EAZA Best Practice Guidelines
for Lesser Kudu (*Tragelaphus imberbis*)

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EAZA Antelope and Giraffid TAG

TAG chair: Sander Hofman, Wild Animal Park Mechelen Planckendael, Royal Zool. Society of Antwerp, Mechelen (Muizen), B2812, Belgium, sander.hofman@kmda.org

First edition: 2018

Editors: Ian Goodwin, Marwell Wildlife, Jiri Hruby, Zoo Dvur Kralove, Friederike von Houwald, Zoo Basel, Ulrike Rademacher, Stuttgart Wilhelma Zoo, Beatrice Steck, Zoo Basel, Fabia Wyss, Zoo Basel

Citation: F. von Houwald, F. Wyss et al. 2018. EAZA Best Practice Guidelines for the Lesser Kudu (*Tragelaphus imberbis*). First edition. European Association of Zoos and Aquaria, Amsterdam, The Netherlands.

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Preamble

Right from the very beginning, it has been the concern of EAZA and the EEPs to encourage and promote the highest possible standards for husbandry of zoo and aquarium animals. For this reason, quite early on, EAZA developed the “Minimum Standards for the Accommodation and Care of Animals in Zoos and Aquaria”. These standards lay down general principles of animal keeping, to which the members of EAZA feel themselves committed. Above and beyond this, some countries have defined regulatory minimum standards for the keeping of individual species regarding the size and furnishings of
enclosures etc. These standards, according to the opinion of authors, should definitely be fulfilled before allowing such animals to be kept within the area of the jurisdiction of those countries. These minimum standards are intended to determine the borderline of acceptable animal welfare. It is not permitted to fall short of these standards. How difficult it is to determine the standards, however, can be seen in the fact that minimum standards vary from country to country.

Above and beyond this, specialists of the EEPs and TAGs have undertaken the considerable task of laying down guidelines for keeping individual animal species. Whilst some aspects of husbandry reported in the guidelines will define minimum standards, in general, these guidelines are not to be understood as minimum requirements; they represent best practice. As such the EAZA Best Practice Guidelines for keeping animals intend rather to describe the desirable design of enclosures and prerequisites for animal keeping that are, according to the present state of knowledge, considered as being optimal for each species. They intend above all to indicate how enclosures should be designed and what conditions should be fulfilled for the optimal care of individual species.

Acknowledgements
The authors are very grateful to Lindsay Banks, Woburn Safari Park, Damien Busset, Safari de Peaugres, Konstantin Ruske, Zoologischer Garten Magdeburg, Laure Pelletier, Zoo Parc de Beauval, Tobias Klumpe, Zoo Osnabrück and Malgorzata Pacholczyk, Miejski Ogrod Zoologiczny w Lodzi, for their valuable comments, information, experiences and pictures.
We would like to thank Veronica Cowl, EAZA Reproduction Management Working Group, for her contribution on contraception and Sally Binding, EAZA Animal Welfare Working Group, for her section on enrichment.
We are also grateful to David Mallon, Co-chair of the IUCN SSC Antelope Specialist Group for his valuable comments on the draft.

Contents

Summary
In the first section, the biology and field data of lesser kudus are presented. Lesser kudus occupie semi-arid areas of north-eastern Africa, commonly known as the Somali-Masai Arid Zone of Ethiopia, Somalia, Kenya and Tanzania. The species is closely associated with Acacia-Commiphora thorn bush; it generally avoids open spaces and long grass. They have a rather loose and flexible social organisation and show little territoriality and hierarchy. In lesser kudus, all group types (all male, all female, harem and mixed) are fairly evenly represented.
With regard to group size, groups of 3-4 animals are most common. Certain females in particular tend to associate in fairly stable small groups. These social units comprise 2-4 females and their young and remain stable for considerable periods of time.
The second section deals with the management of lesser kudus in zoos and how the information gained from the wild can be translated into species-specific husbandry that enables this breeding programme to maintain a healthy and sustainable captive population. It also summarises the experiences made in various zoos over many decades of keeping this species. The chapter includes sections on exhibit design, nutrition and health issues.
Since lesser kudus can be rather skittish, any outdoor enclosure should be structured with plants, hiding places, mounds and other sites that offer them security and enable them to withdraw from potential threats. In addition, areas with soft and hard substrates should be provided to ensure that the hooves are worn.
Inside, a heated building with boxes is needed for this species. The boxes should have a non-slippery ground covered with soft bedding. Depending on the construction of the building and visibility (to zoo visitors) of lesser kudus inside, considerations need to be given to their skittish nature: hanging branches, browse, several stables to withdraw and other retreat areas should always be included.
Lesser kudus are classified as browsers or intermediate type feeders. Most of their diet should therefore consist of browse as – compared to grazer species – their rumen is not able to digest effectively large quantities of high-cellulose roughage such as grass and normal hay.
Data analysed from ZIMS Species 360 reveals that the most common morbidities in lesser kudus include parasite issues (internal and external), traumatic events (fractures, wounds, abscesses) and neonatal pathologies (hypoglycaemia and immunoglobulin passive transfer failure).
In many institutions and in earlier years, the prevalence of cases of muscle weakness and locomotion problems due to white muscle disease (WMD) was rather high. However, during the last years the prevalence seems to have decreased, probably because of more species-specific and adapted nutrition, mainly supplementation of vitamin E and selenium.
With the information provided in the first two sections, the holders will be able to design exhibits, structure them and manage the species according to its species-specific needs. Finally, in section 3, a reference list can be found.

1 Section 1: Biology and field data

Biology

1.1 Taxonomy

- Order: Artiodactyla
- Family: Bovidae
- Genus: Tragelaphus
- Species: Tragelaphus imberbis
- Sub-species: (T. i. imberbis and T. i. australis)
- Common name(s): Lesser kudu

Heller (1913) split the lesser kudu into two subspecies, a northern form, T. i. imberbis, and a southern one, T. i. australis; the latter is said to be generally darker in colour and to lack white spots on the pasterns of the forelegs. However, the exact criteria on which this distinction is based (two females only), and their validity, remain somewhat doubtful, as do the geographic boundaries between the two forms and the degree of possible intergradation (Leuthold, 1979).

In the "Handbook of the Mammals of the World – Volume 2", the authors who wrote the chapter on bovidae, C. Groves, D. Leslie, B. Huffman, R. Valdez, K. Habibi, P. Weinberg, J. Burton, P. Jarman, and W. Robichaud, distinguish two species of lesser kudu: the Northern Lesser Kudu, *Ammelaphus imberbis*, and the Southern Lesser Kudu, *Ammelaphus australis*. They examined skulls and skins and found that the morphological relationships cohere very well with those of Ropiquet's (2006) molecular-based taxonomy.
The Northern lesser kudu is said to occur in the lowlands of east and central Ethiopia (Awash area) and north west Somalia, with the exact southern limit of the Northern lesser kudu's distribution requiring additional research. The Southern Lesser Kudu is assumed to live in the lowlands of southern Ethiopia, Somalia, the extreme south- east of Sudan, the extreme northeast of Uganda, north, central and southern Kenya and eastern Tanzania (Groves, et. al., 2011).

Dr. David Mallon, Co-Chair of the IUCN/SSC Antelope Specialist Group, wrote about this topic on 7 March and 13 August 2012 (pers. Comm.): "The revised classification of the Bovidae in the Handbook of the Mammals of the World is causing a lot of problems. ASG and our IUCN Red listing retains the conservative taxonomy of Wilson & Reeder 2005 (based on the traditional Biological Species Concept). We have a formal policy on taxonomic issues. For lesser kudu, we are sticking with *Tragelaphus imberbis*, and are unlikely to change unless the revision cited is supported by a rigorous DNA analysis.
The new arrangement is based only on minor colour and morphological differences. A third possible form is mentioned but not yet described. I am very unconvinced by the theoretical basis for this and find the evidence cited in favour of 2 species extremely weak. It is also difficult to see how these two 'forms' would at all be distinguished in the wild. There are no natural barriers separating the populations and I am sure they are inter-fertile. Quite possibly, zoos already have 'mixed' animals in their collections.

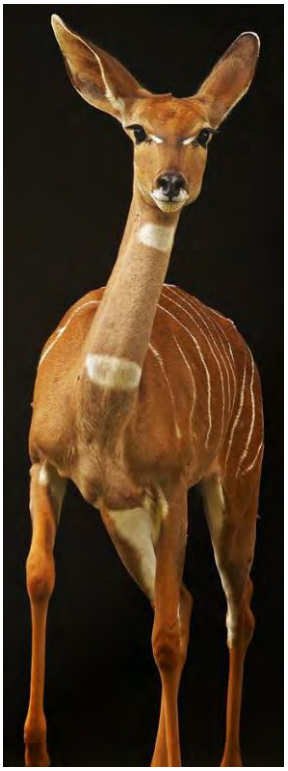
A small working group was set up within the Antelope Specialist Group to examine the change in taxonomy".

1.2 Morphology

Weight: The mean weight of 10 bucks collected in the Tsavo area was 92 kg, with a range of 56-108 kg. An adult male collected in Kenya weighed 98 kg, an adult female 83 kg. An apparently adult female killed by a car weighed 67.6 kg, including a full-term fetus (Leuthold, 1979).

Length and Height: Total length of adult males: between 193 and 196.8 cm; adult females: 177 and 185 cm along body curve. Shoulder height: approximately 110 cm (Leuthold, 1979).

Colouration and description
Sexual dimorphism is pronounced in both size and colouration.
The basic colour of adult males is a fairly dark purplish grey, that of females a bright reddish brown tinged with grey, somewhat greyer on neck and head. Both sexes bear 7 (Groves et al., 2011) or more often 11-14 white vertical stripes originating from a black line running down the middle of the back, which show many individual variations; also, the right and left sides of the same animal are usually quite different in detail. Small white spots may also be present, mainly on the hindquarters. A specific feature of the lesser kudu is the oval white patch at the base of the neck, present in both sexes. The white throat patch occasionally is irregular in shape or partly doubled; rarely, there is a third white patch below the normal throat patch. Both sexes also have an elongated white spot in front of each eye (incomplete chevron) and two white spots on the cheeks, less prominent in females. The colouration of the legs is similar in both sexes, basically tawny in the lower portions, with some white on the inside and a blackish patch below the elbows and knees.
The tail is somewhat "brushy", with a white underside and a black tip in both sexes.
Apart from size and horns, the most prominent feature of the adult males is the upright dorsal hair crest from the nape to near the base of the tail.
The horns, present in males only, measure 50 – 70 cm in straight line, 60-90 cm along the front curve.
With regard to the two subspecies, the northern form, T. i. imberbis, and the southern one, T. i. australis, the latter is said to be generally darker in colour and to lack white spots on the pasterns of the forelegs (Leuthold, 1979).



