Juvenile mortality in captive Lesser Kudu (Tragelaphus imberbis) at Basle zoo and its relation to nutrition and husbandry

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Abstract

Since 1956, when the Basle Zoo (Switzerland) initiated the breeding of lesser kudu (Tragelaphus imberbis), 43% of the lesser kudu juveniles died before reaching an age of 6 mo. In this study, the objective was to obtain the pathological findings, nutritional history, and family tree information in order to evaluate the influence of husbandry on juvenile mortality in these animals. The main cause of death was white muscle disease (WMD), diagnosed in 14 cases (26%) of the deceased juveniles. Although enclosure size had remained constant and animal accessibility to the public was constantly high, both herd size and juvenile mortality had increased from 1956-2004. The diet consumed by the whole group in 2004 had deficient levels of vitamin E and selenium. The increasing linear trend of the mortality rate since the 1960s was significant, and there was a significant correlation between herd size and overall juvenile mortality. In contrast, there was no correlation between herd size and the occurrence of juvenile mortality associated specifically with WMD. Other investigated factors (sex, inbreeding, and season) had no significant effect on overall mortality up to 6 mo of age or on mortality associated with WMD. These results characterize both a dietary and a husbandry problem, and are supported by a lack of similar juvenile mortality in another facility where the diet was supplemented with vitamin E, animal numbers were kept low, and the enclosure structure offered more retreat options for the animals.
case report

JUVENILE MORTALITY IN CAPTIVE LESSER KUDU (TRAGELAPHUS IMBERBIS) AT BASLE ZOO AND ITS RELATION TO NUTRITION AND HUSBANDRY

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Abstract: Since the Basle zoo initiated the breeding of lesser kudu (*Tragelaphus imberbis*) in 1956, 43 percent of the lesser kudu juveniles died before reaching an age of six months. In this evaluation, we collated the pathological findings, nutritional history, family tree and evaluated the influence of husbandry on juvenile mortality in these animals. The main cause of death was white muscle disease, diagnosed in 14 cases (26%) of the deceased juveniles. While enclosure size had remained constant, and animal accessibility by the public was constantly high, both herd size and juvenile mortality had increased from 1956 to 2004. The diet consumed by the whole group in 2004 had deficient calculated levels of vitamin E and selenium. The increasing linear trend of the mortality rate since the 60ies was significant, and there was a significant correlation between herd size and overall juvenile mortality; in contrast, there was no correlation between herd size and the occurrence of juvenile mortality associated specifically with WMD. Other investigated factors (sex, inbreeding, season) had no significant effect on overall mortality up to six months of age or on mortality associated with WMD. These results characterize both a diet and a husbandry problem, and are supported by a lack of similar juvenile mortality in another facility where the diet was supplemented with vitamin E, animal numbers were kept low, and the enclosure structure offered much more retreat options.

Key words: Lesser kudu, *Tragelaphus imberbis*, white muscle disease, vitamin E, diet, herd size, inbreeding
INTRODUCTION

Lesser kudu are found browsing in dry forests and brushes in the north-east of Africa.\cite{1,12} They are considered to be difficult animals in captive situations and therefore rarely kept in zoos. The problem of successfully raising lesser kudu at Basle Zoo was discussed in two previous reports.\cite{11,14} Lang\cite{11} observed that juvenile mortality decreased after installation of a heatable nest box. The author identified too low temperatures as one of the main risks for juvenile mortality. Rüedi et al.\cite{14} noticed a low vitamin E supply in three juvenile animals resulting in deaths associated with white muscle disease (WMD). The authors examined the vitamin E content of some plasma and liver samples of healthy and diseased animals and analyzed the diet offered to the kudu; they suggested changes such as the inclusion of wheat germ to increase dietary vitamin E levels.

Nevertheless, a generally high loss of juveniles, and cases of WMD, seemed to have persisted over the years. The aim of this study was to assess juvenile mortality, the incidence of WMD, and potential contributing causes to this scenario, by evaluating the necropsy reports since 1956, the family trees, and the diets consumed by lesser kudu at Basle Zoo.

