Czech University of Life Sciences Prague (CULS Prague)
Institute of Tropics and Subtropics (ITS)
Department of Animal Science and Food Processing in Tropics and Subtropics (DASFPTS)

Bachelor Thesis:

Which environmental factors influence behaviour of the ruminants

Thesis Author: Josef Hora
Thesis Supervisor: MSc. Radim Kotrba Ph.D.

Czech University of Life Sciences Prague (CULS Prague)
Institute of Tropics and Subtropics (ITS)
Department of Animal Science and Food Processing in Tropics and Subtropics (DASFPTS)

BACHELOR THESIS SUBMISSION FORM

Title: Which environmental factors influence behaviour of ruminants?- Literature review

For: Mr. Josef Hora

Study program: **Tropical and Subtropical Agriculture**

In accordance with the rules set out by the CULS in Prague (§ 20) the head of DASFPTS would like to submit this thesis titled:

Thesis supervisor: MSc. Radim Kotrba, Ph.D.
Date of preliminary thesis submission: October 2007
Submission deadline: 05 2008

Preliminary contents:

1. Introduction
2. Aim of the thesis
3. Analysis of literature
4. Conclusions

Date:

…………………………………..
Thesis supervisor

………………………………….. | …………………………………..
Head of DASFPTS CULS in Prague | Director of ITS CULS in Prague

Author’s Declaration
I hereby declare that I am the only author of this thesis and that I have used only sources that are stated in the bibliography.
Prague, May 15th, 2008, Josef Hora

…………………………………

Prohlašuji, že jsem bakalářskou práci na téma: „Which environmental factors influence behaviour of ruminants?- Literature review“ vypracoval samostatně za použití uvedených zdrojů, svých poznatků a konzultací s vedoucím bakalářské práce.

V Praze dne 11.5.2008, Josef Hora

……………………………………………….

Acknowledgment

I would like to thank my thesis supervisor MSc. Radim Kotrba Ph. D. and Ing. Kateřina Tomášová for their thoughtful suggestions and guidance on the substantive aspects of this work.

Poděkování

Upřímně děkuji MSc. Radimu Kotrbovi, Ph. D. a Ing. Kateřině Tomášové za cenné připomínky, odborné vedení a náměty při zpracování této práce.

Which environmental factors influence behaviour of ruminants?- Literature review

Summary :

This Bachelor thesis examines the phenomenon associated with factors which can influence behaviour of ruminants. However, the topic is very extensive and requires a deep focus I tried to highlight two main groups of factors. In the first part of this work try to describe main biotic factors, which influence behaviour of the ruminants, its origin, mechanisms and examples how they are proved.

The second part of this work try to describe main abiotic factors, which influence behaviour of the ruminants, its origin, mechanisms and examples how they are proved.

Key words: Abiotic factors, biotic factors, ruminants, behaviour, animals, physiology, group, herd, size

Jaké vnější faktory ovlivňují chování přežvýkavců- literární přehled

Souhrn :

Tato práce se zabývá problematikou působení faktorů na chování přežvýkavců. Cílem je popsat hlavní faktory vnějšího i vnitřního prostředí , které mohou ovlivnit chování u přežvýkavců. Práce je rozdělená do dvou tematických celků. První část se zabývá hlavními biotickými faktory, které ovlivňují chování přežvýkavců, jejich původem, působením a příklady jejich projevů. Druhá část se zabývá hlavními abiotickými faktory, které ovlivňují chování přežvýkavců, jejich původem, působením a příklady jejich projevů.

Klíčová slova: Biotické faktory, biotické faktory, přežvýkavci, chování, zvířata, fyziologie, skupina, stádo, velikost

Table of contents :

1. Introduction

Every organism inhibit influence of external environment to maintain his own internal state i.e. all life functions – living, growth, reproduction, thermoregulation or energy expenditure. All together of these conditions create his natural environment (forest, desert, steppe, group etc.). Between live organisms and surrounding environment exists a very close relationship. Environment influences organisms (its action and during this process the influence is accepted and after organism give response (reaction). Single environmental factors have a negative or positive (sometime neutral) meaning for live of organisms. All parts of environmental neighborhood we indicate as ecological factors.

Environmental or ecological factors influence all of the animals life cycle (Losos, 1984) excluding the environmental factors such is geographical components like geographical latitude, elevation like above see level. Any of these components do not influence life of animals directly.

The response of animals to environmental factors are different, mostly are proved in physiological changes and changes in behaviour (Losos, 1984). According to Losos (1984, p. 22) is possible to classify environmental factors into two main parts. The first are biotic factors. Biotic factors are proved like relationships among organisms, animals of different species or between conspecifics. Biotic means living, and biotic factors are the other, living parts of the ecosystem with which an organism must interact. Biotic factors which influence ruminants are for example predators and other animals and organisms, humans and also relationships in the group of animals – sexuality, fighting, hierarchy, calving and mothering and many factors in all the social organization of the herd. All the factors can influence the ruminants in many different ways. For example in moving for water or food supplies, annual cycle, which influence plant growing or water availability. There are also factors which influence mortality in life of ruminants, for example predators, drought or diseases and parasites. Second part describes abiotic factors– all physical and chemical characteristics of the air, water and soil. Abiotic components are the non-living components of the biosphere. Chemical and geological factors, such as rocks and minerals, and physical factors, such as temperature and weather, are referred to as abiotic components. Abiotic factors are also climatic, along with the amount of sunlight, salinity, and pH. For ruminants is interesting climate, temperature, weather, humidity, food, water and some others. Environmental factors may be also duration of night and day, which influence ruminants in their behaviour or group size and much more, which are described below.

2. Basic visual displays of eland (According Underwood, 1975)

GAITS

-Crawl: The animal moves very slowly with at least tree feet on the ground at all times. There is a transverse sequence of footfalls. Used mainly during grazing (Underwood, 1974)

-Diagonal walk: The slower forms are used for movements when within a small stationary group, while the faster forms are typical as animals avoiding aggression, of animals moving between groups and of groups moving from one local point in their home range to another.

-Trot: There is many forms of the trot, but two it seems two forms are normally employed – the first form is “trot“ and the second “extend trot“. The first is possible to see during some group movement, during aggression and by calves to play. The “extend“ version distinctive and is use in during flight and calves at play. (Underwood, 1974)

-Canter and Gallop

Use in extreme panic flight or else in playing calves

LEAPS

Some kinds of ruminants, especially in eland or gazelles, is possible to see perform leaps. It looks very much as if the animal is leaping over some invisible object. In play, this jump sometimes appears to be elicited by unevenness in the ground. (Underwood, 1974)

ALERT AND INVESTIGATORY

Many kinds of non-domestic ruminants apply this type of behaviour in danger.

