cold	1200
Exposed Flesh Freezes	1400

1.2.5.4. Rainfall

Rainfall has been defined as the main driver which has great influence on vegetation growth, hence production of food for herbivores (Owen-Smith & Ogutu 2003). Rainfall mostly occurrs during summer with a mean of about 300mm to 400mm per year (Mucina & Rutherford 2006). The study of (Kerley & Boshoff 1997), described that 70 % of the total rainfall occur during summer and snowfall during winter. According to (Rutherford 1980; O'Connor & Kiker 2004), report that rainfall is the major tool of good quality and quantity of forages. The amount of rainfall controls the vegetation structure as well as the composition (Palmer et al. 1990). The ability of antelope to survive during drought depend basically on dry season rainfall, thus their ability to track heterogeneous resources (IPCC 2007; Lyon 2009). Rainfall may constitute the main energetic limitation for black-tailed deer in summer pelage (Katherine 1998). According to Kingdom (2007), Common eland converge into large groups during and after the rains and separated into sub- groups in the dry season. Rainfall is one of the climatic factor governing herbivore population dynamics in African savanna (Owen-Smith 1990; Mills et al. 1995; Mduma et al. 1999; Georgiadis et al. 2003; Ogutu & Owen-Smith 2003; Owem-Smith et al. 2005), but few studies have investigated its effects on the dynamics of multiple species assemblages of African savanna ungulates (Mills et al. 1995; Ogutu & Owen-Smith2003,2006; Owen-Smith & Ogutu 2003; Owen-Smith & Mills 2006). The demographic responses to rainfall variability by African savanna ungulates have similarly received little attention (Owen-Smith & Mason 2005; Owen-Smith et al. 2005). Ungulates respond both to cumulative past rainfall and seasonal fluctuations in rainfall (Ogutu & Owen-Smith 2003, 2006; Owen-Smitha & Ogutu 2003; Owen-Smith & Mills 2006).

1.2.5.5. Drought

The livestock industry has been all too familiar with drought because ranchers have always had to adapt to precipitation variability. Common drought management decisions have included reducing herd size and feeding harvested forage. Unfortunately, these methods have not eased the stress of long-term drought. According to climate forecasts, drought frequency and severity are expected to increase in coming years, posing greater challenges to livestock producers. As a result, livestock producers will have to rely on integrated and long-term management strategies. However, in regions where drought occurrences are frequent, establishment of drought management policy is needed if livestock survival will be improved. Drought management policies should be aimed at guiding decisions on emergency services (Heathcote 1991; White 1998; O'Meagher et al. 1998). Matching animals to the environment is an effective drought management strategy. Though, the livestock industry has increasingly provided incentives for the selection of breeds that may not be the most suited to harsh rangeland environments. However, drought is the single most important environmental factor that causes fluctuations in livestock populations. Drought severity is manifested by below average rainfall that results in shortages of forage and water (Du Pisani et al. 1998). Drought-induced die-offs of cattle population negatively affect breeding females and young calves more than immature animals and mature males (Donaldson 1986; McCabe 1987; Homewood & Lewis 1987; Cossins & Upton 1988; Coppock 1994). Greater mortality of breeding females and female calves cause significantly delay in herd regaining (Dahl & Hjort 1976; McCabe 1987). Furthermore, losses may be worse by disease outbreak (Campbell 1984), more delaying regeneration of cattle population (Cossins & Upton 1988; Scoones 1992). Mortality and regaining have been explained in terms of pre- and post-drought density of livestock or density-dependent (Coppock 1994) or weak coupling between preened post drought livestock density (Ellis & Swift 1988).

1.2.5.6. Relative humidity

According to Brouček et al. (2006), high temperature and relative humidity during hot periods and wind-chilling during cold are the most important factor affecting animal health and welfare. High ambient temperature attached with high humidity during the day, can adversely affect feed intake and nutrient utilization in sheep (Bhattacharya & Hussain 1974). However, depressing the humidity can improve the antagonistic effect of high temperature and vice versa (Ragsdale et al. 1953; Davis & Merilan 1960; Allen et al. 1963; Johnson et al. 1963). During summer, high ambient temperature, relative humidity and solar radiation together with low wind speed can rise animal heat load, which in turn reduce performance, diminish animal well-being and death (Mader et al. 2006). In view of the rise in global warming, this condition apparently would become more serious problematic to livestock. Like other farm animals, when feedlot cattle are unprotected from heat stress, a heat loss mechanism develops which in turn increased aspiration and sweating. High relative humidity decreases the evaporation and makes dissipation of body heat more difficult when the ambient temperature is close to the cow's body temperature (West 1994).