CASE REPORTS

Basle Zoo

At Basle Zoo lesser kudu were kept on a 400 m$^2$ outdoor enclosure. In addition they had access to the outdoor enclosure of the giraffes, which was situated next to the kudu enclosure and separated by a semipermeable gate. The indoor enclosure consisted of four single boxes (4x9 m$^2$), which were usually combined but could be separated. The whole group was kept together at all times. There was one single box that was not visible for visitors where, after birth, mother and offspring were separated from the group for two
days. In winter, the lesser kudu were kept indoors and the visitors could approach up to very short distances (<1m).

Necropsy reports for 54 juvenile (younger than six months of age) lesser kudus that died between 1956 and 2005 at the Basle Zoo were evaluated for the cause of death and the occurrence of specific diseases. The 54 juveniles died with an average age of 45 days. The most frequent diagnoses at necropsy were WMD (n=14), enteritis (8), renal alterations (7), and starvation (7); among the other causes of death were pneumonia (4) and necrobacillosis (2). The occurrence of WMD did not change notably over the years (Fig. 1). In particular, there was no notable change since the work of Rüedi et al.\textsuperscript{14} from 1980; only in the few years after that study, no loss associated with WMD was noted, which speaks for only a short-lived awareness of the problem after it was investigated.

WMD in 14 juveniles had been classified as severe in eight and medium-grade in six cases. Histopathological investigation revealed typical lesions limited to skeletal muscle fibres in five cases, limited to heart muscle fibres in one case, and combined alterations in eight cases. Histologically, lesions were characterized by multifocal hypercontraction, hyaline degeneration and mineralization of disseminated or grouped myofibers, associated with varying macrophage infiltration and proliferation of satellite cells. The lesions were compatible with the changes usually described in nutritional myopathies in domestic livestock.\textsuperscript{18}

There were four additional animals that showed only mild signs of WMD at necropsy and were therefore assigned to another main “cause of death”-group than WMD. In animals affected with enteritis, bacteriologic culture revealed \textit{Escherichia coli} (partially hemolytic) in three cases, and \textit{Clostridium perfringens} in three cases. There was also a severe infestation with \textit{Clostridium perfringens} in animals with primary diagnoses other
than “enteritis”. Overall, eleven animals (20%) were diagnosed with *Clostridium perfringens* at necropsy. All parasitologic examinations (n = 8) were negative.

In the spring of 2004, all diet items offered to the whole group of lesser kudus, and the leftovers, were weighed for three consecutive days in order to assess the diet. Intake recording on an individual level was not deemed feasible for this survey as it would have caused undue stress for the respective animals. The diet ingested daily by nine animals (one adult male, six adult females of which 2 were lactating, 2 juveniles) in the spring of 2004 consisted of 8.53 kg lucerne hay (*Medicago sativa*), 1.96 kg of a pelleted compound feed (crude protein 15.3%, crude fiber 18.0%, vitamin E 400 mg/kg, selenium 0.5 mg/kg), 2.29 kg carrots, 1.63 kg beetroot, 0.58 kg fennel, 0.49 kg sugarbeet and 0.13 kg chicory. The proportion of roughage to non-roughage food components, on an as-fed basis, was 55:45. The results were entered into Zootrition software V2.5 (St. Louis Zoo, St. Louis, MO) which contained customized information on the composition of the diet items used at Basle zoo, and compared to the recommendations for another browsing ruminant, the okapi (*Okapia johnstoni*), which are implemented in the program. Calculated crude protein levels of this diet were 95% of the recommendations for okapi maintenance, while vitamin E levels were 52%, and selenium levels 60% of the recommendations. During the growing season, the animals additionally received freshly cut grass.

Historically, inbreeding, as judged from the family trees compiled from the lesser kudu register of Basle zoo, often occurred in the herd. Daughters bred with their fathers in 32 cases, mothers with sons in eleven cases and a sister with a brother in one case. Thus, 44 of 133 animals are a product of direct inbreeding. The breeding male who sired offspring from 1985-1994 was diagnosed at autopsy with severe WMD.