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Vocalisations: Often, lesser kudu utter a sharp barking call before fleeing. Lesser kudus also bark at night (Leuthold, 1979).
A female also calls when approaching her young, stopping some 10-30 m away and vocalises. The young normally respond to this call by getting up and, sometimes, may call in return (Leuthold, 1977). Very small lesser kudu utter a distress call, a penetrating bleating cry, when in immediate danger (Leuthold, 1979).

1.3 Physiology:

The authors are not aware of any published parameters from wild animals, probably because the animals are either stressed when in physical restraint or under anesthesia. Some parameters exist from captive animals. Neonates at Zoo Basel are examined on their first or second day of life. The temperature was 38.6°C and 38.7°C in two healthy animals, but 36.9°C in an animal that died the next day, due to inanition. The respiratory rate varied considerably during the examination in physical restraint and ranged from 28 to 56/min.

1.4 Longevity

In Tsavo National Park in Kenya, some wild animals attained at least 8-10 years (Leuthold, 2013).
At Dvur Kralove zoo, the oldest male lived to slightly more than 14 years, 5 months, and

the oldest female to more than 18 years, 11 months. Only a small number of females attained the age of 12 years or more (Vahala, 1992).
According to the SPARKS studbook software, the oldest male (studbook no. 62) died at Stuttgart zoo at the age of 17 years, 9 months and 20 days, and the oldest female (studbook number 380) died at Hannover zoo at the age of 18 years, 1 month and 20 days.

Field data

1.5 Conservation status/Zoogeography/Ecology

The information in this chapter is mostly taken from IUCN SSC Antelope Specialist Group 2016. *Tragelaphus imberbis* (errata version published in 2017). *The IUCN Red List of Threatened Species* 2016: e.T22053A115165887. http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22053A50196563.en. Downloaded on 7 January 2019.

Distribution: The lesser kudu occupies semi-arid areas of north-eastern Africa, commonly
known as the Somali-Masai Arid Zone of Ethiopia, Somalia, Kenya and Tanzania. Its range extends from ca 12° N in the Awash area of Ethiopia southwards through southern Ethiopia, much of Somalia except the northeast (i.e. east of 46° E and north of 08°N), most of Kenya except the southwest, extreme southeast Sudan, extreme northeast Uganda to northeast and central Tanzania. It is probably extinct in Djibouti (IUCN, 2016).

Habitat type: The lesser kudu is closely associated with Acacia-Commiphora thorn bush in semi-arid areas of north-eastern Africa; it generally avoids open spaces and long grass. They are largely confined to lowland areas up to 1200 m but have been recorded at about 1,740 m near Mt Kilimanjaro (IUCN, 2016). The lesser kudu is primarily a browser, consuming mainly leaves of trees, shrubs and herbs (Leuthold, 2013).

In Leuthold's observations made in Tsavo National Park, the lesser kudu was the least sociable species in terms of the frequency of association with other ungulates. Leuthold observed lesser kudu 17 times with gerenuk, 7 times with impala, once each with waterbuck and warthog, once both with gerenuk and impala, once with both gerenuk and waterbuck, and once with both impala and waterbuck. No interactions between the different species were observed. In two cases, the associations were mere aggregations at particularly favourable feeding sites. Lesser kudus are sometimes seen in the company of baboons. They are frequently attended by oxpeckers. There is considerable potential for competition for food among gerenuk, giraffe, elephant and lesser kudu (Leuthold, 1978 and 1979). Lesser kudus also rarely form associations with oryx (Leuthold and Leuthold, 1975).

Population:

	Protected	Areas	Other	Areas	Total	
Country	Pop/Abund	Trend	Pop/Abund	Trend	Pop/Abund	Trend
Sudan	-	-	X	?	X	?
Ethiopia	5,770	S	>8,870	S/D	>14,640	S/D
Djibouti	-	-	-	-	Ex	-
Somalia	C	S/D	C/U	S/D	C/U	S/D
Uganda	-	-	880	S	880	S
Kenya	1,170	D	4,900	S/D	6,070	D
Tanzania	1,200	S	X	S/D	X	S/D
Total	>8,140	D	>14,650	S/D	>22,000	D

(taken from East, 1998).
Total numbers are estimated to number at least 118'000, about 33% of them in protected areas. Numbers are considered to be in decline in much of the range, as a result of hunting, overgrazing, and outbreaks of rinderpest. In some other areas, bush encroachment has increased the amount of suitable habitat, and local range expansion and population increases have been reported. Nevertheless, the level of decline is suspected to have reached at least 20% over a period of 13 years, so approaching the threshold for Vulnerable
under criterion A2cde. The Lesser Kudu will probably persist in the arid scrublands of north-eastern Africa, as long as human and livestock densities remain relatively low in extensive parts of its range such as northern Kenya and southern Ethiopia. It nevertheless faces a continuing, long-term population decline as meat hunting and pastoralism increase within its remaining range. Its status may eventually decline to threatened.

IUCN SSC Red list category: near threatened (assessed in 2016).

Historical distribution:
Ethiopia: Formerly occurred throughout the southern and eastern lowlands; occupies much of its former distribution but localised and no longer occurs in the southern Rift Valley (East, 1988)
Eritrea: The species is said to have occurred in northern Eritrea during Italian colonial times (Leuthold, 1979).
Djibouti: formerly occurred in southern Djibouti, where it is now extinct (East, 1998).
Somalia: formerly occurred widely in the south, and more locally in central and northwestern Somalia, but naturally absent from the northeast (East, 1998).
Uganda: formerly occurred widely in thicket vegetation in the semi-arid northeast and east (Kidepo Valley National Park and Karamoja). Surveys in 1995 confirmed its continued presence only in the eastern part of South Karamoja Controlled Hunting Area, where it still occurs in good numbers (East, 1998).

Threats to the wild population:
Its shyness and preference for thick cover enable it to withstand considerable hunting pressure, e.g., it is relatively plentiful throughout the Ogaden region wherever there is

sufficient dense bush, despite widespread, uncontrolled hunting by local people (East 1999). On the other hand, its susceptibility to rinderpest resulted in a substantial decrease in its numbers in eastern regions of Kenya during the mid-1990s. These populations can be expected to recover following the subsidence of this rinderpest outbreak. There are relatively few parts of the Lesser Kudu's range where protection against poaching reaches moderate levels or better, and eradication of rinderpest from cattle would be a major step towards reducing current pressures on its populations (East 1999).
In addition, human encroachment/intrusion/disturbance and associated habitat modifications and excessive cattle grazing pose further threats to this species (Groves et al., 2011).

Conservation Actions
About one-third of the estimated total population occurs in protected areas. Important populations occur in protected areas such as Awash, Omo and Mago National Parks (Ethiopia), Tsavo National Park (Kenya) and Ruaha National Park and adjoining game reserves (Tanzania), but it occurs in larger numbers outside protected areas (East 1999).

The Lesser Kudu's long-term survival prospects would be enhanced by improved protection and management of the relatively few protected areas which support substantial populations. In addition, its value as a trophy animal gives the species high potential for increased revenue generation in the extensive bushlands where it still occurs in good numbers outside national parks and equivalent reserves (East 1999).

1.6 Diet and feeding behaviour

Food sources and preferred food items: The lesser kudu is primarily a browser, consuming mainly leaves of trees, shrubs and herbs. Their water requirements can largely be fulfilled from the water content of the food plants (IUCN, 2010). They drink rarely from open water (Leuthold, 2013).
Woody plants constitute the main bulk of the diet of lesser kudu, with creepers, vines and herbs accounting for much of the rest. Grasses contribute only an insignificant amount, as do fruits and root tubers of some succulent plants.
"Browse": leaves, stems, inflorescences and, occasionally fruits may be eaten by lesser kudu.
Pronounced local and seasonal variations in the composition of the diet were found. Deciduous trees and bushes, herbs, climbers and grasses account for much smaller proportions of the diet during the dry season, when evergreen species, especially two species of succulents, are crucial for survival.
The composition of the diet is also influenced by the amount and seasonal distribution of rainfall, the occurrence of bush fires, and other factors.
Many of the evergreen trees and bushes may be crucial for lesser kudus to survive periods of drought. Fruits and root tubers have, so far, been eaten only in the dry season. Apart from seasonal variations in availability, this may be related to the relatively high water contents of these food items. In the dry season, lesser kudus also eat the flowers of Anisotes ukambensis, the only parts available as food, in considerable quantities.
Very few individual plant species appear to be principal sources of food for the lesser

kudu, but a large number of species each provides only a small proportion of the diet. Leuthold rates Calyptrotheca taitensis, Euphorbia scheffleri and Salvadora persica the most important food plants of lesser kudu in the areas studied, perhaps surpassed locally by Lawsonia inermis, Anisotes ukambensis and Acacia elatior and seasonally by some other evergreen species.
All creepers and climbers appear to be preferred as food plants when available. With regard to grasses, lesser kudus are highly selective. Only very young grasses of only a few species were eaten.
On the whole, lesser kudus are more selective with regard to a plant's condition and growth stage than with regard to species. A total of 118 plant species were found to be eaten (Leuthold, 1971 and 1979).