Evaporation from the respiratory tract and the outer body surface both are affected directly by the temperature and relative humidity of the air (Kibler & Brody 1953; West 1994). Metabolic activation is connected to state of stress which causes reduction in production and thus economic losses, as well as increased energy requirement. According to NRC (2001), increased in breathless score may also increase energy requirement by 7-25 %. Ravagnolo et al. (2000) reported that for test-day yield, depression caused by heat is a function of the top, average, or lowest temperatures and humidity during 24 h. By understanding the temperature humidity index (THI) alone is useful to determining the influence of heat stress for feedlot cattle (Mader et al. 2006). Temperature-humidity index is used in its place of the temperature itself (Ingram 1965; Šleger & Neuberger 2006) and numerous THI have been established by using dry bulb temperature, in combination with wet bulb temperature, relative humidity, or dew point (Buffington et al. 1981; Roseler et al. 1997; Gaughan et al. 2008). In practice, it may be useful to understand the influence of temperature and humidity as individual or collectively. West (2003), suggested that combinations of temperature, relative humidity and radiant energy influence heat loss in the cow.

1.2.5.7. Wet bulb

The wet-bulb temperature is the lowest temperature which may be accomplished by evaporative cooling of a water-wetted (or even ice-covered), ventilated surface. By disparity, the dew point is the temperature to which the ambient air must be cooled to reach 100 % relative humidity assuming there is no evaporation into the air; it is the point where humidity condensate (dew) and rain would form. For a parcel of air that is less than saturated (i.e., air with less than 100 percent relative humidity), the wet-bulb temperature is lower than the dry – bulb temperature, but higher than the dew point temperature. The lower the relative humidity (the drier the air), the greater the gaps between each pair of these three temperatures. On the other hand, when the relative humidity rises to 100 %, the three figures coincide. For air at a known pressure and dry-bulb temperature, the thermodynamic wet-bulb temperature corresponds to unique values of the relative humidity and the dew point temperature. However, the wet bulb globe temperature (WBGT) index is the current method used to assess environmental contributions to heat stress in an occupational setting.

1.2.5.8. Heat Index

Heat stress occurs when the body cannot adequately cool itself due to the combined contributions of metabolic heat, environmental factors and clothing in the case of human. However, Heat Index was adopted by the National Oceanic Atmospheric Administration’s (NOAA) National Weather Service (NWS) in 1980, and it was originally developed by Steadman as an assessment for sultriness, but commonly referred to as the Apparent Temperature. Parameters involved in Apparent Temperature were water vapor pressure, surface area of skin, significant diameter of a human, clothing, core temperature, activity, effective wind speed, clothing resistance to heat transfer, radiation to and from the skin’s surface, sweating rate, ventilation rate, skin resistance to heat transfer, and surface resistance to moisture transfer (Steadman 1979). Steadman’s Apparent Temperature assessed thermal comfort by using an iterative solution for multiple variables in multiple equations that represent the body’s heat and moisture transfer.

1.2.5.9. Barometric pressure

Brown et al. (1957), report that many studies on a diversity of organisms have discovered significant correlations between barometric pressure and various biological activities. Other studies, show that there is a correlation between motor activity and barometric pressure in domestic dogs, rats (Hodge 1897; Stewart 1898). However, barometric pressure may provide a useful environmental signal, but its ecological or evolutionary significance remains largely unidentified (Kreithen & Keeton 1974).

2. Aims of the thesis and hypothesis

Despite Eland is significantly well adapted to harsh environment with high potential, however, the main objective is to determine the preferred weather condition for daily budget of this species to help the farmers to increase their production by optimizing the feeding and husbandry schedule.

Specific objectives of this study were:

1. To investigate the influence of weather condition on daily budget or activities of eland in captivity in outdoor conditions.

2. To determine preferred weather condition (ambient temperature, humidity, wind etc.), for the most important behaviour or daily activity pattern by farmed common eland in outdoor condition.

The Hypothesis

H1- Weather condition or individual weather elements influence the activity or specific behaviour of the captive eland in outdoor conditions.

H1. 1- Wind effect will be relatively high.