LYING

-Normal Lying

The actual process of lying is similar in much kinds of large ruminants. Activities in lying -

normally grooming, sleeping or doing nothing. (Underwood, 1974)

GROOMING

This activity is specific for every kind of ruminants. Among some African types of ruminants involve two actions, scratching and licking.

GRAZING

One of the main life activity of ruminants is grazing, there can be found two forms behaviour in this activity:

Intensive grazing the animal stay almost in approximately place for several minutes,

In „casual“ grazing is the animal moving. It has it's nose low in investigation of the ground and time to time take one or two bites. (Underwood, 1974)

BROWSING

Some kinds of large ruminants use the special method of gain the feed. This method is called browsing. In feeding off trees or shrubs, the animals shows two types of behaviour: firstly fixation of attention on the plant, approach and feeding from the available leaves. Secondly, hooking the horns into the branches and brake off all inaccessible branches.

URINATION AND DEFECATION

The bull urinates in slow, weak stream, while the cow product large volume of urine, rapidly and strongly. Some kinds of ruminants showed an interest in other's urine, drinking it while it flowed, licking and sniffing the urine when it is on the ground and sometimes rubbing their faces in the urine. Sometimes the animal use flehmen – testing the urine of the other animals.

3. RUMINANTS - PHYSIOLOGY

Pre-gastric ungulate (ruminants, e.g. cattle, sheep, goats, giraffes, camels, antelopes etc.) has its own anatomical and physiological adaptation and behavioural implications. Adult ruminants are polygastric with a three- or four- chambered stomach. In the latter species (e.g. the cattle) there are the rumen, reticulum, omasum and abomasum (or true stomach), while camelids lack the omasum The rumen is the first chamber and is a fermentation „vat" of active bacteria, protozoa and fungi. Digesta is processed further in the reticulum ‚from which it is regurgitated as „cuds". After rumination, food passes back to the rumen for additional fermentation, before passing to the omasum for further mechanical processing, and than to the „true stomach" or the abomasum, where ruminal microorganisms are digested (Schmidt-Nielson, 1997)**.** This type of digestive apparatus has several behavioural implications. First, non-foraging mouth movements in the form of rumination are the key part of behavioural repertoire, e.g. occupying 6-8h/day in cattle (Phillips 2002). There is interesting, that rumination can be accompanied by non-REM sleep (Tobler & Schweirin 1996). Second, the type of food selected and its intake rate affect ruminal microbial action: constraints which half shape ruminant foraging behaviour. Third, because fermentation generates organic acids, ruminal pH must be controlled to protect the stomach and sustain microbial fermentation. This is largely achieved via salivation, which peaks during chewing and rumination, the salivary bicarbonates and phosphates acting as buffers when swallowed (Sauvant et al. 1999). Fourth, stomach development is itself shaped by the food ingested. In calves, for example, the digestive tract only fully develops post-weaning, the rumen not beginning to function until animals begin consuming solids (Van Soest, 1994). So if fed non-naturalistic foodstuff, rumino-reticulum development is altered, e.g. zoo giraffes can show grazer-like reduced ruminal surface areas and very well developed reticula, compared with wild , naturally browsing conspecifics (Hoffmann and Matern 1988).

Modern ecology has only one body of diet predicting theory – the natural selection acts to maximise the capture rate of some nutrient (Westorby 1974). In the case of ungulates (ruminants), this theory has been supported by studies of selection for specific nutrients. Studies of selection for example in African ungulates have shown selection for vegetation type (Vesey – Fitgerald 1960), individual species (Lamprey, 1963) and plant parts (Bell 1971). Several of these studies have been directly correlated with nutrient content (Roth & Osterberg 1971).

General model of antelope feeding strategy in which the nature and dispersion of food items determines the feeding style. Large antelope are capable of surveying and moving over larger areas than small antelope, but cannot, for physical and physiological reasons, feed delicately enough to select the highly nutritious parts of plants from parts of low value. They, therefore, tend to feed on large quantities of continuously distributed species while smaller animals are more selective. There is five feeding styles based on this considerations (Jarman 1974).

Within the physical and physiological constraints given by Jarman's theory, selection for plant species and for seasonal variation in food value occurs. There exists a model of „fallible nutritional wisdom“ in which an generalized herbivore is capable of detecting its own needs and the value of its food intake in meeting those needs. There is a continuous intake of food, which is characterized by tendency of explore food plants and whose efficiency as an overall diet is assessed by long delay learning (Westorby 1974).

Eland are very flexible in their feeding behaviour. This is shown both in their choice of individual food species in response to their nutritive values (Kerr et al. 1970) and in their change in feeding style thorough the year.

The switch from grazing to browsing in the dry season is probably a response to the drop in food values in the ground level forage and change the food orientation to higher level. In the short term, eland can be very selective, even in midwinter. The basis of this selection is probably either directly or indirectly on the nutritive value of the plants available (Westorby 1974).

Jarman (1974) classifies eland as having a type „E“ feeding strategy. It means, that they have a broad spectrum non-selective feeders, who rely on taking in large quantities of low value forage for their food requirements. However, observations on the short term movement of eland and their response to local flushes and to seasonal changes in vegetation suggest, that although they are capable of surviving on a type „E“ diet, they may also employ a style „C“ feeding strategy under the right conditions. Style „C“ has animals who „feed on a range of grasses and browse, rather selectively, in a range of vegetation types within a fairly large home area. The diet changes seasonally, as does their preference for vegetation types (Jarman 1974). The interpretation of feeding strategy used by the more opportunistic feeders will depend greatly on the local conditions, especially on food distribution. If, for example, the main food source of eland were forbs, its feeding strategy would be considerably different to that if it were feeding on tuffs of grass.

Apart from the food level taken, eland have another feeding characteristic. Their nibbling and stripping techniques which will affect the nature of the food available to them give them greater selectivity than a straightforward cropping technique. Instead of using the tongue to take in the tussock of grass or whole forbs, antelope are capable of being much more selective than an other ruminant – buffalo. Whether this make eland more efficient feeders will depend on whether these methods will yield more concentrated food types than buffalo's feeding style and on the digestive efficiencies of the two species.

As eland are usually timid and difficult to observe when free-ranging, they are often only mentioned in passing even when constituting a major part of the herbivore biomass (Mason 1973). In research of social behaviour of ruminants, Underwood (1974) describe behaviour of eland like representative species of semi-domesticated ruminants and try to explain semi-domestic ruminant's ecology on the species of eland.

Feeding habits and population structure are important in determining the social organization of species and the organization of eland activities reflected changes in the influence of environmental factors on their behaviour.

4. Biotic factors

4.1 PREDATORS

Predation is the biotic environmental factor, which has undoubtedly influence on ruminants behaviour and all the herd. Grouping of animals and size of herds has a relation to the types of predators, which the animals have to defend – for example animals of the open plains are subject to attack by lions, cheetah and hunting dogs. They group together in the hope that it will be the other, which will be hunted, rather than an instinctive belief in safety in numbers. (Spinage, 1986).