The number of animals kept per year, of births, and of losses, were compiled from the lesser kudu register of the Basle Zoo. During the initial decade, the herd of lesser kudu
Mortality in captive lesser kudu consisted of two to six animals but increased steadily up to eleven animals in 2004. Statistical analyses of birth and mortality data were performed using Statistika™ 5.0 (StatSoft®, Tulsa, Oklahoma, USA). Logistic regressions were used (PROC LOGISTIC from SAS, Release 8.01, SAS Institute Inc., 2002) investigating if the overall mortality up to six months of age and mortality due to WMD were affected by sex, inbreeding, season of birth, and decade of birth; additionally, correlations between herd size (measured as number of births per year) and mortalities were tested. The results of the logistic regression analyses revealed a significant effect of the decade of birth on the mortality rate up to six months of age. The linear trend of the mortality rate since the 60ies, 1959-1969: 13% (n=31), 1970-1979: 21% (n=19), 1980-1989: 28% (n=18), 1990-1999: 55% (n=47), 2000-2005: 75% (n=20), was significant (p<0.001). All other investigated factors as sex, inbreeding, season had no significant effect on mortality up to six month of age, or for the mortality associated with WMD; as for WMD, the decade of birth did not have a significant effect, either. There was a significant correlation between the herd size, as characterized by the number of births per year, and the occurrence of juvenile mortality (r²=0.48, p<0.001; Fig. 2); however, there was no correlation between the number of births per year and the occurrence of juvenile mortality associated with WMD (r²=0.03, p=0.39).

Stuttgart Zoo

For comparison, we collected data of husbandry, nutrition and juvenile mortality in lesser kudu at another zoo (Zoological and Botanical Garden Wilhelma, Stuttgart, Germany). In contrast to Basle, the Wilhelma Zoo in Stuttgart keeps lesser kudu with a juvenile mortality average of 20%. The outside and inside enclosures are not accessible to the visitors in Stuttgart. Similar to Basle Zoo, there is a semipermeable fence to the giraffe enclosure, well visible to the visitors, but the lesser kudu are able to withdraw from it at all
times and can return to their hidden outdoor enclosure. There are ten boxes for the lesser kudu group, whose size is comparable to that of Basle Zoo. In Stuttgart Zoo the buck is separated at night. Once young males get sexually mature in Stuttgart Zoo, they are removed from the group to prevent inbreeding. The same happens if the breeding male starts to cover his female offspring. After birth, mother and offspring are separated from the group for three or four weeks and in wintertime up to four months. Juveniles obtain a single preventive vitamin E/ selenium injection on their first day. In addition the food of the whole group is supplemented with an oral vitamin E/ selenium formulation (Vitamin E/Selen Liquid RS, Chevita AG, Pfaffenhofen, Germany) which is sprayed over the food three times a week. In pregnant females the formulation is applied daily one week before and after birth. Kudus have access to branches with leaves ad libitum throughout the vegetation period. The regular diet consists of lucerne, grass, pellets, oat flakes, soft food, potatoes, various sorts of bread and corncobs.

DISCUSSION

Although the problem of low vitamin E and selenium status has been recognized at Basle Zoo for a long time, cases of WMD have occurred continuously over the years, as documented by pathology reports and serum biochemistry and vitamin E levels in various animals. In general, vitamin E deficiency is a well-recognized problem in zoo animal management. The lack of cases around the time of the first investigation into the problem at Basle Zoo, but its later re-occurrence, underlines that changes in management must be implemented in a manner that guarantees their persistence over time. While parenteral application of vitamin E/selenium achieves increased serum levels and potentially also a reduction of serum biochemistry abnormalities WMD as documented by Rüedi et al., applying medication parenterally to animals of such nervous nature always is stressful and
impractical. Instead, the application of vitamin E/selenium supplements to the diet are to be preferred as described by Graffam et al.\textsuperscript{7} or in practice at Stuttgart Zoo. In particular, the supplementation of mother animals with vitamin E and selenium is extremely important; both are mainly supplied to offspring via colostrum and milk. In sheep, serum values of vitamin E and selenium from the mother are positively correlated with the content of their colostrum and with the serum values of lambs after intake of colostrum.\textsuperscript{9,13}