H1. 2- Temperature will affect but relatively low while relative humidity effect will be relatively high.

H2- Weather condition or individual weather elements has no effect on the activity or specific behaviour of the eland in outdoor enclosure.

3. Methods

3.1. Location

The research was conducted at the experimental farm in Lány (50° 07’ 23’’N, 13° 57’ 02’’E; altitude 421 m) which is about forty -three kilometres (43 km) north-west from the capital city of Prague, Czech Republic. There are about fifty- two (52) individuals animals in the herd of common eland on the farm under the management of department of Animal Science and Food Processing Faculty of Tropical Agrisciences Czech University of Life Sciences Prague (CULS Prague).

3.2. Materials

Fifty-two (52) animals were used which involve adult males and females, juveniles and calves. Animals were observed through a defined sampling technique (scan sampling technique Altman 1979) and identified by natural (horns, size) and artificial (coloured numbered ear tags) markings. Canon 10X30 IS Binoculars was used to identified distance animals (Figure 5).

The weather condition was recorded by Kestrel 4500 device (Figure 4). This device record weather condition such as: wind direction, crosswind, altitude, pressure trend, barometric pressure, wet bulb temperature, relative humidity, air, water, and snow temperature, current, average, and maximum air speed, time and date etc. its design to work in five different languages (English, French, Spanish, German, and Italian).

Figure 4. Kestrel 4500 Used to measure weather conditions.

Figure 5. Canon 10X30 IS Binoculars used to identified distance animals.

Figure 6. Common eland at experimental farm in Lány, Czech Republic.

Source:www.ftz.czu.cz

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3.3. Observed activities

The behaviour of the studied animals (Figure 6.) which were recorded include: resting (RS), rumination(RM), eating outside the ban (EOB), eating inside the ban (EIB), nursing (NS), suckling (SK), mating (MT), fighting (FT), playing-fight(PFT), urination(UR), defecation (DF), and drinking water (DW).

3.4. Method of observation

Prior to the start of daily recording of the activity of the animals, the weather of the day was recorded using the Kestrel 4500. Thus, this was achieved through the following:

Installation of the tripod: the tripod is removed from its jacket and all the clips on the leg were unclipped and freed; afterward they were clipped again to have a firm stand (Figure 7). The tripod was vertically erected in order not to affect the reading of the device. This was achieved by properly adjusting the bubble at the top to align with the circle in the middle. Precaution was taking to make sure the tripod was not close to shade, metallic objects, influence from children or animals, magnetic materials etc, which might likely influence the compass calibration of the device. The vane helps in compassing and it was properly fixed by joining the various components and screwed to the tripod.

Time and date was also set by pressing the red button (●) to go to the main setup menu, the navigation keys alongside the central key were used to achieve a proper date and time setting. In addition, the Kestrel 4500 has a built in digital compass which was also calibrated. However, this was done by pressing the calibration mode and rotate it through 360 degrees three times, the unit confirms that calibration has been completed. This allows you to track and log wind direction as well as wind speed. By setting a reference target or runway heading, the Kestrel 4500 will automatically calculate crosswind, headwind and tailwind when measuring the wind speed. The Kestrel 4500 can be set up to log data automatically (as well as manually) at programmable intervals, in order to display a history of weather information. Graphs display up to 2900 data points and the value, time and date of capture point can be shown. The stored data was also uploaded to the PC, for analysis/storage with the optional Kestrel Interface and Communicator software.

Figure 7. Kestrel 4500 device fixed on the tripod.

After installing and ensuring the proper working condition for the Kestrel device, the next step ahead was the data collection which was achieved through a defined sampling technique. Scan sampling technique (Altman 1974) was used (this is where a whole group of the subject is rapidly scanned at regular intervals and the behaviour of everyone was recorded). However, before starting the observation and recording I usually waited for at least 15mins for habituation and then proceed. In the whole herd of the species, the animals were observed for 20mins and the activities observed were also recorded in the record sheet. Hence, in every hour, there was 20mins for the scanned of whole group of species which make a total of 40 mins for the observation and 20mins for resting before the subsequent circle of scan. A total of 204 observation session were recorded from 2017 September 19th to December 3rd.