In the first line, the predators influence ruminant's survival. Predators in one hand and parasites in the other hand. In fact, predation does not seem to be important for the adults of some large ruminants, of which only small per cent fall prey to carnivores. The young are more vulnerable.

For example the pronghorns in North America need to be especially vigilant in the spring. The fact that spring lambing period coincides with coyote birthing can lead to high predation because coyotes need to feed their pups (Shelton, 2004).

There may be a relationship between seasonal risk of predation and group size in some species. Females of both impala (*Aepyceros melampus*and) greater kudu (*Tragelaphus strepsiceros*) in southern Africa gather in rather larger groups at the time of peak calving than at other times of the year. Although this also happens to be a time of abundant food supply, it was suggested that this aggregation is a product of the increased risk of predation brought about by the presence of calves.

Predators like biotic environmental factor urge the ruminants to anti-predator behaviour. It is prove in four type of behaviour, which ruminants apply in case of predation (Jarman, 1974). It is i) avoidance of detection by, contact with, or exposure to predators; ii) flight after detection, but before attack; iii) flight under attack; iv) threatening, or even attacking, the predator (Jarman, 1974).

4.1.1 Typical group size and the requirements for grouping.

For a number of animals in herd to form a prolonged, cohesive and co-ordinated group while feeding the individuals must move at similar average speeds, in roughly the same direction, and within perceptual range of each other. If there are strong advantages in neighboring animals following divergent feeding paths, or if individuals must move at very different speeds to meet their feeding requirements, or if they must keep so far apart that they do not respond in co-ordination with each other, the group will fragment. Feeding style in most species places a limit on the maximum number of individuals that can feed together as a co-ordinated, cohesive group, it´s dynamisms is influenced also by much more other factors, for example predation, calving, sexuality, hierarchy and other relationships among animals in group. Wild ruminants can create many types of groups – from one, pair or three members in one group, for example dik-diks in Africa to hundreds and thousands individuals in one herd like some buffalos or eland (Jarman, 1974).

4.1.2 Group size and predation (According to Jarman, 1974)

There is close connection between the size of herd and predation. The specie's reaction to its food supply and to the threat of predation interact to produce the typical group size. In several species the typical group size varies with seasonal or regional variations in availability and dispersion of food, and similar variations in group size may in some in- stances be associated with variations in the threat of predation. Some types of ruminants mass into the herd because this behaviour provides many advantages. One of the advantage is the protection against the predators. The herd is influenced by many factors, which affect it's display. Predation as the environmental factor influence displays of the herd, especially in the dynamism. When the predators attack the herd, animals in the herd have many possibilities, how to react and defense. Often all the herd stop its present activities and animals are concentrated mainly to the predators. Some, especially in small groups try to by inconspicuous. In the presence of predators the group either freeze, lie down and freeze, or run to cover and freeze. Under attack from larger predators some species run, sometimes in a specialized fashion, like impala, a herd of which may "explode" in all directions at the moment of attack, quickly reuniting to run away. Some other species like wildebeest or hartebeest save in the anonymity of the herd (Jarman, 1974).

4.1.3 Movements in response to other factors (According to Underwood, 1975)

Movement of animals are not influence by food resources only, there are some other factors. This factors can be divided into two distinct groups – social and physical.

Social factors

The movement of individual animals are governed partly by the behaviour of other members of the group. The cohesion of the group is maintained by „voting" determinated the group activities. When an animal starts to move away from the group, other individuals, who are ready to move may follow suit, while animals which are in the midst of a bout e.g. ruminating are less likely to follow. Whether the initial movements results in the whole group moving depend on how the first individuals are moving (for example in flights, trot, at a walk to some definite objective, grazing etc. - see also Chapter 1 – Basic behaviour types). Moving depend also on the state of the group, whether it is at ease or has recently been disturbed, its composition (calves are more ready to follow than other classes), the number of animal in the initiating the movements (single animals, whatever they are doing, will rarely ignore movements by the rest of a large group). There are some other factors like time of day, season, ecotype, terrain.

4.2 BEHAVIOURAL RESPONSE TO PRESENCE OF A HUMAN

Presence of humans is one of the environmental factor, that influence behaviour of ruminants. But ecological variables such a food selection or predation are relevant for animals in the wild. Wild animals in captivity often maintain natural patterns of behaviour although obvious ecological differences exist in the captive environment. Valerie Del Thompson (1989) focused to the environmental factor a human (zoo-keeper) and responses animals to his presence.

The first reaction of animals to presence of zookeeper is stress, which is manifested in some ways. The first reaction is visual orientation and approach, and also the amount of time devoted to eating and drinking and the number of vocalizations. Time spent eating and drinking significantly decreased when the keeper was in the enclosure and also increase number of vocalizations (Thompson, 1989). Next behavioural response is vigilance. Animals in zoo are not subject to natural predators, they are vulnerable to capture by their zookeepers. The animals would react to zookeepers as they would be a potential predators and increased visual orientation towards the zookeeper. Visitors-oriented responses by zoo-animal may also account for interspecific vigilance between exhibits, because neither the visiting public or neighboring species of animals commonly represent either a source of danger or a source of food (Thompson, 1989).

5. Abiotic factors

5.1 FOOD

<u>5.1.1 Food selection</u>

The food selection is one of the most influencing factor of animal´s behaviour. The food selection by animals is highly variable, depending on availability, preference and, apparently, nutritional requirements (Skinner et. al., 1967). It is necessary to say, that the food selection availability, preference and nutritional requirements are factors, which influence behaviour of all the ruminants.

Ruminants select nutritious diets from a diverse array of plant species that vary in kinds and concentrations of nutrients and toxins, and meet their nutritional requirements that vary with age, physiological state, and environmental conditions. Thus, ruminants possess a degree of nutritional wisdom in the sense that they generally select foods that meet nutritional needs and avoid foods that cause toxicosis. There is little reason to believe that nutritional wisdom 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. (Jarman, 1974)

Young ruminants can learn from mother and peers what is and is not appropriate to eat, and this apparently plays a critical role in the transmission of nutritional wisdom among generations.

Goats evidently eat small amounts of each food, and during the next few days they limit intake of the potentially microflora in the rumen. Animals eat nutritious plants that contain toxins, but they generally limit intake in accord with the concentration of the toxin. Unpleasant feelings of physical discomfort (i.e., malaise) are caused by excesses of nutrients and toxins and by nutrient deficits, and animals acquire aversions to foods that cause malaise. Toxins cause malaise, which in turn causes animals to eat small amounts of a variety of plants .For example, goats prefer older twigs to current season's twigs from the shrub blackbrush.