Feeding method: while foraging, lesser kudus move about in small groups, plucking leaves and other plant parts from trees and shrubs, or from the ground, as they go along. Final selection is almost certainly based on olfactory examination. This is suggested by the way in which the animals search over different parts of a plant with their noses. Olfactory searching is apparently also used to find fallen fruits under trees and shrubs (Leuthold, 1979). When feeding on leaves, the lesser kudu grabs the tip of a leaf with its premolars, head held sideways, pulls the leaf out and starts chewing it, progressing from the tip towards the base, the leaf gradually disappearing in the mouth (Leuthold, 1971). Occasionally, lesser kudus drop onto the carpal joints while feeding from a root tuber; such kneeling was not recorded in other circumstances. Animals can then jockey for positions providing access to a root tuber and sometimes are overtly aggressive towards conspecifics (Leuthold, 2013).
Near maximum heights of plants reached are 175-180 cm for females and 190 – 195 cm for males. Sometimes, an animal attempted to reach even higher by lifting one foreleg, erecting the head as high as possible and "angling" with the tongue for a food item. Lesser kudus were never observed standing on the hind legs only (Leuthold, 1979). Foraging takes up about 35% of the animals' time (Leuthold, 2013) and generally predominated in the early morning and late afternoon. Rumination took place during resting periods (Mitchell, 1977).

Specific dietary requirements:
Possibly even more than other species, lesser kudus are susceptible to selenium deficiency and probably vitamin E deficiency as well. A relation of low serum selenium and vitamin E levels to high neonatal mortality was observed in Zoo Basel (Kaufmann et al., 2015).

1.7 Reproduction (sexual)

Developmental stages: The newborn young initially spends most of its time lying quietly in dense vegetation while the mother may feed some distance away. As the young gets older, at 3 – 4 weeks of age, it follows its mother more and more on feeding trips and usually joins her group as well (Leuthold 1979 and 2013). Weaning occurs at about six months (Groves et al., 2011). At about 1 year of age, female lesser kudus are nearly the size of adult females, though more lightly built. Young males are initially coloured like females. From the age of less than 1 year, their coat gradually becomes darker and greyer, beginning on the head and neck. Also, the dorsal hair crest, most

pronounced at the back of the neck and over the shoulders, begins to develop. By about 2 years of age, the colour change is virtually completed, and the young males then differ from adult ones mainly in body size, build and horn length. Perhaps the main diagnostic feature of fully adult males is their thick neck. This is probably not developed fully before about 5 years.
Between 18 and 24 months, a young animal, particularly if it is a male, usually leaves its mother's group (Leuthold, 1979).

Age of sexual maturity:
Female lesser kudus can reach sexual maturity at little over one year of age, usually before 15 months.
Males are assumed to be sexually mature little after the females, but as opposed to captive ones, wild males will often reproduce only when they are four to five years old (Leuthold, 1979).
At Dvur Kralove, males and females reached sexual maturity at the ages of 16 and 19 months respectively (Vahala, 1992).

Seasonality of cycling: In captivity, females appear to be polyestrous. The oestrus cycles of two females were 21 and 22 days. The oestrus cycle length consisted of the amount of time between two successive copulations in the same female (Vahala, 1992).

Gestation period: Leuthold estimates it to be about 7.5 – 8 months (Leuthold, 1979). In zoos, gestation periods ranging from 222 (usually 244 days) to 8 months and 20 days were found (Lang, 1976, Houston et al., 1987, Vahala, 1992).

Offspring size/number: One young is born at a time (Leuthold, 2013), twin pregnancies are rare (Peters et al, 2008). Wild neonates in Tsavo NP were 4.1 – 7.5 kg at birth (Groves et al., 2011).

Birth details and seasons: Births occur in all months of the year and there is no marked breeding season. At the time of giving birth, a female temporarily leaves her group and may remain isolated with her newborn young for some time (pre- and postpartum isolation) (Leuthold, 1979).

1.8 Behaviour

Activity: General accounts of lesser kudus characterise the species as being active mainly in the early morning and late afternoon, with a prolonged period of inactivity in the middle of the day. Leuthold found substantial numbers of animals being inactive in the middle of the morning (7-8 h) (Leuthold, 1979).
According to Mitchell, 1977, feeding made up 35% of daytime activities. It started soon after dawn and lasted until approximately 10 h, when most animals selected suitable cover and commenced ruminating, again for a variable length of time. This period was often broken by a brief resumption of feeding, lasting about 1 h, followed by a second resting period, which was broken off at some time during the afternoon, and feeding continued sporadically until dusk. Static behaviour (standing, lying) comprised 36% overall and predominated between 10.30 h und 14 h, with small peaks at about 9 h, 11 h und 13 h and low values between 7 – 9 h and after 15 h.

Moving, with 29% of total observation time, was most prominent early in the morning and late in the afternoon (Mitchell, 1977, Leuthold, 1979).
However, activity patterns on individual days showed considerable day-to-day variation. Mitchell noted a phase of increased movement between 16 – 18 h and stated that lesser kudus moved out of densely wooded gullies at that time. Occasionally, Leuthold also saw lesser kudus in an open area in the early morning. These observations suggest that the lesser kudus in Tsavo National Park may have used somewhat different habitat types during the day and at night, possibly as part of their anti-predator strategy (Mitchell, 1977, Leuthold, 1979).
The home ranges of several adult males overlapped considerably, some nearly entirely (Leuthold, 1974) and no overt signs of defense of an area, or of advertisement, have been noticed (Leuthold, 1977), but there seems to be a hierarchy among adult males living in the same area, which tend to avoid close contact (Leuthold, 2013).

Locomotion: In Tsavo National Park, groups may move about 0.5 km/day between foraging areas.
Lesser kudus are excellent jumpers and can leap over bushes and other obstacles 2 – 1.5 m high with ease (Groves et al., 2011). According to Huffmann's website "UltimateUngulates", Leaps of up to 2 m have been recorded, though these are not common

Predators: martial eagle, lion, leopard, spotted hyena, wild dog. Leuthold suspects that yellow baboons kill young lesser kudus occasionally (Leuthold, 1979; Leuthold, 2013).

Social Behaviour:
Inter-specific social interaction: see 1.5. The lesser kudu was the least sociable species in terms of the frequency of association with other ungulates. Leuthold observed lesser kudus with gerenuk, impala, waterbuck, warthog, and oryx. No interactions between the different species were observed. In two cases, the associations were mere aggregations at particularly favourable feeding sites (Leuthold 1975 and 1979).

Intra-specific social interaction:
The social organisation of the lesser kudu appears loose and flexible, showing little of the territorial or hierarchical structures found in other bovids (Mitchell, 1977).
In lesser kudus, all group types (all male, all female, harem and mixed) are fairly evenly represented (Leuthold, W. and B. M., 1975).
Males were often seen singularly. With regard to group size, groups of 3-4 animals are most common, with the largest group observed being 24 specimens. There are no close and prolonged associations among males older than about one year and adult males associate only rarely. Adult males tend to be solitary to a larger extent than subadult males.
No close and lasting associations exist between males and females either.
Pure female groups also occur. Certain females in particular tended to associate in fairly stable small groups. These social units comprise 2-4 females and their young and remain stable for considerable periods of time. They are essentially closed, as no permanent transfers of known individuals from one unit to another were recorded, except in a few cases of units breaking up as a result of the death of an adult female (Leuthold, 1979).

Social development and dispersal of young:
The development of social relations in a young male: after the juvenile hiding period, he

will join his mother's group with her and remain with it up to the age of 1 ½ to 2 years. Then – the exact age at which this happens varies considerably – he will gradually separate from his mother's group, perhaps partly as a result of harassment of adult males associating with the group at times. During the following 2-3 years, he will live partly in the company of other subadult males and partly alone, the tendency to be alone becoming more marked as he approaches full physical and social maturity.
Females may remain with their mother's groups at least up to the age of sexual maturity and perhaps beyond (Leuthold, 1979). A few observations suggest that at least some of the nuclear groups consist initially of mother-daughter or sister-sister units (Leuthold, 1974).

Intra-specific communication:
When being seriously alarmed, lesser kudus often utter a loud bark, which may be important as a signal to conspecifics, as may be the curling of the tail while running. This exposes the white "brush" on the underside that serves as a visual signal.
Behaviour with social and/or communicative functions, such as mutual grooming, is rarely seen in free-ranging lesser kudus.
Behavioural elements seen in "tense" situations include the males' erecting the dorsal hair crest, stiff-legged "determined" walking, brief rushes and actual chases of opponents. Also prominent is shrub-horning during and/or after such encounters. The agonistic behaviour of females, relatively rare, involves a short rush and/or butting with the forehead against the head or side of the other animal (Leuthold 1979 and 2013).
Vocalisations: see 1.2.

Sexual Behaviour:

Courtship behaviour and mating
In premating behaviour, the male approaches the female from behind in an extreme low-stretch posture and rubs his cheeks against her hindquarters. If the female tolerates his approach, he slowly advances along her side, keeping his cheek against the female's chest; he may also put his head under the female's chest and push or lift her slightly. Having
reached the female's shoulder region, still in low-stretch posture, the male then lifts his head and rubs his cheek along the neck and head of the female. During the low-stretch approach and, particularly, cheek-rubbing, the male makes rapid gasping movements with his mouth. Prior to mounting, the male lays his head and neck onto the female's haunches, which may be an intention movement for mounting (Leuthold, 1979). This may be accompanied by low vocalisations barely audible in the field (Leuthold, 2013). The mounting posture of all Tragelaphines is characterised by the head and neck being held very low over the female's back.
Females in oestrus seem to emanate olfactory stimuli (Leuthold, 1979).

Competition
Reactions of adult males to the presence of subadult males varied greatly, from virtual ignoring to overt antagonism. The type of reaction shown appeared to depend partly on the age of the subadult males and partly on other circumstances, e.g. on whether or not any females were present. In a number of cases, the adult male was distinctly less tolerant of relatively old subadult males than of younger ones. Actual agonistic behaviour in such

situations included intimidation postures (e.g., erection of the dorsal hair crest, raising the tail slightly and spreading the white hair on its underside), “determined” walking and brief rushes towards the subadult male and actual chasing at speed, during which both antagonists curled their tails upward. The subadult males always evaded the attacks by stepping aside or running away altogether, but often simply by circling around bushes, termite mounds, etc., yet remaining nearby. Twice the adult male, after having chased away a subadult male, made sexual advances towards one or more of the females present (Leuthold, 1979).