3.5. Statically Analysis

Data were statistically analysed using SPSS software version 20.0 (IBM SPSS, 2012). The significance level was established at α=0.05. The results were expressed as mean **(**±SD) value. All data were initially tested for normality by one-sample Kolmogorov-Smirnov Test. Correlations among weather element as well as the corresponding behaviours were also analysed using non- parametric correlations (Spearman correlations). Weather element and behaviours were not independent from each other; thus, we conducted a Principal Component Analysis (PCA) using varimax rotation to reduce the variables to the minimum independent factors.

A generalized linear models (GLM) were designed to test the effect of previous grouped factor temperature (TP), wet bulb (WB), relative humidity (RH), wind speed (WS), wind chill (WC), barometric pressure (BP), heat index (HI), dew point (DP) on the activity budget of the eland eating inside barn (EIB), eating outside barn (EOB), resting (RT), rumination(RM) and nursing + suckling (NS+SK).

4. Result

Normality of all variables used in the following analyses was measured by One sample Kolmogorov-Smirnov test, and all of them were not normally distributed. Also, visual inspection of their histograms, normal Q-Q plots and the corresponding box plots showed that were not normally distributed for all the variebles.

4.1. Preliminary description of percentage representation of Eland activities.

Initially there were about 12 activities or behaviours observed in this study, however because of the less frequency of some of the ativities obsreved we decided to select those with high frequency to test effects of the weather elements. We also decided to combined nursing (NS) and suckling (SK) as NS+SK since they are closely related.

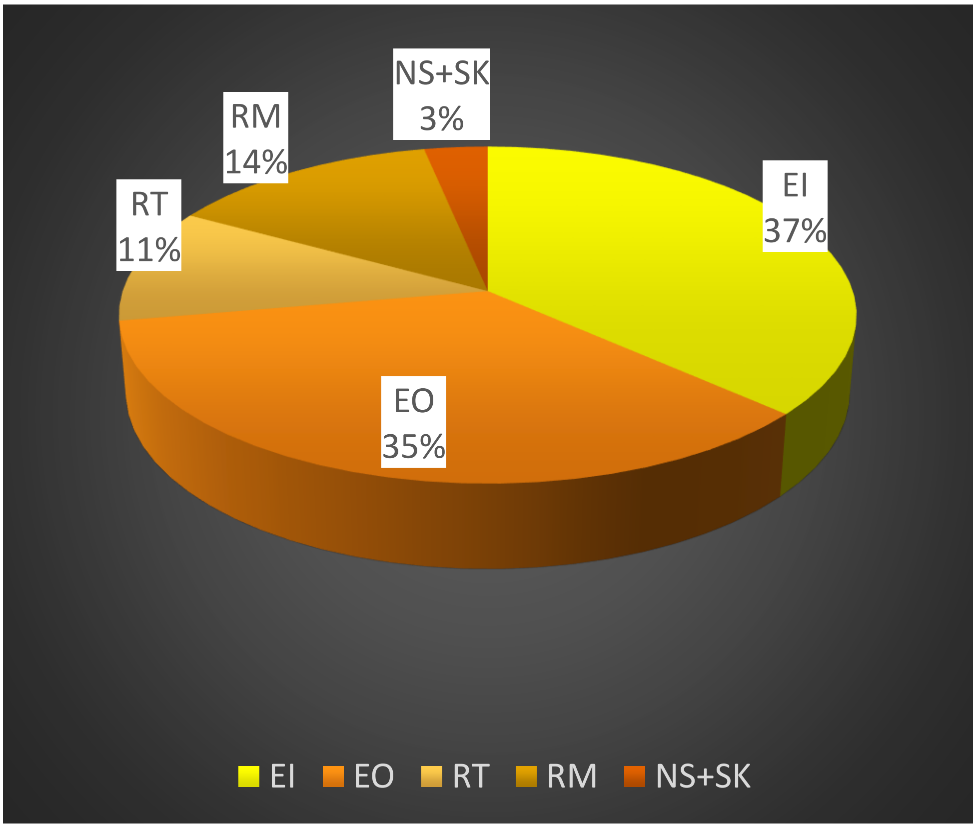

Figure 8. Frquency of selected observed behaviours of captive eland.

Note: EIB-Eating inside barn, EOB-Eating outside barn, RT-Resting, RM-Rumination, NS+SK-Nursing + Suckling.

Since it has been shown from the prelimunary result above that the Eland mostly prefered eating inside barn with a high percentage (37 %) than eating out side and the other selected activities (Figure 8) which may be due to the influence of the weather elements or one of the weather element.