Apart from the fact that the diet as measured for this study was deficient in both vitamin E and selenium, the feeding of fresh grass in summer is a probable additional factor that can lead to WMD: grass grown in the jura region of Switzerland is known to be deficient in selenium.\textsuperscript{10} Therefore, such grass should not be fed unsupplemented to susceptible species. It is planned to increase the supply of browse forage to the lesser kudu by ensilaging tree foliage; however, unless analyses show a different result, foliage from locally grown trees should also be considered critical in terms of selenium content.

The susceptibility to \textit{Clostridium perfringens}, which was also detected in some animals affected with WMD, indicates a high infection pressure or a weak immune system. A low supply of the juveniles with vitamin E and selenium could have resulted in an insufficient immune defense,\textsuperscript{17} just as stress (group size, no hiding opportunities) or an inadequate feeding could have: during a study between 1991 and 1998 in different stocks from Niedersachsen (Germany) 125 sheeps and 23 goats with a suspicion of vitamin E/selenium deficiency were examined. Twenty percent of sheep with vitamin E/selenium deficiency did not show any muscle or liver alterations, but unspecific symptoms like anaemia and hypoproteinaemia, partly in combination with endoparasitism, diarrhea and cachexia.\textsuperscript{2} Thus, it appears likely that a generally poor vitamin E status of Basle lesser kudus could have made juveniles susceptible to a variety of other diseases,\textsuperscript{16} although no measurements on immunological function were performed.
In contrast to our suspicion, it could not be shown that the inbreeding that occurred at Basle Zoo had a measurable effect on the health status of neonate animals - as demonstrated in other species. Therefore, even though inbreeding is undesirable and should be prevented, it cannot be blamed for the high juvenile mortality at Basle Zoo. Instead, other management factors seem to be of utmost importance: The fact that both herd size and juvenile mortality increased over the decades, and that there was a significant correlation of the number of births with the number of juvenile deaths per year but not with the number of deaths associated with WMD, suggests that social stress itself should be regarded as another important factor in the high juvenile mortality. Compared to Stuttgart Zoo, the lesser kudu at Basle are exposed to increased stress due to the lack of opportunities to withdraw from visitors, due to the continuous presence of the adult male in the herd, and due to the high stocking number of animals. The separation of the male at night, as performed at Stuttgart, corresponds to the natural behavior of the species; free-ranging males rarely stay together with the females. Social stress caused by overcrowding leads to maternal malnutrition, parasitism, disease and higher juvenile mortality rates in white-tailed deer (*Odocoileus virginianus*). In another browsing species commonly regarded as “nervous”, the black rhinoceros (*Diceros bicornis*), the accessibility of the enclosure to visitors has been demonstrated to be a direct correlate of increased fecal stress hormone levels and the occurrence of disease. A group size of six adults is recommended for the lesser kudu, but the Basle group has continuously been larger since 1991. In addition to dietary measures addressing the vitamin E/selenium supplementation, a general reduction in herd size seemed warranted and was predicted to also reduce overall juvenile mortality.

CONCLUSIONS
Due to the results of this study, the herd size at Basle Zoo was reduced to six adult animals; an oral vitamin E/selenium supplement (Vitamin E-Selen Liquid RS, Chevita, Pfaffenhofen, Germany) in the daily ration (calculated dose per animal and day: alpha tocopherol acetate 1800 IU, sodium selenite 0.5 µg). In addition, measures that limit visitor access to all parts of the animals’ enclosures have been installed in the form of wood covers and plant groups. The efficacy of these measures will have to be evaluated over the coming years.

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LITERATURE CITED


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