When competing, mature males spar by pushing and twisting with their horns laid together lengthwise and the spirals engaged (Groves et al., 2011). Serious fights are rare, but in such cases, the horns occasionally become inextricably wedged together, so that the antagonists cannot separate again and eventually die (Leuthold, 1979).

Section 2: Management in Zoos and Aquariums

2.1 Enclosure

When planning outdoor and indoor exhibits for this species, one should be aware that lesser kudus live in bush savannahs and can be rather skittish.

The **outdoor enclosure** should thus be structured with plants (dead or artificial bushes), hiding places, mounds and other sites that offer them security and enable them to withdraw from potential threats. In addition, areas with soft (for example sand) and hard substrates should be provided to ensure that the hooves are worn from below but also in between the hooves to avoid lateral growth.

Basel zoo outdoor exhibit, vegetation for retreat, copyright Zoo Basel

Vegetation for retreat, Copyright Zoo Basel

Equally, when planning **an indoor facility**, one should take into consideration that this species is easily spooked and stressed. They are also sensitive to cold, therefore the indoor housing will need good planning to fulfil their needs:

- Several stables are needed (viewing stable, hot room, i.e. an area where a female can give birth or where animals can retreat to when feeling cold)
- A stable that is accessible for visitors should be large enough (depth), so that animals can withdraw from the visitors' noise/activities. Structures, such as branches hanging from the ceiling or artificial bushes inside the viewing stable will allow the animals to stand behind them and allow the visitors to still see them.
- Access to several other stables should be provided so they can withdraw completely
  When feeling insecure or stressed
- All stables should be connected to each other with sliding doors
- All stables should be connected in a way that the animals can move in circles
- Offer several comfort zones (warm areas, cool areas in summer, dark areas, soft substrate) to meet the behavioural and physical needs of each individual during all seasons
- Offer safe access to and from house (no stressor to alert the animals when going in and out). Installing artificial structures, such as bushes or branches, in the vicinity of the exit and entrance will enable them to slowly move forward, feeling well hidden behind a structure, but still being able to oversee the situation and to enter the new area without feeling stressed.
- Visitors should have no direct contact with the animals

2.1.1 Boundary

Outside:

Primary barriers to use

1. **Water moats** can be a problem for calves when first venturing into the outside of their enclosure. They can swim, but depending on the season, this should be avoided by all means. If water is used as a boundary, it is important to make sure that the animal can easily get in and out with access to shallow and non-slippery exit points. Being able to prevent access when surface is frozen is also important. They will use a water moat to drink, so it is important to offer a shallow and non-slippery area where they can safely reach the water without sliding into it.
2. **Dry moat** works with a bank / slope on the animal's side that is not steep. It has to be deep and wide enough as they can jump (esp. when under stress). The surface of the slope should not be slippery.
3. **Fence:** Depending on the type of wire mesh, it is considered to be useful as it has the potential to also function as a bouncing back structure. Height: at least 2m, the width of mesh / squares should be small enough so that offspring cannot stick its head through (important in the lower part of the fence). Experience has shown that animals may run / jump through a fence if stressed. This suggests that the fence should be constructed / designed in a way that it is seen as a barrier and should not cause the illusion of not being there. Often, it also helps to provide a structure in front of parts of the fence, allowing the animals to retreat behind this before they hit the fence.
4. Electric fence: Not recommended as primary barrier

Dry moat, copyright Zoo Osnabrück

Dry moat, copyright Zoo Parc de Beauval

Fence covered with reed, copyright Zoo Lodz

Fence covered with vegetation and an additional barrier in front of the fence that enables the kudus to hide behind, copyright Zoo Basel

Water moat with access to the water for drinking, copyright Zoo Basel

Inside:
Public barriers

- Glass, up to the ceiling (with sound still reaching animals), and natural materials (trees, logs, branches, etc.) inside the stable in front of the glass to keep animals away from glass.

Glass separating visitors from animals, copyright Marwell Wildlife

- Wooden panels / wall with small windows

Copyright Stuttgart Wilhelma Zoo

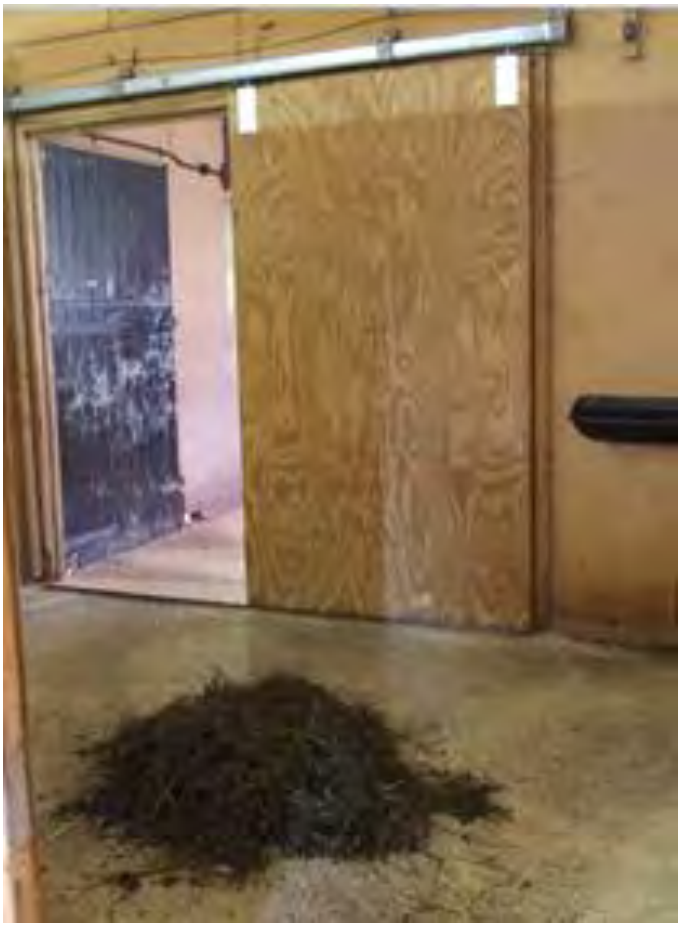
Copyright Zoo Dvur Kralove

Distance between the public and the visual barrier of the holding pen

- Distance should ensure that visitors cannot tap glass or disturb the animals inside the stable

Boundaries used between holding pens

- Wood is used for solid barriers, which should be 1,2m high with horizontal bars on top (up to at least 2m, the higher the better as they can jump high). Vertical bars are not recommended as the animals could potentially break their horns or stick their hooves in between. The width between horizontal bars should be less than 10 cm (to prevent the possible risk of the animals becoming trapped and strangling).
  The issue of broken horns is known from other antelope species but has, to our knowledge, never been reported in lesser kudus.



Solid walls and doors, copyright Marwell Wildlife

Gaps between wood should be narrow, so that horns cannot get stuck, copyright Zoo Lodz

2.1.2 Substrate

Outside:
Kudus live in dry bush savannahs, so their hooves are designed to wear and grow rapidly.
It is recommended to offer a variety of substrates (soft – hard; dry – wet, non-abrasive – abrasive) to make sure that the hooves are worn, avoiding overgrowth and deformation. Deep litter (substrates) such as sand that enables the hooves to stay straight and not to grow laterally should also be provided.

Suitable substrates:

- Grass
- Bare earth
- Sand (not to be used in feeding areas as the accidental intake can potentially lead to sand impaction
- Other: wood chip mixed with pebbles, mulch, hard core (compacted gravel / sand), marl

Hard stand, copyright Marwell wildlife

Marl as substrate, copyright Zoo Basel

Earth, copyright Safari de Peaugres

Inside:
A non-slippery surface should be provided since their flight response entails the risk to fall or slip). When there are several stables, various substrates could be offered in different stables:

- Tarmac, asphalt: http://www.lautenschlager-kopp.de/html/partner.html (produces asphalt approved by veterinarians)
- Stallit floor (Stallit GmbH, A – 8783 Gaishorn/Stmk, Au 44, http://www.stallit.com/joomla/index.php/en/)
- Natural substrates (deep litter of soft earth or compacted soil that can occasionally be renewed). Experience with this has not yet been made in this species but proves useful in rhinos and giraffes.

Areas with hard substrate should partly be covered with straw, wood chips or other natural substrates to offer comfort zones for resting.

Copyright Zoo Parc de Beauval

Copyright Zoo Basel

2.1.3 Furnishings and Maintenance

Outside Exhibit:

Shaded areas

Natural shade is always preferable, feeding places that offer shade are recommended as this also provides shelter against rain and protects food.

- Trees (protect the bark against rubbing of horns)
- Bushes
- Shelter

Wooden shelters should be offered to protect them against rain, wind, sun
Natural shelter from trees, etc. is also readily used

Visual barriers

The exhibit should be structured with visual barriers (bushes, branches, trees, logs, etc.) to allow the animals to withdraw from stressful situations. This species lives in the bush savannah and thus needs to have several visual barriers in their outdoor enclosure.

Upper picture: dead plants put near the access to the indoor area to allow animals safe access outside

Lower picture: kudus nearly “disappear” in the vegetation (artificial bushes on outdoor exhibit), copyright Zoo Basel

- Mound / hill (made of soil, sand, etc.), covered with grass
- Bushes will offer protection from wind

Hiding place, copyright Zoo Lodz

Hiding place, copyright Zoo Basel

Other structures

Higher structures such as bolts or hills are also readily used by the animals to withdraw from frightening situations but also to explore new areas. A hill/mound is often used by the male to mark his territory and he will use his horns and rub them in the slope of the mound.
Sand pits are used for marking the territory
Dead trees, logs, branches on the floor are used to hide, play or rest.

Inside facility:

- furnishings and hiding places
  Depending on the construction of the building and visibility (to zoo visitors) of lesser kudus inside, considerations need to be given to their skittish nature: hanging branches, browse, several stables to withdraw and other retreat areas should always be included.

Copyright Zoo Basel

Copyright Marwell Wildlife

In addition, hanging branches, browse, etc. inside will offer the animals a form of enrichment when they are inside for extended periods of time (night, winter, bad weather conditions).
It is recommended that new holders also offer structures in new stables even if they are not accessible to visitors. Experiences have shown that lesser kudus will make use of them, either to interact with them or to retreat from other group members.