4.2. Relationship among the weather parameters

Spearman's correlation was performed to investigate wether these individual weather element are associated to one another or they are independent to each other.

Table 3. Correlation among weather parameters.

	WS	TP	WC	RH	HI	DP	WB
TP	-0.171*						
WC	-0.185**	0.999**					
RH	-0.089	-0.694**	-0.692**				
HI	-0.312**	0.939**	0.937**	-0.513**			
DP	-0.246**	0.809**	0.810**	-0.212**	0.807**		
WB	-0.232**	0.962**	0.961**	-0.521**	0.931**	0.925**	
BP	-0.281**	0.493**	0.486**	0.004	0.650**	0.539**	0.538**

*Correlation is significant at the 0.05 level (2-taled).

**Correlation is significant at the 0.01 level (2-tailed).

Note: WS-Wind speed (m/s), TP-Temperature(°C), WC-Wind chill (°C), RH-Relative humidity (%), HI-Heat index(°C), DP-Dew point (°C), WB-Wet bulb (°C), BP-Barometric pressure (mb).

Most of the weather elements were positively correlated among them selves at both , but with the exception of RH and WS which were negetively correlated at both (Table 3).

In most instances the correlation was found highly significant. However, the correlation between RH and WS, RH and BP was not significant at all levels.

4.3. Relationship between weather parameters and activity budget

Spearman´s correlation between the weather parameters and the percentage representation of observed behaviours was conducted to find out how they were connected to weather parameters or individual weather element.

Table 4. Correlation showing the degree of relationship between the weather parameters and activity budget.

	EIB (%)	EOB (%)	RT (%)	RM (%)	NS+SK (%)
WS	0.383**	-0.301**	-0.105	-0.017	-0.036
TP	-0.514**	0.262**	0.320**	0s.098	0.012
WC	-0.511**	0.254**	0.324**	0.102	0.014
RH	0.307**	-0.159*	-0.197**	-0.083	0.032
HI	-0.597**	0.366**	0.304**	0.064	0.009
DP	-0.392**	0.145*	0.260**	0.114	0.048
WB	-0.501**	0.254**	0.301**	0.098	0.022
BP	-0.362**	0.287**	0.127	-0.014	0.015

*Correlation is significant at the 0.05 level (2-taled).

**Correlation is significant at the 0.01 level (2-tailed).

Note: EIB-Eating inside barn, EOB-Eating outside barn, RS-Resting, RM-Rumination, NS+SK-Nursing + Suckling.

It has been shown that the correlation between the wether parameters and activity budget of the Eland was detected for both positive and negetive correlation (Table 4). In most instances the correlation was found highly significant. However, in some cases the correlation was found no significant between weather parameters and rumination (RM) and the combination of nursing and suckling (NS+SK).

4.4. Principal component analysis (PCA)

Since most of the preliminary analysis showed significant results, principal component analysis was conducted to find the linear combination of the set of variables that has a maximum variance and removing of its effect as shown in Table 5.

Table 5. Factor loading from the Principal Component Analysis performed on weather elements. Those with greatest effect on the extracted factors are shown in bold (loading ≥ 0.7, {Budaev 2010}).

	FAC1	**FAC2**	**FAC3**
Cumulated Explained Variance (%)	67.099	16.587	9.283
Eigenvalue	5.368	1.327	0.743
WS	-0.162	-0.008	**0.986**
TP	0.655	**0.749**	-0.072
WC	0.649	**0.751**	-0.088
RH	0.017	**-0.957**	-0.084
HI	**0.765**	0.565	-0.201
DP	**0.844**	0.335	-0.113
WB	**0.764**	0.608	-0.115
BP	**0.865**	-0.108	-0.137

Note: FAC-Factor.

The first factor has a strong positive loading for HI, DP, WB and BP. This indicate that the variables in factor1 are strongly and positively correlated; meaning that if one increase then, the others increase as well. This can be viewed as strong relationship of HI, DP, WB and BP as well as their effects. The second factor has a strong positive loading for TP, WC and most strongly negative loading for RH. The third factor has a most strongly positive loading for WS.

4.5. Generalized linear models

A special class of model known as generalized linear models was conducted to describe the response or effect of multiple variables on activity budget.

Table 6. Generalized linear models showing the effect of previous grouped factors on activity budget.