The result of selection is usually to take food items rich in protein and deficient in fiber; occasionally plants may be taken for their water, sugar, or mineral content. Selection can be seen to be performed at several different levels. For example an antelope may first select the vegetation type that will best satisfy its feeding requirements; this is a major part of habitat selection. Within the vegetation type it may select the stands of plants or the species that most suit it, and then from those plants it may select the parts which it finally eats (Provenza, 1995).

5.1.2 Availability of food

This factors is sometimes changing and influencing by rainfalls, climate etc. Many species of ruminants are living in areas, where is the best availability of food for them and they are adapted for obtaining food in conditions of areas where they live. For example antelope communities are most diverse, in numbers of species, and produce the greatest biomasses, where plant production within two meters of the ground is greatest, as in grassland, savanna, or light woodland.

5.1.3 Movements in response to food resources

Availability is particular problem because of the mosaic of vegetation types, which vary on composition even in different stands of the same type. An animals daily movements might take it through many such stands. There is also different availability of vegetation types at various times of the year (Underwood, 1975).

The example of food selection is demonstrated by the eland. Several cows were using one area and fed almost completely in the *Acacia caffra*, *Combretum apiculatum* and *Themeda triandra* tree savanna (Theron 1974). The preferences were shown in the vegetation utilized. The proportions of grazing to browsing varied considerably through the year. Eland feeding on freshly burnt areas in summer necessarily ate only grass or else browse from over one and half meter off the ground. Changes occurred throughout the year and from one vegetation type to next – even in midwinter the animals were not limited to one food plant or even one stratum of the vegetation. In one vegetation type e.g. The hydrophilic communities, the lowest level may bear the main winter food plants – still-green grasses, *Olea africana* seedlings (a favorite food) and forbs. Nearby in the *Acacia* sp. communities is the main food source and would be at the higher vegetation levels - evergreen *Euclea crispa*, *Acacia* sp. leaves and towards the end of dry season, blossoms.

5.2 CAPTIVE AND WILD – FACTORS INFLUENCE THE MORTALITY

The captive and the wild are two states, which influence behaviour of ruminants. In this chapter is explained, how the captive and the wild influence factor mortality.
There are some differences in mortality in the captive and in the wild, this could be easily explained on semi – domestic ruminants, which is possible find in both state. Semi – domestic ruminant is the eland and Underwood (1974) describe differences in mortality between captive and wild animals by them.

The high mortality of unweaned calves is surprising, considering that there are few predators in Loskop reservation Like black backed jackals (*Canis mesomelas*), there are also some leopards (*Panthera pardus*) and brown hyena (*Hyaena brunnea*). There were small percent of predation on animals. Almost all mortalities were due either to accident, disease or unknown causes, the latter deaths were usually attributed to snakebite (Underwood,1975).

In semi – domesticated herd of eland in Rhodesia, mortalities during firs months of life were 32% (Roth et al. 1972), which were mainly caused either by difficulties with the birth itself or else by poor mothering by the dams. In either case, such a calf would be unlikely to be sight in the wild, which may account for the low maximum of calves and would indicate that the population size is underestimated. When calves were take in captivity at Loskop, the survival rate from birth to weaning was 80 – 100 per cent. Animals kept after this age almost invariably survived till their release and the adulthood. Mortality in the captive unweaned calf and young to juvenile classes is therefore much lower than in the wild. The main advantages offered by the management regime used were veterinary care and supplementary food, both in the late stages of pregnancy and for calf and dam while the calf was suckling. Also there was almost complete protection of calves and dams from predators.

5.3 DROUGHT

In some areas where ruminants live, they can fight against the environmental factor, which is often lethal to them. The drought influence the animals mainly in areas, where is rare rainfalls and during the year a lack of water.

During a drought, animals generally die of a lack of food rather than from a lack of water. There is a problem, that if the animal stay permanent near the water supplies, the food in the neighborhood quickly becomes eaten out. In the other hand, if they range too far away searching for it, then of course they will die of thirst. For example the desert species in Niger did not move south for water but for food (Spinage, 1986).

Disease, predators and drought are today the main environmental factors in Africa and other places, where desert and sub-desert species live, which influence mortality of ruminants and the other animals also. With greater part of Africa prone the periodic drought, this factor alone is probably the most widespread and the most important factor limiting the numbers of herbivores today (Spinage, 1986).

5.4 WATER

Water as abiotic factor, which influence all living organisms in the world. Ruminants depend on the water and its obtaining influence their behaviour in migration for water sources and form their food strategy – they try to obtain water from very different plant species. The ruminant's behaviour influence also rainfall, presence of rivers and lakes.

Independence from free water, or the lack of a need to drink, represents the greatest challenge facing to evolution of mammals. Its achievement signifies the highest level of specialization (Spinage, 1986).

Early explorers, hunters and naturalist, made frequent reference to the fact, that some species of antelope appeared to exist without drinking, especially the addax (*Addax nasomaculatus*) and scimitar-horned oryx (*Oryx dammah*). But just as remarkable is the tolerance to heat of desert species. At Sahara dessert the temperatures may reach 50°C, and on sand dunes as much as 70°C. And of course nights can be bitterly cold in the desert, but paradoxically this may help the animals to survive here (Spinage 1986).

In the hot environment antelopes (and also other ruminants) are faced with two apparently incompatible challenges: maintaining body temperature and conserving the water. Since water is used to cool the body to maintain its temperature, there is possible to see the difficulty with which animals are faced in this environment. An object gain heat from the environment in proportion to its surface area, but as the surface area doubles in size, so the volume trebles. Thus the larger the animal, then the less the surface area. But this does not to lead to large size in desert animals, because once the larger body is heated up, it than has the problem of getting rid of the heat. The happy medium seems to be achieved by gazelles in the range of 18 to 70 kg weight, although the addax can weigh up to 120 kg, while at the other extreme are the dik-diks of 4 kg (Spinage, 1986).

5.4.1 Obtaining water

None of ruminant can exist without drinking water, but is does not necessarily have to be free water. Antelopes of arid region obtain their water from eating of succulent plants and from eating at dawn, when the vegetation is clothed with a dew. The Grant´s gazelle end the beisa (*Oryx beisa*), for example, have been found to eat a leaves of a plant called *Disperma* sp., which is so dry and shriveled during the daytime, that it can be crumbled to dust in the fingers, its water contains only 1 per cent. But during the night it absorbs water like blotting paper and the moisture content rises to an amazing 30 per cent. This has been shown to be ample to cover the water needs of these species of antelopes (Spinage, 1986).

Water can be also obtained from the break-down, or oxidation, of food. For every gram of hay that a gazelle digested, it obtained half a gram of water. The production of water from fat deposits however, is now generally considered to be improbable as a strategy, contrary to what was once thought, for the chemical reaction involved in the breakdown demands more water that it produces.