- A separate calving stable is necessary. This stable needs to offer a warm area /hot spot for the calf and an area where the calf can hide behind (for example, behind straw bale).

2.1.4 Environment

Outside:

Temperature

During low temperatures, individuals should be given the choice of both inside and outside access). If this is not possible, the animals should be given outside access as often as possible weather permitting (cold, wind, storm). The management should be adapted, so that the animals are given free choice to go inside or outside and should be managed in a way that they can go out several times a day for a short period of time (especially when temperatures are below 0°C).

Copyright Zoo Basel

Inside:

Minimum temperature in winter

- Stables should be at least 18 °C
- Calving areas need to be between 24 and 28°C
- A system that offers various options of warm places is seriously recommended
    - Winter: Animals that move from very warm stables (22°C and more) to outside winter conditions may be physically challenged. It is assumed that this can be potentially stressful and harmful to them. Therefore, very warm stables are not recommended; instead, various comfort zones seem to work just as well and help reduce the overall energy costs of a building.

maximum temperature in summer

25°C is a recommended ambient temperature in the summer. If temperatures are higher, good ventilation is needed in the stables. For new indoor houses, automatic air conditioning is advisable as this can be adapted to individual situations and can also help to control levels of ammonia in the air.

- New born calves should have the option to choose warm sites

- UV light can be an option depending on the design of the stables and how much access to the outside of enclosure the animals have during different seasons.

2.1.5 Dimensions

Outdoor area
In the ESB members, the exhibit size varied, at the time of writing, between 230 m2 and approximately 9000 m2.

Given that suggested dimensions and sizes for outdoor and indoor exhibits change over time and also vary in different countries (for example as far as minimum exhibit sizes are concerned) we prefer not to recommend certain sizes but refer holders to their respective national legal requirements, which need to be met.

Due to the shy and secretive nature of this species, the daily management is easier in larger exhibits with greater distances to visitors. A zoo that has experience with antelopes and good management will be able to keep this species successfully in smaller exhibits. If space is an issue, more emphasis needs to be put on well-structured outdoor and indoor areas.

At the time of writing, i.e. in 2018, the Swiss Animal Protection Act requires at least 500 m2 for a herd of up to 6 individuals outside and at least 5 m2 per individual inside.

Indoor exhibit
In the ESB holders, the total inside area available to lesser kudus varied between 32 m2 and 150 m2. The size required obviously depends on the group size. For zoos that consider keeping this species in future, two suitable scenarios are presented:

Scenario 1
If visitors have access to the stables, the latter should offer the following features:
- A large show stable / room. The room should provide enough space that the animals will feel comfortable when withdrawing from the visitors. The deeper the stable, the more easily this is achieved.
- Non visible calving stable
- Several stables to withdraw from visitors. They need to be accessible from the show room.

All stables need to be connected and be accessible for the keeper. In addition, a keeper's corridor is required behind the stables. It is recommended to have direct access to the outside exhibit from several stables. The show room needs to be well structured to allow the animals to feel safe and relaxed and to offer the visitors the possibility to observe this fine animal from up close.

Direct access from indoor to outdoor exhibit, copyright Zoo Basel

Scenario 2
If there is no visitors' access, the stables will need to fulfil the same conditions (possibility to withdraw, calving den, etc.) as for the first scenario. The stables should be designed in a way that the keeper can see the animals and vice versa.

2.2 Feeding

Lesser kudus are classified as browsers or intermediate type feeders, depending on the source of information (Leuthold, 2013; Wolfe, 2015). Most of their diet should therefore consist of browse as – compared to grazer species – their rumen is not able to digest effectively large quantities of high-cellulose roughage such as grass and normal hay. Browse does not contain more sugar or starch than grass but it contains a higher amount of soluble fibers, such as pectins and is therefore more easily digestible for browser species.
In the past, browsing animals were often fed with high-concentrate feeds such as pellets because of their reduced body condition and hay intake when fed with grass hay only. At earlier times, the pellets were composed of large amounts of easily digestible energy such as starch and sugar and led to rumen acidosis and indigestion, thus further complicating the problem of reduced body condition. Continued rumen acidosis may lead to rumenitis and subsequently to systemic acidosis, indigestion and cachexia, mineral imbalances, laminitis and poor quality hoof growth (Wolfe, 2015).

Specific requirements for lesser kudus are not known, however, it seems appropriate to use the requirements for other antelope species or domestic cattle or smaller ruminants such as goats or sheep.
Perhaps even more than other species, lesser kudus are susceptible to selenium deficiency and probably vitamin E deficiency as well. A relation of low serum selenium and vitamin E levels to high neonatal mortality was observed in Zoo Basel (Kaufmann et al., 2015). Selenium not only affects muscle health, but also acts as an antioxidant and affects the immune system. High neonatal mortality has been found in relation to food composition that was deficient in selenium and vitamin E (Besselmann et al., 2008). Roughage from the region around Zoo Basel (Jura) is known to be deficient in selenium due to its deficiency in the soil, as is the case in many other regions in Europe. Therefore, supplementation of these elements may be necessary in most zoos.

At Basel zoo, a vitamin E deficiency of the lesser kudus is suspected to have caused juveniles to become susceptible to a variety of diseases, although no measurements on immunological function were performed (Besselmann et al, 2008).
The whole group, with special consideration of breeding females, was thus supplied, via oral application, with 30-50 mg/kg alphatocopherol and 0.3-0.5 mg/kg selenium PO; vitamin E/ selen liquid RS, Chevita AG, Pfaffenhofen (Besselmann et al., 2007).
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2.2.1 Basic Diet

The diet of lesser kudus should consist of good quality leafy roughage (mostly alfalfa as hay, fresh or as silage, that may be mixed with grass hay) ad libitum. Marwell Wildlife procures alfalfa and Lucerne haylage from the following company:
http://www.itchenvalleytransport.co.uk/specialised-forage-products

Additionally, leaves and branches should be provided as much as possible. During the summer months, they are provided as fresh browse. In the winter months, either thawed branches or leaf silage should be provided. In addition to leaf silage, branches should be offered for gnawing off the bark as this provides important fibers and serves as enrichment.

Preferred browse are: Goat willow (Salix caprea), other willow species (Salix sp.), oak species (Quercus sp.), Chestnut species (Castanea sp.), lime tree (Tilia sp.).

Pelleted food in order to supplement minerals and vitamins should be provided as well. In general, an amount of 20-30% dry matter of the ration should consist of pellets (approx. 0.5 kg per adult animal). This amount may be reduced in summer when e.g. fresh grass is available that increases the amount of protein as well as other nutrients. The ration of pellets should be split into at least two feedings to avoid rumen acidosis, especially when they contain higher starch levels. Different types of pellets are used in different institutions: ZSL Browser pellets, Kasper browser pellets, Mazuri browser pellets or Granovit (http://www.granovit.ch/de) browser pellets. Important characteristics are a high fibre and low starch content as well as supplementation of minerals and vitamins. Special attention should be paid to the form that selenium is provided. Studies performed by Zoo Basel (Wyss et al, 2017) showed that after the form

of selenium in the pellets was changed from inorganic to organic, serum selenium levels were higher in all animals (neonates, adults) tested than before the change
In addition to roughage, browse and pellets, an ad libitum mineral lick stone should be provided.
To increase the amount of energy in the diet, especially for animals with special needs e.g. in late-term pregnancy, lactation, or in older or sick animals, adding pectin to the diet may be a good possibility. Pectin is a content of browse, a soluble fibre recognized in domestic ruminant nutrition as high-energy "concentrate" to replace starch-containing grain products and it has much less acidotic potential than grains (Clauss and Dierenfeld). Feeds other than browse that contain pectin are sugar or red beet, or apple, especially in the form of pomace. Pomace is the part that remains after juice has been extracted and it contains a low but variable amount of carbohydrates (most sugars are in the juice), high fibre content and many important nutrients. In Zoo Basel, dried beet pulp pellets (Zucker-) Trockenrübenschnitzel, Landi Landshut Genossenschaft, CH-3315 Bätterkinden, Switzerland) are soaked in water and fed to lesser kudus, with good success. Soaking in water prior to feeding is very important because of the great potency to swell.
Feeding in all institutions consists of providing ad libitum hay (lucerne and/or grass hay), pellets (see above) and browse (either fresh, as silage or frozen in winter). Additionally, some institutions provide fresh grass in summer or a mixture of vegetables. Some zoos also supplement the ration with a selenium/vitamin E supplement (e.g. SalvanaStar E/Selen).
High carbohydrate or sugary feed (grains, bread, fruits, high sugery vegetables) should be avoided due to the risk of development of rumen acidosis.

2.2.2 Special Dietary Requirements

Pregnant and lactating females generally receive the same diet as the rest of the herd. However, during late-term pregnancy or lactation, increased energy requirements may be covered with additional nutrients such as pectin sources (see above). Zoo Basel supplements the diet of pregnant females from one month prior to to one month after parturition with an organic selenium supplement (not commercially available), the same supplement that has been incorporated in the browser pellet used in this institution (Browser, No. 3699, Granovit Zoofeed, CH-4303 Kaiseraugst, Switzerland). Since these pellets as well as the supplementation around parturition were fed, serum levels of newborns as well as randomly sampled adult animals have raised markedly to optimal levels (compared with domestic cattle and antelope species) (Kaufmann, et al., 2015, Hammer, et al., 2006).
Further evaluation is currently performed to see if the amount of selenium in the pellets is enough without the additional supplementation of pregnant females.
As described above, if more concentrated energy is needed for convalescent animals or in other situations, feeds containing pectin may be used, such as dried beet pulp pellets.
Juveniles start to nibble on solid food quite early in life, at the age of 2-3 weeks. Care should be taken that the food is in reach (very low trough or on the floor) and that the food is small enough, e.g. small cut/chopped pieces.

2.2.3 Method of Feeding

Outside

Alfalfa should be provided ad libitum.
Certain individuals prefer to feed from the ground and offspring need to have the opportunity to feed from the ground (alfalfa, leaves, branches). Offering several “plates” of food is an easy way to not only provide access to food for every individual (young and old) but they can also be strategically placed, so that the visitors can observe the animals feeding. A mobile plate can be cleaned and will prevent the animals feeding off of the ground from ingesting foreign objects and possible health implications, such as sand ingestion.