Target	Variable	β	Standard error	95% confidence interval	p-Value
EIB (%)	Intercept	34.891	1.5380	31.877, 37.906	0.000
	FAC1	-9.962	1.5418	-12.894, -6.940	0.000
	FAC2	-9.392	1.5418	-12.414, -6.370	0.000
	FAC3	9.276	1.5418	6.254, 12.298	0.000
EOB (%)	Intercept	33.622	1.8671	29.963, 37.282	0.000
	FAC1	5.916	1.8717	2.248, 9.585	0.002
	FAC2	4.354	1.8717	0.685, 8.022	0.020
	FAC3	-8.016	1.8717	-11.685, -4.348	0.000
RT (%)	Intercept	10.373	0.9785	8.456, 12.291	0.000
	FAC1	2.856	0.9809	0.933, 4.778	0.004
	FAC2	3.549	0.9809	1.626, 5.471	0.000

Note-FAC-(see table 5), EIB %-percentage eating inside barn, EOB %-percentage eating outside barn, RT %-percentage resting.

The model displays the estimated mean and standard error of the coefficient, 95 % confidence interval and a t-test with associated p-value for the coefficient. The models also described that FAC1and FAC2 have a negetive significant effect on percentage EIB %. While on the other hand FAC3 has positive significant effect on EIB % (Table 6) respectively. However, in the case of EOB %, FAC1 and FAC2 have positive significant effect and FAC3 has negetive significant effect. Moreover, only FAC1 and FAC2 have significant effect on % RT which is also positve. No significant effect was found on RM % and NSSK % respectively.

5. Discussion

This study revealed that weather elements have effect on some of the activities of eland in outdoor enclosure. The analysis of the weather elements on percentage representation of the observed activities supported the fact that most of the studied weather elements have a significant effect on the activities of captive eland. Nevertheless, the effect was found negetively on eating inside barn by HI, DP, WB, BP, TP, WC, RH. On the other hand eating outside barn was positively affected by HI, DP, WB, BP, TP, WC, RH. Eating inside barn was positively influenced by WS, while eating outside barn was negetively affected by WS. In addition, resting was also affected positively by HI, DP, WB, BP, TP, WC, RH. Nevertheless, only TP, RH, WC and WS may have an actual effect on the observed percentage representation activities. However, the significant effects of TP and WC were found highly and negatively significant on eating inside barn, highly and positively significant on both eating outside barn and resting behaviours. While on the other hand RH was found highly positively significant on eating inside barn and negatively significant on both eating outside barn and resting. Moreover, WS was found positively significant on eating inside barn and negatively significant on eating outside barn. Notwithstanding, RH is well supported by our results as key weather element, it appears that it has greatest effect. And it also has greatest difference in effect between eating inside barn and eating outside barn. In addition, it is the only weather element that is showing consistence difference in correlation between weather elements and percentage representation of observed activities.

As key environmental factors, relative humidity and temperature play an important role in air quality (Tian et al. 2014; Cheng et al. 2015) and climate control (Sherwood and Fu 2014). In the previous studies, high relative humidity and temperature was found to have adverse effect on feed intake and nutrient utilization in sheep and lead to heat stress in cattle (Jaśkowski et al. 2005, Daniel 2008). This may explain the negative effect by HI, DP, WB, BP, TP, WC, RH on eating inside barn in our result and may also be due to effect of TP and RH which influence the effect of the other weather elements. However, high temperature and relative humidity can result to heat stress incorporation with metabolic heat which result to decrease in feed intake as well as to increase body temperature and evokes a physiological response in cattle (Berman 2005; Dikmen & Hansen 2009). Indeed, our result will be similar to study of Paola et al. (2015). These authors report that temperature can affect the grazing behaviour in ruminants by adjusting the total grazing period to avoid utmost expose to heat or cold. The study of Ames & Insley (1975), also described the effect of TP and WC. These authors found that WC incorporates the combined effects of TP and wind which can influence the thermal balance of an animal, hence reduce the feed intake. High TP and RH during hot periods and WC during cold were described as factor affecting feed consumption (Brouček et al. (2006),