It is reported for the addax (and it has been also for the elephant) that it possesses a compartment in the stomach containing water. Such water is of course no more than the ruminal fluid, which is indeed likely to be more watery in a concentrate feeder which takes in little bulk (Spinage, 1986).

We may divided antelopes into three categories: firstly there are those that do not and will not drink water, even when it is available to them. This category includes, for example, such species as the addax, scimitar-horned oryx or the gerenuk. There are then those, which can make do without, but will drink when water is available. Among these we can list the Cape eland, which although able to exist in fairly dry conditions, when penned and unable to wander in search of the succulents that it depends upon for its water, requires as much drinking water as cattle. Finally there are those which cannot do without drinking water, of which one of the most extreme example is the waterbuck.

5.4.2 Conserving water (According to Spinage, 1986)

After an antelope has taken in water, whether free or in the food, then where water is limited it must try to conserve it. Water loss takes place through the urine, the faeces, respiration, and panting or sweating.

The first three avenues of loss are concerned with the maintenance of essential body activities, the latter with maintaining the body temperature or homeothermy. A mammal normally maintains its body temperature within fairly narrow limits, for if the temperature rises to high damage to the brain is usually the firs effect, followed by a general breakdown of cell function.

To control water loss some species use one method, some other, and yet others rely upon a combination of methods depending upon the extremes of temperature, which they are adapted to withstand. Is possible to see, how the circulation of urea through the rumen has been proposed as a possible mechanism for water conservation, as it is primarily for the removal of urea that the urine requires relatively large amounts of water. But almost all species concentrate the urine, the know exception being the waterbuck (*Kobus ellipsiprymnus*). All species also reduce the amount of water loss in the faeces. Each liter of air, which is exhaled during respiration, contains about one two-hundredth of cubic centimeter of water, which does not sound much, but a liter of air is soon expelled by a large animal and this loss totals up to about a liter of water per day per 100 kg of body weight. This can be kept down by a lowered metabolic rate, achieved by resting during the heat (Spinage, 1986).

5.5 TEMPERATURE

5.5.1 Cold and hot environment

Studies have shown how temperature, affect grazing behaviour in ruminants. Animals will shift grazing periods and alter total grazing time in order to avoid extremes of heat or cold exposure. Changes in barometric pressure and resulting weather changes will also trigger changes in animal movement and foraging activities. Reduced grazing time is often made up for by an increase in bite rate (Fraser, 2004).

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. Thermal cover, in the form of natural relief or trees, reduces heat loss due to radiation and wind. Research has shown that sheep lying down experience 20% less heat loss than sheep standing up. Positioning of the body to maximize exposure to the sun also helps to reduce heat losses. The cost of grazing activity may exceed the nutritional value of forage harvested under cold conditions, and animals may compensate by remaining inactive. Feeding periods may also be altered to coincide with periods of maximum sunshine (Fraser, 2004).

5.5.2 Physiological responses

During extremely hot weather, animals lose heat through sweating, panting, and re-radiation. Panting costs an additional 7–25% over resting metabolism, and water consumption must increase in order to replace the fluids lost during this process. Food intake is consequently reduced due to the distention caused by water intake, and overall production declines accordingly. Large animals are capable of increasing their body temperature slightly during the day and radiating this extra heat by night; small animals do not have this luxury. Animals respond to cold stress by increasing metabolic rates once a lower critical temperature is reached. In order to meet this additional energy demand, they must increase forage intake or burn fat and protein reserves. During cold weather, forage digestibility is reduced and livestock may compensate for this by increasing passage rates and consumption (Fraser, 2004).

5.5.3 Maintaining body temperature

Ruminants have to have almost no change in internal body temperature, and every species try to keep continual temperature. But in different conditions every species have different methods how to do it. Maintaining body temperature raises greater problem. The hotter the environment usually the cooler it is at night. An animal can thus lose heat to the environment at night in the desert, and thus in contrast to that found in Arctic mammals which need to conserve heat, the thickness of the coat decreases with increasing body size, favoring heat loss rather than protection against heat gain. But in the humid regions for part of the year it can be just as hot at nights as during the day, and this may be limiting to some species (Spinage, 1986).

The effect of simulated hot desert conditions have been looked at in a range of antelopes in East Africa, namely the Grant´s *(Gazella granti)* and Thomson´s gazelles (*Gazella thomsoni*), oryx, wildebeest (*Connochaetes gnou)* and eland. Evaporation, in the form of water lost be panting and sweating accounted form from 58 to 83 per cent of the total water lost when the animal could drink freely, the rest being lost in faeces and urine. When the animals were dehydrated, evaporation was reduced by from 12 to 51 per cent, the amounts being equal to, or greater than, the combined reduction in loss by faeces and urine. When evaporation under a heat load was compared with that a normal temperature, 22°C, it was found that the increase in evaporative water loss was equivalent to 2 to 3 per cent of body weight per day when water was calculated that under the latter conditions, the additional water of evaporation required for a twelve hour day at 40°C, was reduced by 0.04 to 2.2 l per 100 kg of weight per day. Thus the hotter and drier the animal, the less water it loses (Spinage, 1986).

5.5.4 The methods of dissipating the heat

Large and small animal use two different methods to dissipate heat. When water was in short supply small gazelles, such as the Thompson's and Grant´s, allowed their body temperatures to increase until they exceeded the surrounding air temperature. The smaller the animal, than quicker does this take place. A large animal like the eland, by contrast, has a low body temperature in the morning and warms up slowly through the day when subjected to the same conditions as were the gazelles. The oryx use a combination of both methods (Spinage, 1986).

5.5.5 Saving water and cooling by evaporation

Once the highest temperature that the animal can withstand has been reached, then it must use evaporative cooling. So if a large animal, such as the eland, has taken until mid-day to warm up, it then only has to maintain evaporative cooling for about five hours until the air temperature drops in the evening and it can start losing heat to the environment (Spinage, 1986).

This is an effective way of saving water in a larger animal because of its smaller surface area, relatively speaking, and its lower rate of metabolism, than that of a smaller animal.

The small animal, however, may reach a higher body temperature within one hour, and must then spend the rest of the day keeping it from rising higher, but by letting its temperature rise it saves on evaporative cooling. Both the Grant´s gazelle and the oryx were found to let their body temperatures rise much higher than other species which were investigated (Spinage, 1986). In contrast to gazelles and the wildebeest, which pant, the oryx sweats. But when dehydrated, the oryx no longer sweated, even when the air temperature was as high as 46°C (Spinage, 1986). Both the Grant´s and the oryx could maintain the body temperature of 46.5°C for up to six hours with no observable ill effects, although such temperatures of internal body are lethal to most mammals. This result in large water saving, for in an air temperature of 45°C an antelope with a body temperature of 46,5°C will no longer gain heat from the environment, but *will lose heat to it.* This tolerance to such high body temperatures may be the key to the success of the desert antelopes. But there is a question: How can they tolerate such temperatures when other's can't?