Young animals start to ingest food offered to the adults very early. It is important to remember to chop the size accordingly as they will not be able to chew large pieces of food. Copyright Zoo Basel

Hay racks: several zoos provide hay racks inside but these can also be used outside (construction outside the stable). Incidents with horns are not common but can occur and need to be taken into account when planning.
Otherwise, food is provided in troughs or on the floor. When put on the floor, one has to be aware that the animals will defecate/urinate on it. In this case it is helpful to offer several smaller portions several times a day.
It has proven useful to have a trough below a rack of Lucerne/alfalfa as it will help to collect the leaves. Those are adored by the lesser kudus and will help to reduce waste of food that otherwise falls on the ground and is walked on and not eaten.

Browse should be offered as much as possible. It is preferred by the animals when it is either provided on the floor or when positioned in a natural vertical way. Care should be taken so the offspring can reach the food offered outside!

Copyright Woburn Safari Park

Copyright Safari de Peaugres

Copyright Stuttgart Wilhelma Zoo

Copyright Zoo Basel

Copyright Zoo Lodz

Inside:
Young animals should be able to feed off the ground (alfalfa, leaves, branches) or the troughs should be low enough so that the young can easily reach them.
Juvenile animals start to nibble on solid food quite early, at the age of around 2 – 3 weeks. Therefore, small-cut food items (alfalfa, leaves, pellets) should be within reach for them.
Alfalfa should again be available ad lib.

Calves need to be able to reach the food inside, copyright Zoo Basel

Vegetables and pellets are provided on the floor or in slightly elevated troughs 1 – 3 times a day. Vegetables are offered chopped, while lettuce (if added to the diet) can be presented whole.
Fruits are not recommended, neither is bread.

2.2.4 Water

Access to fresh water always needs to be available (keep the height of the drinking device in mind for the young to be able to reach).
Lesser kudus are not able to push down any levers in an automatic drinking device (as is used for horses or cows). When using an automatic refilling water system, a device that uses a ball cock should be provided.

2.3 Social structure

2.3.1 Basic Social Structure

General observations
The social structure in the wild is very flexible. Group composition often changes and males are not always present in the herd. The breeding bull is generally alone; younger bulls can associate in groups. The females do bond, but the bonding is flexible and will vary.

Captive situation
For management reasons, it might be advisable to separate the bull at certain times. Certain zoos prefer that the bull is with the herd in summer in order to have calves born in spring. This makes the management of offspring easier (see chapter birth)
The management very much depends on the climate prevailing in the respective zoo. Aggression between bulls and females is rarely seen.

Certain zoos separate the bull from the females overnight, others do not.

Successful/unsuccessful structures:
1.4 – 1.6 seems to be a suitable group size in various zoos.

Copyright Zoo Basel

2.3.2 Changing Group Structure

Introduction of females / males

Male to females
After quarantine, the male should be given the opportunity to get used to the new outside enclosure to ensure that he gets to know the escape routes and boundaries. Allowing the male to have visual and, when possible, physical contact through bars with the females in the inside stables will be beneficial before the introduction of the male to the females. Most males are very calm and gentle. Still it should be noted that no unnecessary obstacles should obstruct the way if the male starts to run after the females.
Introductions inside can take place depending on the space and season. Various zoos have successfully introduced the male to the females in the outdoor enclosure. As most zoos will receive a young breeding bull, introductions are rather easy and straightforward.

Female to the group (without breeding bull)
Solitary females should be introduced to the other females inside. She should not be sent outside alone as this might cause too much stress and may lead to flight reactions and accidents. As females are in general very gentle, the introduction is rather straightforward.

After a new female has been introduced to the other females and the outdoor exhibit, the next step can be to introduce her to the male.

Bachelor group
Young bulls have successfully been kept together, but it should be noted that it is better to associate younger males (1 -1.5 years) together and not to introduce young males with the breeding bull. This might lead to aggression from the leading bull towards the younger males. Stuttgart zoo has good experiences with joining young males with the breeding bull for a period of time to avoid that the young bulls mate with their mothers. However, not every breeding bull will treat the younger males gently. If fighting occurs, separation of the animals is the only solution.
Due to the above mentioned uncertainties regarding the behaviour of the breeding bull towards offspring, it is advisable to plan for an extra stable or exhibit, where male offspring can be kept until they are transported to another zoo.
If the breeding bull is separated from the females for a period of time, an extra paddock is needed.
Young males can potentially breed at the age of 14 – 15 months, depending on the presence of the breeding bull.

Three young males feeding peacefully together, copyright Zoo Basel

Management of bachelor groups
Past experiences have shown that males can be removed, and others can join the group without causing much unrest in the group. Some interactions may occur but usually they are harmless and will not require the separation of one male.
Introducing a former breeding bull – that was removed from the breeding herd – to the former bachelor group can cause unrest and might lead to serious aggression (experience made in Dvur Kralove).

Bachelor groups can be very attractive and are much easier to manage than those of other ungulate species.

Copyright Zoo Dvur Kralove

2.3.3 Sharing Enclosures with Other Species

Mixed species exhibits
General remark: Several zoos, such as Basel or Stuttgart, provide an enclosure that is accessible only for lesser kudus. From their exhibit, the animals can move into other exhibits, such as the adjacent giraffe enclosure. The management of the species works well in this system.

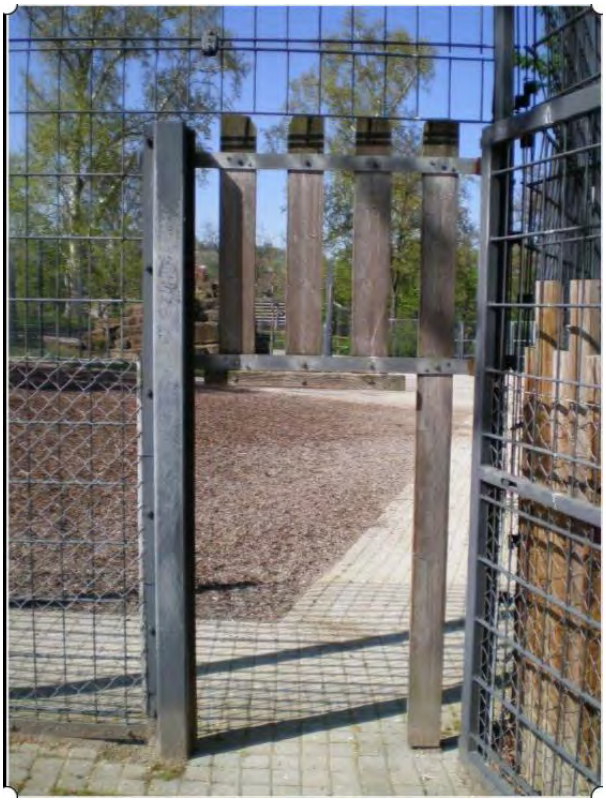
The following species have been kept together with lesser kudus:
Bongos (Tragelaphus eurycerus) (Marwell Wildlife, Woburn Safari Park, Zoo Parc de Beauval)
Giraffes (Giraffa camelopardalis) (Stuttgart Wilhelma Zoo, Zoo Basel)
Barbary macaques (Macaca Sylvanus) (Woburn Safari Park)
Patas monkeys (Erythrocebus patas) (Woburn Safari Park)
Carunculated cranes (Balearica pavonina) (Zoo Parc de Beauval)
Blue cranes (Grus paradisea) (Zoologischer Garten Magdeburg, Zoo Osnabrück)
Blesbok (Damaliscus pygargus), nile lechwe (Kobus megaceros), waterbuck (Kobus ellipsiprymnus), greater kudu (Tragelaphus strepsiceros) (only males in all species) (Zoo Dvur Kralove)

It is not recommended to mix ungulates with pinioned birds as the birds are often injured or accidentally killed.

Problems

Tragelaphus species do hybridise, therefore when mixing bongos for example with lesser kudus, single sex groups should be formed.

Certain males can become very self-confident. This behaviour has led to the death of lesser kudus interfering with giraffes and other ungulate species.



Passage for lesser kudus from their enclosure to that for the giraffes, copyright Stuttgart Wilhelma Zoo

Access to giraffe exhibit, copyright Zoo Basel

Lesser kudus sharing the giraffe exhibit, copyright Zoo Basel

2.4 Breeding

2.4.1 Courtship and Mating

Mating is difficult to observe but subtle changes in behaviour do show when females are in oestrus. Oestrus behaviour resembles that of other ungulates species. Mating can take place at all times.

Courtship behaviour, copyright Zoo Basel

The authors are not aware of any cases where males injured females during courtship.
Cycling intervals: 21 – 22 days
Gestation period: 243 days on average (240 – 250)
First possible age of breeding observed in zoos: 20 months in females / 14 -15 months in males

2.4.2 Pregnancy

Pregnant females are separated from the herd a few days prior to birth (judging from the conception date/mating behaviour, swelling of udder, girth) and most zoos will keep her inside.
It is recommended to time birth to occur in spring as calves will cope better with the milder climate. The stable should be prepared by providing a thick layer of straw – hay mix, warm areas (above 25°C) for the calf to use if wanted and a non-slippery surface. The "old fashioned" deep litter bed is not preferred as this leads to high levels of ammonia and can cause irritations in the resting calf.

It is possible to have more than one female in a breeding stable provided that there is enough room available for each individual. In general, females get along well with each other.

Often, the presence of an experienced female will help a primiparous female to remain relaxed when separated.
If room temperature is at 18°C, it is advisable to provide additional heating lamps for the calf.
In the wild, calves hide behind shelter (bushes, branches). In zoos, this can be done by offering a bale of straw or branches for the calf to hide behind.

Young calf seeking shelter behind a straw bale and under the hot spot, copyright Zoo Basel

2.4.3 Details on contraception possibilities

Contraception is not currently used in the ESB as the demand for animals is higher than the number of surviving births (data taken from the ESB, 2017).

The EAZA Group on Zoo Animal Contraception has developed guidelines for Lesser kudu, which are available with the ESB coordinator. Should contraception become important for the management of this programme, these guidelines will be added to a future edition of this document.