Eating outside barn was positively affected by HI, DP, WB, BP, TP, WC, RH, this may be due to effect of TP and WC (Calamari et al., 1994; Frazzi et al., 1997). The comfort sensation depends on many other variable factors such as temperature, incoming and outgoing radiations, convection and wind speed, conduction and humidity (Siple & Passel 1945). However, wind chill factor is described as the cooling sensation due to the exposure to the wind temperature environment and increase feed intake in dairy cattle (Brauner & Shacham 1995; Steadman 1971). Our result suggests that an increase in temperature and wind chill result to high feed intake. It may be also interesting that maybe it was due to thermoregulatory mechanism that eland exhibit to improves the feeding intake as observed by Kotrba et al. (2007). These authors reported that Eland can respond to thermoregulation as the cattle at ambient temperature. Therefore, the feeding activities outside the barn by the eland can be improved through the evaporative cooling by temperature, wind chill and thermoregulation mechanism to increase heat dissipation. Eland exhibit feeding in the early morning and late evening (i.e when temperature is cool) to avoid heat stress (Lewis 1978; Pappas 2002; Bothma et al. 2002; Thouse 2013).

The combined effect of the weather elements was positively affects the resting behaviour and may be due to heat stress in the environment which can lead the eland to seek for rest in order to conserve their energy. The incorporation of environmental stressor which include wind speed, solar radiation and ambient temperature affect the daily budget of common eland (Huey 1991; Fuller et al.1999; Hetem et al. 2007). During extreme heat, livestock will graze during early morning and late evening, seek shade during the hottest part of the day, and walk long distances to obtain water. During extreme cold, animals may attempt to minimize energy losses by seeking thermal cover, lying down, orienting their bodies towards the sun, and remaining inactive. This was also observed by (Skinner & Chimimba 2005; Pappas 2002), described that eland often rest especially during extreme hot day to avoid heat stress and during extreme cold to conserve their energy. According to Pappas 2002; Bothma et al. 2002 and Skinner & Chimimba 2005 eland avoid heat during the day and seek for shade. Moreover, cattle select resting sites to avoid extreme wind in winter (Senft & Rittenhouse 1985a), and to conserve energy which may defer the grazing until ambient temperatures increase (Malechek & Smith 1976).

Wind speed positively influenced eating inside barn, this may be due to the need of adequate ventilation because of the heat load inside the barn. Even a very small wind can result in a large air exchange rate through the barn when the sidewalls are fully open, necessary to ensure an adequate and comfortable warm weather environment for the animals. At the same time, a difference in temperature from inside the barn to the outside ambient occurs, the warm moist air in the barn being less dense than the outside air. Therefore, this is similar with the study of Nelson (1995). This author revealed that heat loss by eland can be influenced by high wind speed. It was also identified that wind speed has a significant effect on heat loss from cattle (Webster 1974). Changes in body temperature are related to balance between the amount of heat gained by the animal, either through metabolic heat production or from the environment, and the amount of heat lost by the animal to its environment (Gordon et al. 1982).

However, wind speed affect eating outside barn negatively, this may be due to high wind speed or extreme cold which result to unbalance of thermal condition between the eland and the environment, and in turn can lead to the high demand of energy. Partly because of this increased demand for energy, it has been reported that cattle lose weight or have lower weight gains when exposed to cold or high wind (Webster 1970; Hidiroglou &Lessard 1971) which result to decrease in grazing time and forage intake (Malechek & Smith 1976; Adams 1989). However, exposure to wind alone can only result to minor reduction in feed consumption.

6. conclusion

It is necessary to investigate animal raising conditions in order to prevent the factors that are potentially harmful to animals. This study revealed that weather condition can affect the activities of captive eland in outdoor enclosure. Relative humidity, temperature, wind chill and wind speed have been showed to pose adverse effects on captive Eland welfare, affecting the feeding activities which can result to poor growth and development. However, direct control or even measurement of temperature, relative humidity, wind chill and wind speed levels is not part of current practice and does not receive much attention. It may be that monitoring and directly controlling temperature, relative humidity, wind chill and wind speed could result in a significant improvement of Eland husbandry in the future, and make a substantial contribution to their welfare, as well as prevent them from adverse effect of this environmental stressor.

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Appendices

List of the Appendices:

Appendix 1: Weather elements

True North:

True north is a navigational term referring to the direction of the North Pole relative to the navigator's position. The direction of true north is marked in the skies by the celestial north pole.

Magnetic North:

The point on the Earth's surface where the Earth's magnetic field points directly downwards. This pole is constantly wandering.