5.5.6 Physiology of tolerance to high temperatures

Dr. Taylor of Harvard University, who conducted most of these experiments, suggested that the arterial blood to the brain is cooled by venous blood returning from the nasal sinuses be means of the *rete mirabilia*, the „marvelous network". This is a small, sponge-like network of the carotid artery about the size of a large pea, situated at the base of the brain, and which lies in a venous pool of the blood returning from the nasal mucosa, the internal linings of the nose. This is the same structure that has been proposed as preventing giddiness in the giraffe, when it suddenly rises its head from ground level to nearly 5 meters high (Spinage, 1986).

All of the antelopes have long noses which house large, delicate sinuses whose function may be designed to cool the blood, as well as providing them with a large sensitive area for scenting purposes. When this cooled blood comes into close contact in the *rete mirabilia* with the warm arterial blood which is on its way to the brain, an exchange oh heat could take a place, as has been demonstrated in the sheep. But this can only be part of the explanation, for it is inconceivable that the blood could lose 8.4°C, the difference between normal body temperature of a Grant´s gazelle, 38.1°C, and the body temperatures that it can reach of 46.5°C, in the time taken for two cross-currents of blood to pass one another (Spinage, 1986).

These experiments served to explain an apparent paradox surrounding the Thompson's and Grant´s gazelle, for whereas the latter inhabits drier and hotter country than does the Thompson's , yet it needs more water. Now under a heat load, evaporation accounts for most of the water loss in both species when drinking water is freely available. This amounts to some 80 per cent, the losses from urine and faeces being relatively minor. When the temperature is 40°C, a very hot day in northern Kenya, both animals pant. Although both have functional sweat glands water loss did not increase significantly via this pathway because the animals tended to sweat in burst. However, if water was restricted, then they both stopped panting, the loss by evaporation being reduced by 63 per cent in the Thompson's and 31 per cent in the Grant´s. The animals then let their body temperatures rise to 41.6°C and 41.0°C in the Thompson's and Grant´s respectively, compared with their normal temperatures of 37.8°C and 38.1°C. The paradox is that the Grant´s requires more water for evaporation than the Thompson's because it has only reduced its evaporation by 31 per cent compared to the Thompson's 63 per cent. There is an other question: How they can it live in hotter and drier areas?

5.5.7 Possibility of living in the heat and dryness

The answer was found when both gazelles were exposed to the heat of 45°C, a temperature which the Thompson's gazelle would probably not normally experience. When the temperature jump over 42°C, the Thompson's increased its evaporation by panting in order to maintain its body temperature well below the air temperature, so that it was only 42.5°C when the air temperature had reached 45°C. But the Grant´s, on the other hand, allows its body temperature to raise to 46°C, thus conserving water that would otherwise be lost by increased evaporation. Like other desert antelopes it would let its body cool down at night, when the ambient temperature had fallen. Thus, contrary to the Thompson's, it can exploit a relatively waterless environment where the temperature is likely to rise to high levels (Spinage, 1986).

But Dr. Taylor´s detective work on this species didn't stop here, because the Grant´s still requires about 1 to 3 l of water a day, equivalent to some 4 per cent of its body weight of 45 to 80 kilograms. By watching the Grant´s during a drought in an arid area of northern Kenya, Taylor found that they fed at night on *Disperma*, which we have seen was able to amply furnish the Grant´s water requirements with the water that the plant absorbed from the night air (Spinage, 1986).

True desert species, such as the addax and the scimitar-horned oryx, have probably developed such a such strategies as we find in the Grant´s gazelle to an even higher degree. What is surprising about them is their tolerance to heat and ability to remain in the open under a scorching desert sun during the hottest part of the day without apparent discomfort. But Brocklehurst, who hunted addax in 1920s when they were more plentiful, found that they would huddle together under the sparse shade of an isolated thorn tree during the heat of the day whenever such protection was available. He also found that when the nights were cold they would lie in hollows in the sand, which they had dug out in order to get at the roots of a small shrub (Spinage, 1986).

5.5.8 Changing colours of the coat

The addax changes it color with the season, being pale to almost white in spring and summer and grayish brown to brown in autumn and winter. It is instructive in this respect to see how the kongoni (*Alcelaphus buselaphus cokei*) or Cokey´s hartebeest (*Alcelaphus buselaphus*), an eastern race of the bubal hartebeest (*Alcelaphus buselaphus buselaphus*), which remains out of the sun during the hottest of days, manage to cope with its environment. It is obviously not as advanced in this respect as the now extinct northern race must have been, nor indeed the western race which extends its range up into the sahel (Spinage, 1986).

Like the gazelles, the hartebeest use panting for evaporative cooling, but the tip of each hair of the kongoni´s coat is white, the stem reddish-brown. This combination produces a somewhat light-coloured coat, which reflects incoming sunlight by as much as 42 per cent, compared, say, to the Cape eland, whose reddish-colored coat only reflects 22 per cent. Thus only slightly more than 50 per cent of the incoming heat load can be absorbed. We can now see why the addax changes its coat color with the season, the desert winters being sufficiently cold to necessitate some increase in heat retention. Radiation also penetrates more deeply into loose, than into dense, flat coats, and here the hartebeest gains again. In total it loses about 25 per cent of its heat load by evaporative water loss, panting accounting for nearly twice the amount lost by sweating. Panting has been suggested as a more effective means of keeping the body temperature down, because the body surface temperature will than be higher and thus attract less inflow of heat from a hot environment.

As in desert animals, the kongoni has considerably lower fasting metabolic rate (that is, the rate of energy turnover when it is not feeding) than have such species as the wildebeest or the eland. The kongoni also requires only 72 per cent of the water that an eland does as a result of its heat-combating strategies (Spinage, 1986).

The East African beisa oyx is another antelope that has been shown to require very little water, a fully grown bull weighing 20 kilograms needs only slightly 4 l a day - almost half of that required a wildebeest (Spinage, 1986). In a hot environment this only increases to 6 l, still less than wildebeest needs at the temperature of 22°C, a cool African day. But the wildebeest strives to keep its body temperature constant, even in temperatures of up to 50°C, panting in preference to sweating. This difference in water requirements explains the difference in distribution between the two animals, with the wildebeest limited to moist woodland and the oryx able to inhabit semi-arid regions (Spinage, 1986).

Most attention has been paid to the physiology of the eland, in view of a supposed potential for domestication. But it has been demonstrated that, where water is limited, than the oryx is far superior as a potential meat producer. Studies of the eland physiology have been restricted to the Cape eland, which although preferring the moister woodlands, also ventures into semi-arid country, traveling long distances from water. By contrast, the Giant eland favors higher rainfall areas, but its physiological demands are as yet unstudied (Spinage, 1986).