2.4.4 Birth

Females usually give birth at night or in the morning, rarely during the day. Births generally occur without complications.
It is not necessary for keepers to be present. Females are more relaxed without the presence of a keeper. A camera may be useful.

There have been a few cases where primiparous females tended to neglect the calf. Historically, hand rearing played an important role in the management of this species. Since the husbandry and management have improved in the past years, this method is no longer needed.

2.4.5 Development and Care of Young

First-time examination of the calf: most zoos will perform a veterinary check-up in the first days of life (sexing, chip, weight).
Care should be taken not to disturb the bonding of the female and the calf in the first hours and days. Ideally, staff should enter the breeding stable when the female is out. After handling the calf, make sure to wipe the calf with straw to remove any foreign smell / human scent.

It is important to observe primiparous females. If the bonding with the calf is strong, vets can handle the calf in the first week, if not, they should wait another week.

Lesser kudu calves remain hidden during most of the day. They can go without feeding for a few hours (while the mother is outside). Suckling occurs when the female returns. During the first two weeks, calves will seek the warm spots. After two weeks, the calves will become more curious and start to explore their surroundings. At the age of two months, the calves will leave their nesting area and follow the mother.

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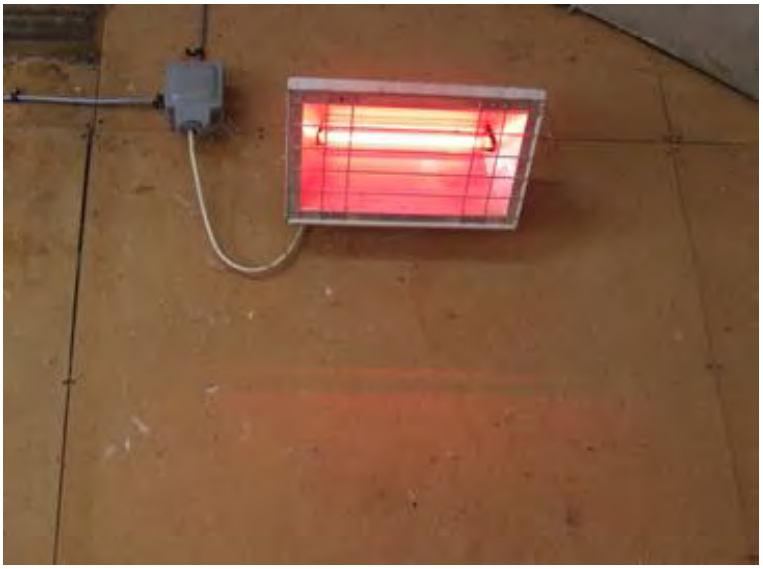

Hot spot in the Hotbox, copyright Marwell Wildlife

copyright Zoo Basel (pictures previous page and above), lesser kudu young seeking warm spots that provide shelter

A calf suckling actively after dam returned from outdoor exhibit (left), young calf becoming curious (right), copyright Zoo Basel

Two females together to comfort each other when separated from the group for birthing, copyright Zoo Basel

Introduction of female to group (without breeding bull)
Females with calves can join the group 2 – 3 weeks after giving birth (depending on the weather).
If the bull remains within the breeding group, the female should be introduced to the group alone. The calf can be introduced a few days later. The reason for doing so is that the male will chase the female (checking for oestrus behaviour) and the calf may get injured when trying to keep up with the mother.

Calves will usually follow their mother at the age of around 2 months. At that age, the calf can go outside with the group, weather permitting.

Gentle behaviour of male towards calf, copyright Zoo Basel

30-day mortality was 23% as of the end of 2017 (Steck, 2018).

2.4.6 Hand-Rearing

Hand-rearing is not recommended (see above).

2.4.7 Population management

In the regional collection plan of the EAZA Antelope TAG (2018), the RCP status of the lesser kudu is ESB, has a conservation role, the species is recommended to be kept in zoos and received a score of 14. A target population size is not determined.

For the genetic health of the ESB population, it is important to broaden the founder base and to exchange animals between Europe and other continents to improve gene diversity, reduce the level of inbreeding and the average mean kinship. In addition, more males should receive the opportunity to breed to further improve the retention of gene diversity.

2.5 Behavioural enrichment

Food enrichment
Branches, live trees and bushes that can grow through the fence or are located inside the exhibit, offer natural forage opportunities, such as grazing and browsing.

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Non-food enrichment
It is recommended to create a well-structured exhibit including hills, tree logs, visual barriers, various substrates such as sand pits, deep litter, etc. Structures will enable the male to create a territory, place markings, rub the horn, perform scent marking and other important behaviours.

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Breeding groups and mixed species exhibits also provide social enrichment.

The idea of enrichment is that the lesser kudus can perform as much natural behaviour as possible.

Additional Enrichment Ideas (Sally Binding, EAZA Animal Welfare Coordinator)

Behavioural Enrichment

Behavioural enrichment (also known as environmental enrichment) can be defined as providing animals with the opportunity to perform specifies-specific behaviours and make species appropriate choices, with the goal of enhancing animal welfare. Provision of welfare enhancing, effective enrichment stems from a thorough understanding of the species behavioural biology, anatomical adaptations and natural history; combined with knowledge of the animals' individual needs. This information can then be used to establish behavioural motivations needing to be met in captivity and the goals of enrichment i.e. how is the enrichment going to improve the animal's welfare? It is important that the ratio of different enrichment is represented correctly, considering, for example, the animal's age, natural behavioural biology and season. For example, as a browsing herbivore, kudus should spend the majority of their day eating, are high flight animals and have excellent sensory awareness. Therefore, these factors should be considered in planning the ratio that the different enrichment should be represented.

Enrichment can be catagorised in a range of ways. However, the following five categories are commonly used:

Social Enrichment

The ideal re. social enrichment for kudu is housing in groups that reflect their natural social groups. However, where this is not possible, experience from other institutions can aid in advising suitable mixed species exhibits. Social enrichment for kudu can include the use of other animal scents (avoiding causing a fear response), as, as per the wild, will provide interesting communication signals. Positive interaction with animal care taking team can also be used as a form of social enrichment. This may include a formal training programme or simply positive keeper-animal rapport.

Cognitive Enrichment

Cognitive enrichment relates to providing the animals with the mental challenges, decision making and thought processes that relate to those they would experience in the wild, and to keep them psychologically stimulated. Therefore, there is more to cognitive enrichment than simply puzzle feeders and the problem solving challenges we associate

with, for example, great apes. In the wild, kudu will be taking in their sensory surrounds, processing the information and modifying their behavior accordingly. This may be as simple as processing new scents to see who is in the area, exploring new items which they encounter or communicating with conspecifics. These behavioural opportunities can be provided in captivity through, for example, use of different sprays or animal scents, providing novel food items/unusual browse, novel items for them to explore, moving of items within the enclosure or development of training programmes. All opportunities for the kudu to experience something novel will evoke a cognitive process of problem solving which is an essential skill for wild survival – What is it? What does it do? Can I use it? Can it hurt me? Can I eat it? What to do with it now? When animals 'ignore' enrichment which is new to them, this is often the crucial cognitive process they are going through before choosing whether to interact with it.

Physical enrichment

Physical enrichment largely relates to the opportunities provided in enclosure design and physical structures that are included within the enclosure. However, provision of species-appropriate temperature, lighting, humidity and UV are also essential elements, for example, including areas for the kudu to both cool down and warm up such as shade and heat spots. It is recommended to create a well-structured exhibit including hills, tree logs, visual barriers, various substrates such as sand pits, deep litter, etc. Structures will enable the male to create a territory, place markings, rub the horn, perform scent marking and other important behaviours. Territory marking is an important consideration when cleaning enclosures, as the area should not be 'over cleaned' to the extent that the animal's scent is fully removed. Kudu are nervous, prey species and therefore the enclosure and furnishing should ensure that they have ample space for flight and hiding behaviours, without feeling cornered or restricted. As with all animal enclosures, for their welfare it is recommended that the public can only access two adjacent sides of the enclosure to that the kudu do not feel surrounded. Visual barriers are essential elements for all animals; including visual barriers from conspecifics, other animals and the public. However, the kudu should still be able to feed, socialise, experience day light etc, whilst being able to seek sanctuary out of public view. It is often experienced that the more visual barriers an enclosure has, the more active and visible the animals are, as they feel more confident that they can retreat to a 'safe space' with ease when they need to; as opposed to maintaining a safe distance at the back of the enclosure. It is important for animals' welfare that they can choose not to be visual should they want to be. In the wild kudu avoid the open savannah and choose the

security of thickets and bush. Visual barriers and 'safe spaces' can be created through, for example, planting throughout the enclosure, large piles of branches, thickets for the kudu to hide in etc.

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Sensory Enrichment

Sensory enrichment should reflect the senses most utilized by kudu in the wild. This can mean not only stimulation of senses through, for example, scents, but also lessening exposure to sound, sights etc., which may be detrimental to the kudu's welfare. This may include, for example, increased planting for visual and to act as sound dampeners. Large amounts of different natural substrates and structures will also help to mitigate against the high sound volume during busy zoo times. Scent enrichment can also include the incorporation of items to promote scent marking and exploring communication through other animals' scent. Visual enrichment may include novel items and sound enrichment may include items such as wind chimes, bamboo/pipes with pebbles inside etc. Taste

enrichment may include a novel food item or smear. Tactile enrichment may include new substrates, brush heads, moving items for the animals to interact with etc. The important note with all sensory enrichment is that the kudu must be able to avoid the item/sight/smell/sound/taste if they find it aversive.
Therefore, new scents should be placed in one part of the enclosure and be able to be removed if disliked or in order to rotate enrichment to keep it interesting. Scent sprays can be sprayed onto a stone which can be removed. Noise items such as wine chimes should be at the control of the animal and not as a constant sound.

Food Enrichment

As browsers, kudu should be provided with the opportunity to browse on appropriate plant material for most of the 24 h period, therefore including ample browse during the night period. Browse should be presented in a manner which mimics their natural feeding behaviours, for example, allows them to use their tongue to extract leaves and feeding from a range of heights, notably, off the ground.