Wind Chill:

The cooling effect of combining wind and temperature. The wind chill gives a more accurate reading of how cold it really feels to the human body. The Kestrel Meter's wind chill is based on the National Weather Service standards as of November 1, 2001.

Relative Humidity:

The amount of water vapor in the air divided by the maximum amount of water vapor the air could hold at that temperature, expressed as a percentage.

Temperature:

The ambient air temperature.

Heat Index:

A practical measure of how hot the current combination of relative humidity and temperature feels to a human body. Higher relative humidity makes it seem hotter because the body's ability to cool itself by evaporating perspiration is reduced.

Dewpoint:

The temperature to which air must be cooled in order for condensation to occur. The difference between dewpoint and temperature is referred to as the "temperature/dew point spread". A low dewpoint spread indicates high relative humidity, while a large dewpoint spread indicates dry conditions

Wet Bulb:

The lowest temperature to which a thermometer can be cooled by evaporating water into the air at constant pressure. This measurement is a holdover from the use of an instrument called a sling psychrometer. To measure wet bulb temperature with a sling psychrometer, a thermometer with a wet cloth covering over the bulb is spun rapidly through the air. If the relative humidity is high, there will be little evaporative cooling and the wet bulb temperature will be quite close to the ambient temperature. Some exercise physiology guides use wet bulb temperature, rather than heat index, as a measure of the safety of exercise in hot and humid conditions.

Barometric Pressure:

The air pressure of your location reduced to sea level. Pressure will change as weather systems move into your location. Falling pressure indicates the arrival of a low-pressure system and expected precipitation or storm conditions. Steady or rising pressure indicates clear weather. A correct altitude must be input for the Kestrel Meter to display barometric pressure correctly.

Altitude:

The distance above sea level. The Kestrel Meter calculates altitude based on the measured station pressure and the input barometric pressure - or “reference pressure”

Density Altitude:

The altitude at which you would be, given the current air density. Often used by pilots to determine how an aircraft will perform. Also, of interest to individuals who tune high performance internal combustion engines, such as race car engines.

Cross Wind:

A crosswind is any wind that has a perpendicular component to the line or direction of travel. This affects the aerodynamics of many forms of transport. Moving non-parallel to the wind's direction creates a crosswind component on the object and thus increasing the apparent wind on the object; such use of cross wind travel is used to advantage by sailing craft, kiteboarding craft, power kiting, etc. On the other side, crosswind moves the path of vehicles sideways and can be a hazard.

Appendix. 2: Activity budget

Standing, lying, walking and playing-fight actitivitis.

Eating inside barn

Eating outside barn

APPENDIX 3: Statistical tables.

The tables below are the full initial models of the statistical analysis. FAC1, FAC2 and FAC3 are corresponding to factor one, factor two, factor three of table six to eight in chapter four above respectively.

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	34.891	1.5380	31.877	37.906	514.640	1	.000
FAC1_1	-9.962	1.5418	-12.984	-6.940	41.745	1	.000
FAC2_1	-9.392	1.5418	-12.414	-6.370	37.104	1	.000
FAC3_1	9.276	1.5418	6.254	12.298	36.194	1	.000
(Scale)	482.566[a]	47.7812	397.443	585.920			

Dependent Variable: EI

Model: (Intercept), FAC1_1, FAC2_1, FAC3_1

a. Maximum likelihood estimate.

Parameter Estimates

Paramete	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	33.622	1.8671	29.963	37.282	324.272	1	.000
FAC1_1	5.916	1.8717	2.248	9.585	9.991	1	.002
FAC2_1	4.354	1.8717	.685	8.022	5.410	1	.020
FAC3_1	-8.016	1.8717	-11.685	-4.348	18.344	1	.000
(Scale)	711.166[a]	70.4159	585.719	863.481			

Dependent Variable: EO

Model: (Intercept), FAC1_1, FAC2_1, FAC3_1

a. Maximum likelihood estimate.

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	10.373	.9785	8.456	12.291	112.398	1	.000
FAC1_1	2.856	.9809	.933	4.778	8.476	1	.004
FAC2_1	3.549	.9809	1.626	5.471	13.090	1	.000
FAC3_1	-1.161	.9809	-3.084	.761	1.402	1	.236
(Scale)	195.308[a]	19.3384	160.856	237.138			

Dependent Variable: RT

Model: (Intercept), FAC1_1, FAC2_1, FAC3_1

a. Maximum likelihood estimate.