5.6 WIND

Other environmental factor is wind (mainly its direction and strength) is important in daily activities, especially movements. The orientation of the group of animals with respect to wind depends on some other factors or conditions (Underwood, 1975). For example it is size of the herd, size of the animals, wind force and intensity and, of course, landscape and terrain. Wind influence the herds of ruminants especially in the wild. But some ruminants, which live in temperate climatic zone and in forests are influence less (elk, deer etc.) than animals living in the places almost without trees and forests – savannah, dessert (steppe antelopes as hartebeest, wildebeests, eland or saiga etc.). For example eland sometimes almost follow the wind direction, the herd movements seem very closely linked with the wind (Underwood, 1975).

5.7 RAIN

The major vegetation zones in places were ruminants lives are largely determined by the seasonality and quantity of rainfall, and altitude. Where rainfall is heavy and well distributed through the year forest grows; where it is less heavy but still well dispersed, non-deciduous woodland, or savannah, or grassland grows; where it is less heavy, but strictly seasonal, deciduous woodland or scrub grows; and where it is light and erratic desert, or semi-desert, scrub is the only vegetation that will be supported (Underwood, 1975). Ruminants are found in almost all the numerous vegetation types, but their representation in each varies considerably in terms of the proportion they form of the local animal biomass, and of numbers of species. This variation is related to one characteristic in particular of the vegetation communities. There are animal communities, savannah and certain light woodland or grassland communities, such an antelopes, desert plant communities or forest communities, such a elk (Underwood 1975). But most of ruminants does not live in one type of vegetation region and migrate there where can find the best supplies of the food. For example, for antelopes in general grasses predominate in the available zone of plant communities in grassland, savannah and light woodland, while browse plants predominate in this zone in forest at one extreme of the rainfall gradient, and in desert scrub at the other (Underwood 1975).

The direct influence of rain to the ruminants is sometimes possible to see on their movements. It is also depends on the intensity of the rain. The animals in the rain changes moving, try to hide, flight or stop. When the animals are in heavy downpour, sometimes start to run at the beginning and try to hide. It was possible to see in gazelles. The nursery herd calves were suddenly in heavy rain and the start to run (flight) to particular directions. In milder rain, animals sometimes move into sheltered places (valleys) and try to hide. On the other hand they stay in the open or in light shade. (Underwood 1975).

The effect of rain on movement is also seen in the restricted animals – they tended to remain ruminating or browsing in closed habitats rather than moving into the open.

5.8 DIFFERENCES BETWEEN RAINY AND DRY SEASON

Changes of seasons are proved in many factors. Different plants vegetation, different species of plants, different digestibility and nutrients content in plants, different temperatures, air humidity, change of access to the water for animals etc. The animals (ruminant) react to this periodical changes, often they are repeating behavioural manifestation every year. There can be noticed behavioural changes in migration for food and water sources, another climate conditions and many other reasons (Underwood 1975).

There are differences in daily activities of eland in dry and rainy seasons, especially in the distribution of time spent diurnal feeding activities (Underwood 1975).. In winter, there are periods of grazing alternating with rumination, while browsing tends to occur in early morning or evening. In summer, on the other hand, there is a distinct tendency for animals to ruminate during the afternoon, while browsing has a three to four hourly cycle throughout the day, usually at the expense of grazing (Underwood 1975).

During winter there were four main phases of activity during daylight. The earliest was a sequence of intensive feeding, then ruminating followed by walking. This often involved a move from one vegetation type to another and was frequently either uphill or out into the open flats from the lowland woodland areas. At noon and in the early afternoon, the groups would feed and ruminate in approximately the same spot for two hours or more, then begin a walking/browsing period. The various halts were usually in distinct vegetation types, but no pattern of movement was very obvious (Underwood 1975).

The tendencies of behaviour describe the typical winter groups behaviour, but there was considerable variations of behaviour. These variations were limited by size of area, feeding timetable, internal cycles, opportunism or animal's knowledge of area (Underwood 1975). Opportunism was seen in concentration of animals around food sources regardless of the time of day. Animal's knowledge of the area was indicated by the direct movements to and from stands of vegetation and similar resources – trips to licks and water might be made throughout the day and had the appearance of deviations from the day's route (Underwood 1975).

The summer activity pattern was rather different in several ways. Although the day was longer, most activities showed fewer peaks. This is most obvious in active feedings, in ruminating and in walking. This is probably an adaptation to the afternoon heat, since the main resting activity has it's peak from 14h00 to 17h00 (Underwood 1975).

The typical summer group of eland was therefore usually sighted either resting or feeding in the open, fed intensively, then made a fairly long - about one kilometer – move during the early morning, followed by slower groups as the animals grazed along . After the group stopped, other animals started ruminating or continued feeding. The afternoon resting period finished, when the whole group began moving and feeding again. This moving was sometimes stopped and animals change direction until sunset. Feeding began again after dark (Underwood 1975).

Table 1 : Proportion of time spent on activities by eland at Loskop Dam Nature Reserve in the dry and rainy season. (%)

	Dry season	Rainy season
Doing nothing	10	19
Ruminating	24	22
Grooming	2	3
Walking	7	12
Grazing	39	34
„Normal" browsing	14	6
Browsing of the branches broken down with the horns	2	1
Other activities	2	2

5.9 ANNUAL ACTIVITY CYCLE

All the activities, connecting with changes of the seasons, are manifest in the annual activity cycle, which almost all animals adhere. This annual activity cycle help to the animals survive and is based on many years of experiences.

Animals (like eland) do more active feeding during the night in summer than at night in winter. Much more time is spent on feeding activities during the dry season than in the rain season. All non-feeding activities show an increase during the rain season, the most prominent is being inactive. This reflect increase inactivity because daytime heat (Underwood 1975).

In rain season the food is more nutritious, therefore there is less of feeding requirements. Walking also increase at this time and ruminating (the main resting activity) increase relative to other feeding activities. The increase of walking is a result of much clearer division activity in summer, although animals probably move greater distances during winter, these movements are usually part of grazing or browsing periods - summer feeding is much more stationary and is interspersed with walking. Grooming has its maximum later, probably because insect pests continue to increase until cold kills most of them (Underwood 1975).

The annual cycle of activities, particularly feeding activities, is highly correlated with cycles of rainfall, vegetation and other aspect of the ecology. In the short term, the temperature, rainfall and the various nutritional values of the plants taken, are so inter-related, that is not possible to distinguish the effect due to any particular factor (Underwood 1975). According to Underwood, the nutritional content of the available food is probably the most important single factor directly affecting animals at the place, where he took the research. Surface water is there also available, the temperatures rarely drops far below freezing, there is no winter snow and summer temperatures are high but not unbearable. On the other hand it is certain, that temperature, water availability, insect, parasites and much more other environmental factors influence the animals differently in different areas.