In the wild, kudu also browse on a variety of different plant materials, therefore browse should be varied. This will also provide sensory enrichment through taste stimulation. Suspending browse from overhead wire can also act as a temporary visual barrier and will increase the challenge as it will be flexible.
A variety of feed bags can be made from heavy duty plastic, firehose and wire mesh. Rolling feeders are good food enrichment if additional herbivore pellets are used, and are effective in both slowing down consumption and promoting the animal working for the food. Browse can also be spiked into high rollers. All safe methods of ensuring access to browse for a full 24 h period and that are challenging in eating methods, notably, when the animals have to manipulate items with their tongue, are essential enrichment for kudus.

2.6 Handling

2.6.1 Individual Identification and Sexing

Identification

- Stripe patterns: Photos of each individual should be taken (both sides). In big groups, this system is more difficult.
- Each individual should have a transponder implanted.
- Dvur Kralove carries out ear notching. Interested zoos can contact them. (An interesting system for larger groups).
- Ear tags can be ripped out and may cause problems.

A female having her left and right ear notched, copyright Zoo Basel

2.6.2. General Handling

Access to the outdoor / indoor exhibit

Lesser kudus will use their outdoor enclosure whenever the opportunity arises. Depending on the design, weather, visibility for the visitors, they may prefer evenings and mornings. Every attempt should be made to offer them as much access to the outside as possible.

Plastic curtains at doors offer the animals access to either enclosure day and night and also during colder days. The animals can thus choose where they want to be.

Depending on individual zoo set-ups and weather conditions, lesser kudus can stay outside at night or can be stalled inside.

There have been reports that lesser kudus injured themselves at night and the reasons were not clear, but may have been associated with flight behaviour, possibly caused by the presence of foxes.

Structures to hide behind (hill, artificial bushes, etc.) in the outside enclosure will help to reduce stress.

Cameras inside or outside might be a useful tool to add in order to understand the behaviour of lesser kudus when using the outdoor exhibit.

Keeper access / interaction

Depending on the design and size of the stables and enclosure, it is advisable to move the animals outside for cleaning. When working, the keeper should be calm and avoid sudden movements. The animals will get used to the routine and to the staff working with them and can become quite tame and confident.

2.6.3 Catching/Restraining

Up to 4 – 6 weeks of age
Restraining young animals is rather easy as they will hide on the floor and will not run away. It is important to make sure that they are not spooked when approached, otherwise they get scared and will injure themselves. The use of a towel to cover the head is recommended.

Older calves and adults
Catching by hand is not recommended. Standing sedations are difficult and usually do not work as anticipated. For any procedure (taking blood, etc.), a sedation is necessary.

2.6.4 Transportation

Crate training
If a crate can be installed in a way that it becomes part of the daily routine, crate training can be very useful. Otherwise, crate training is difficult.

Crating
In general, the animals are anaesthetised prior to transport in order to perform all the necessary veterinary procedures. Afterwards the animals are placed in the crate and will wake up inside the crate.

Preparation of container / box
Several animals can be transported together (females or young males). In this case, the boxes need to have enough space to allow each animal to lay down. The floor needs to be non-slippery and covered by a thick layer of bedding. Ventilation needs to be assured! The size depends on the number of animals, the company and way of transportation.

Single animal crates
There are several options:
Option 1: small crate
The width needs to be adjusted to avoid that the animal can turn or make a head stand.

Option 2: squared box
If larger crates are chosen, attention needs to be paid that there is enough room for the animal to move without getting stuck.
Ventilation and surface: see comments above.
The inside of the roof should be protected to avoid injuries when the animals may jump up.

2.6.5 Safety

Since this species is rather skittish and will flee from humans, they are not particularly dangerous, and keepers can work while the animals are in the same exhibit. However, hand-reared male antelopes can be dangerous for humans, especially when the keepers are in the same enclosure. This is another reason why hand-rearing is not recommended.

2.7 Veterinary: Considerations for health and welfare

2.7.1 Main health problems

Data analysed from ZIMS Species 360 reveals that the most common morbidities in lesser kudus include parasite issues (internal and external), traumatic events (fractures, wounds, abscesses) and neonatal pathologies (hypoglycaemia and immunoglobulin passive transfer failure).
In many institutions and in earlier years, the prevalence of cases of muscle weakness and locomotion problems due to white muscle disease (WMD) was rather high. However, during the last years the prevalence seems to have decreased. This is most probably associated with more species-specific and adapted nutrition, mainly supplementation of vitamin E and selenium. Vitamin E and selenium supplementation using an injectable product (Tocoselenit, Dr. E. Graeub AG, CH-3018 Bern, Switzerland) was routinely performed in Zoo Basel on the first day of life. However, serum selenium levels of the supplemented animals were not higher in the third week than on the first day (day of supplementation). It may be that serum levels increased only in the short-term or that selenium reservoirs were filled without an effect on serum selenium levels. However, it is well known from farm animal medicine that organic selenium is much better resorbed and transferred to milk and foetuses than anorganic selenium. (Stewart, 2012, Petrera, 2009). Since the pellets at Zoo Basel were supplemented with organic selenium (see 2.2.1 Basic Diet), serum selenium levels have been markedly higher in all neonates and among randomly sampled adults. Coinciding with this increase, the mortality of neonates and juveniles has decreased markedly.
Traumatic injuries are often associated with the skittish nature of this species. As the management and intensive treatment of traumatic injuries is difficult, prevention is of utmost importance. Provision of structures for hiding, avoidance of slippery substrates and quiet but targeted handling of the animals are recommended for prevention (for more information, see husbandry chapters). Soft-tissue trauma (exertional myopathy) may be associated with white muscle disease (WMD) and subsequent vitamin E and selenium deficiency.

Few specific infectious diseases are known in this species. However, neonates and juvenile animals may be especially prone to develop clinical disease due to their naïve immune system. The most commonly affected organ systems are gastrointestinal (diarrhea, enterotoxemia from Clostridium perfringens spp.) and respiratory (pneumonia).

Endoparasite infections are common, but usually do not cause any serious problems unless high burdens are present. Detected parasites in fecal flotation are coccidians, strongyloides, Capillaria sp. and Trichuris sp.
Increasing numbers of coccidia in the feces were detected in the cold periods when the animals spent more time in the stable.

Deformation of hooves / legs
Deformed claws have been quite prevalent at earlier times. A combination of factors e.g. malnutrition, high inbreeding coefficients and suboptimal substrates (concrete or other substrates that do not allow the claws to sink in) leading to inadequate wear have been suspected to be associated with this deformation because - as soon as these factors were corrected, deformed claws were not seen any more at Zoo Basel.

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Teeth
In addition, mandibular swellings and abscesses (conditions similar to lumpy jaw or necrobacillosis known in Cervidae) have decreased markedly in prevalence with improved husbandry and nutrition. It seems that the adequate wear of the cheek teeth because of sufficient fibre intake and overall improved fitness has led to this decrease.

2.7.2 Sedation / anaesthesia protocol

Anesthesia data analysed from ZIMS Species 360 reveals that anesthesia protocols with carfentanil combined with alpha-2-agonists with/without ketamine are most commonly used. Another common protocol is a combination of butorphanol (0.05-0.46 mg/kg), ketamine (0.77-6.67 mg/kg) and medetomidine (0.018-0.33 mg/kg), antagonized with atipamezole and naltrexone. The writer has made good experiences with this protocol, using 0.12 mg/kg butorphanol, 5 mg/kg ketamine and 0.12 mg/kg medetomidine for light anesthesia and supplemented with isoflurane if needed.

For transport sedation, the long-acting tranquilizer perphenazine has been used with good success in a dose of 1mg/kg perphenazine enanthate, 2-3 days before loading. Extensive information on sedation and anesthesia of lesser kudus is available (Wolfe, 2015).

2.7.3 Vaccination protocol

Lesser kudus are not routinely vaccinated and a regional risk assessment concerning infectious cattle diseases is recommended.

2.7.4 Findings from Necropsy reports

The analysis of necropsy reports from Zoo Basel (1956 – today) revealed that almost ¾ of the newborn animals died within the first year, and within those, 50% died within the first two months and 15% within the first week. These numbers are in agreement with a high neonatal mortality in other zoos (Steck, B., 2018). The most common causes of death were reproductive issues (inanition, not accepted by dam, weak neonates). Deaths during the second month of life occurred due to infectious causes, white muscle disease and trauma. It seems that the second month is the most critical period and appears to be associated with weaning. Most infections affected the gastrointestinal system during this period, compared to infections in the third month of life, which most commonly affected the respiratory system, causing (broncho-) pneumonia. After the third month of life, the causes of death were mostly traumatic with a slightly increasing prevalence of infections when the animals got older.

2.8. Specific problems

Loss of horns
Males released outside in spring often use their horns to dig in the ground and fight. In doing so, a horn can break. The broken end needs to be removed and the edges of the remaining horn need to be rounded.

Overgrown hooves
If the lesser kudus can use variety of substrates in the outdoor enclosure (sand, gravel, earth, mud, marl, hard core), this will help reduce overgrown hooves.

In the lesser kudu ESB, the mortality in all age groups is high. In 2017, there were 19 death cases in a population of 70 animals. The fact that death cases outnumber births leads to a decreasing population despite high institutional interest (Steck, 2013, 2017).

Due to legal obstacles (imports of ungulates from third countries), required veterinary tests and past genetic issues with regard to subspecies, it has not been possible to mix the two separate populations in Europe and Maktoum, a former member of the ESB. Exchanges of animals with Maktoum, UAE, DECAN, Djibouti, and the American breeding programme would be very important to reduce inbreeding and improve the gene diversity (Steck, 2015, 2017).

2.9. Recommended research

Evaluation of necropsy reports and analysis of death causes in infant, juvenile and adult lesser kudus to identify common health problems and possible treatments, to improve the survival rate and enable the ESB to grow.

Various holders suggested research into

- Optimising the diet
- Investigating the cause of the lack of Vitamin E
- Metabolic causes for the formation of abscesses

Molecular genetic research into the population to determine the relatedness of individuals in order to fill the gaps in the pedigree. Only in that way can reliable conclusions be drawn from genetic analysis and proper population management be carried out to sustain a viable and healthy captive population of lesser kudus.

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