5.10 SEASONAL CHANGES IN GROUP STRUCTURE

Changes in group size and composition of animal herds depends often on their seasonal behaviour. It's mean, that the ruminants are influenced by the season and their behaviour as adapted to the seasonal changes. Often in many different ways (Buys, 1987). For example the environmental factors dry and rainy season influence herd structure of animals (Buys, 1987).Changes in group size and compositions followed a strict seasonal cycle. During the rainy season the females and young formed a single herd, but in winter this herd split up into smaller groups, which varied in size and composition on a daily basis (Buys, 1987).

On the herds of eland is possible to see starting formation to the large herds during the summer. Scotcher (1982) postulated, that the formation of this large herds during summer is likely to be a measure for protection of the calves rather than a response to an increase in food quality.

6. CONCLUSIONS

1. The topic of this thesis- Which environmental factors influence behaviour of ruminants?- Literature review – is very extensive, so the thesis is target the two main parts – biotic and abiotic factors.

2. Among the most important biotic factors, which influence behaviour of ruminants, belong interspecific relations – predators and parasites. The species of predators directly affect behaviour of ruminants, their movements and forming of their herds, specially in the wild. In the captivity the big predators have almost no interest. In the captivity is an important factor a presence of humans, which can cause stressful events for the animals especially during handling or manipulation. The second most important biotic factor are intraspecific relations – relationships among individuals of species. There are most important dominance, sexual behaviour and mothering and calving.

3. Abiotic factors are physical and chemical, and both influence directly animals on one hand, on the other hand are in relationships with neighborhood and influence for example by seasonality of plant growth, water supplies etc.

Among most important abiotic factors influencing the ruminants behaviour belongs duration of night and day (influences grazing, movements, ruminating, sleeping etc.), temperature (influences physiological functions of ruminants), wind (influences movements, search for cover etc.), rain (influences movements, food and water supplies, search for cover etc.) or seasonal changes (influences sexual behaviour, forming of the herds or long distance movements- mostly for food and water supplies especially for ruminants in arid areas).

The ruminants live in different climatic zones throughout the world, so there are some differences, which influence behaviour of ruminants. For example in arid areas are the most lethal factors for the animals diseases, predators, food availability and drought.

4. Environmental factors directly influence behaviour of the ruminants and the ruminants react to them. This reactions are proved by behavioural changes and physiological interactions. When the environmental factors impact during long time, it is lead to selection of permanent morphological, behavioural and physiological changes.

5. In the captive ruminants is very important to study and understand all environmental factors, which can influence animal's behaviour, because it helps us to better understand animal's reactions and can exclude a negative influences of the environment.

7. REFERENCES

Bell, R.H.V. (1971) A Grazing ecosystem in the Serengeti. Sci. Am. p. 86 - 93

Buys, D. (1987) The Ecology of Eland (Taurotragus oryx) in the Western Transwaal Highveld, Faculty of Science, University of Pretoria. p. 15 – 78.

Fraser, D. (2004) Rangeland health brochure 8, B.C. Ministry of forest, Range management, p.1 - 20

Hofmann, R.R. and Matern, B. (1988) Changes in gastrointestinal morphology related to nutrition in giraffes. Interbational Zoo Yearbook 27, p. 168 – 176.

Jarman, P.J., (1974) The social organization of antelope in relation to their ecology. Behaviour p. 215 – 267.

Kerr, M. A., Wilson, V.J., and Roth, H.H. (1970) Studies of the agricultural utilization of semi-domestic eland (T. Oryx) in Rhodesia. 2. Feeding habits and food preferences. Rhod. J. Agric. Res. p. 71 – 77.

Lamprey, H.F. (1963) Ecological separation of the large mammals species in tha Tarangire Game Reserve, Tanganyika. E. Afr. Wild. J. p. 63 – 92.

Losos, Bohumil a kol., (1984) Ekologie živočichů, Státní pedagogické nakladatelství Praha, p. 1 - 29

Mason, D.R.M. (1973) Range use and population structure of ungulates in the Jack Scott Nature Reserve. Unpublished Msc. Thesis, University of Pretoria.

Philips, C. (2002) Cattle behaviour and welfare. Blackwell publishing, Oxford, UK.

Provenza, F. D. (1995) Postingestive feedback as an elementary determinant of food preference and intake in ruminants. Journal Of Range Management 48, January 1995, p. 1

– 16.

Roth, H.H., Kerr, M.A. And Poselt J. (1972) Studies of the agricultural utilization of semi-domestic eland (T. Oryx) in Rhodesia. Reproduction and herd increase. Z. Tierzücht. Zücht Biol. p. 569 – 583

Roth, H.H. And Osterberg, R. (1971) Studies of the agricultural utilization of semi-domestic eland (T. Oryx) in Rhodesia. Chemical composition of eland browse. Rhod. J. Agric. Res. p. 45 – 51.

Sauvant, D., Mech, F. and Martens, D. (1999) Components of ruminal acidosis and acidogenic effects od diets. INRA Productions Animales 12, p. 49 – 60.

Scotcher, J.S.B. (1982) Interrelations of vegetation and eland (*Taurotragus oryx*) in Giant´s Castle Game Reserve, Natal. Ph.D Thesis, University of the Witwatersrand.

Shelton, M (2004) Sheep and Goat Research journal, Wildlife Service, p. 1 - 26

Schmidt-Nielson, K. (1997) Animal Physiology: Adaptation and environment, 5th. Edn. Cambridge University Press, UK.

Skinner, J.D., (1967) An appraisal of the eland as a farm animal in Africa. Anim. Breed. Abstr. p. 177 - 186

Spinage, C.A., (1986) The natural history of antelopes, Croom helm, London, p. 1 – 205.

Theron, G.K., (1974) Ekologiese studie van die plantegroei van die Loskopdam Natuurreservaat. Unpublished D.Sc. Thesis, University of Pretoria.

del Thompson, V. (1989) Behavioural Response of 12 Ungulate Species in Captivity to the Presence of Humans. Zoological society of San Diego. p. 276

Tobler, I. And Schwirin, B. (1996) Behavioural slept in the giraffe (*Giraffa cameleopardalis*) in a zoological garden. Journal of sleep Research 5, p. 21 – 32.

Underwood, R. (1975) Social behaviour of the eland (*Taurotragus oryx*) on Loskop Dam Nature Reserve, MSc. Thesis, p.1 – 278.

van Soest, P.J. (1994) Nutritional Ecology of the Ruminant, 2nd. edn. Cornell University Press, Ithaca, New York.

Vessey-Fitzgerald, D.F. (1960) Grazing succession among East African game animals. J. Mammal. p. 160 – 172.

Westorby, M. (1974) An analysis of diet selection by large generalist herbivores. Am. Nat. 108