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SHORT COMMUNICATION

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Blood mineral profile of the critically endangered Western Derby eland (*Taurotragus derbianus derbianus*) in two conservation breeding reserves in Senegal

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Abstract

For many nondomestic species, nutritional requirements and the challenges faced in their current habitats are unknown. This is the case of small semi-captive population of the critically endangered Western Derby eland held in two wildlife reserves (the Bandia and the Fathala) in Senegal. The aim of this study was to determine the mineral profile (Ca, P, Mg, Cu, Fe, Zn, Se, K, S) in blood serum and to identify potential mineral deficiencies. Serum data (11 individuals) were compared to other Tragelaphineae, where it was lower in almost all elements. Considerably low concentrations were recorded for Cu, Fe and Zn. Animals in the Bandia reserve had higher serum levels of Fe and K compared to the Fathala reserve and a higher serum level of S in the Fathala reserve compared to the Bandia reserve. Recorded mineral levels may reflect most likely the limited mineral background in the local environment. The knowledge of adequate nutritional requirements and health status of these animals is relevant for the conservation breeding programme. No other serum mineral reference values exist for Western Derby eland, neither for free-ranging nor captive animals. Therefore, the knowledge of reference intervals for minerals in serum may serve for monitoring of the population's health.

KEYWORDS
antelope, blood serum biochemistry, mineral nutrition, ruminant, West Africa

The Western Derby eland (WDE) (*Taurotragus derbianus derbianus*) is a large West-African savannah-dwelling antelope with fewer than 200 remaining individuals in their last refuge in Senegal. Apart from the wild population in the Niokolo Koba National Park, there is a small semi-captive population (101 individuals) held in the Bandia and the Fathala wildlife reserves as part of a conservation breeding programme (Brandlová et al., 2017). WDE is a browser, and its diet composes mainly of leaves, shoots of woody plants and fruits. These food items form 98.8% of WDE's diet in the wild, while in the Bandia reserve it represents 77.5% of diet volume, because of supplementary feeding of *Acacia albida* pods, groundnut hay and livestock feed. Animals in the Bandia reserve are fed regularly and in larger amounts compared to the Fathala reserve (Hejcmanová, Homolka, Antonínová, Hejcman, & Podhájecká, 2010). Supplementary feeding is provided by rangers mainly in dry and hot dry seasons. There is also occasional provision of mineral licks (of unknown mineral composition) on the Fathala reserve only. The knowledge of adequate nutritional requirements and health status is important for the conservation breeding programme. Knowing reference intervals for minerals in serum is relevant for monitoring population health, and for investigating the lower rate or reproduction in the Fathala reserve compared to the Bandia reserve (Brandlová et al., 2017). The only relevant information is reference values for the eastern subspecies of Giant eland from ZIMS (2013). The aim of the present study was therefore to describe the mineral status of WDEs through the mineral profiles (Ca, P, Mg, Cu, Fe, Zn, Se, K, S) in blood serum.

Our study was conducted on WDEs in two breeding reserves in Senegal. The Bandia reserve is located 65 km southward from Dakar in the Sahel-Sudanese savannah, which is dominated by *Acacia* spp. and *Balanites aegyptiaca*. The Fathala reserve is located 250 km southward from Dakar in the Sudano-Guinean savannah, which is dominated by *Acacia* spp., *Combretaceae* family trees, and *Danielia oliveri* (Hejcmanová et al., 2010). Both reserves have a dry and wet seasonal climate, receiving approx. 350 mm and 800 mm of rainfall annually in the Bandia and Fathala reserves, respectively.

Blood was sampled from 11 young animals (1–3 years old) in total (4 males from the Fathala reserve; 2 males and 5 females from the Bandia reserve) during translocations in the dry season in March 2017. Individual animals were selected on basis of the genetic kinship (to avoid inbreeding of related individuals) under the supervision of conservationists rather than the need of this research. Animals were immobilized with a combination of medetomidine (Medetomidine 10 mg/ml; Kyron Laboratories), butorphanolum (Nalgosed 10 mg/ml; Bioveta, a.s.), azaperone (Stresnil 40 mg/ml; Janssen Animal Health) and ketamine (Narkamon 100 mg/ml; Bioveta, a.s.), and blood was taken from the *Vena saphena lateralis* 18–33 min after application of drugs and before the i.v. application of antidotes atipamezole (Revertor 5 mg/ml; CP-Pharma Handelsges, GmbH) and naloxone (Naloxone WZT Polfa 0.4 mg/ml; Warszawskie Zaklady Farmaceutyczne Polfa S.A.). The blood was collected in 5 ml blood serum plastic tubes with a separating gel (VACUETTE; Dialab). Animals were immobilized by one dart shot from distance in open space of boma in the early morning hours. Detailed health status of individual animals was not known before darting; however, no clinical signs of diseases or health problems, for example poor growth, hair loss or discoloration, weakness and swollen joints, were observed. The samples were centrifuged by portable manual centrifuge after 1 hr of settling. The centrifuged, clear serum was placed in a deep freeze in Eppendorf tubes. Serum samples were transported to the Czech Republic in cooling box filled with gel cooling packs. Temperature could not be controlled during 12 hr of transportation from Senegal to Czech Republic. The samples were frozen immediately after transportation to Czech Republic again.

The samples were examined in accredited laboratory at the State Veterinary Institute in Prague 16 days after sampling. The concentrations of P, Ca and Mg were determined by an IDEXX VetTest Chemistry Analyzer, the concentrations of S, Se, Fe and Zn were determined by an ICP-OES (Thermo Scientific™ iCAP 6000 Series; Thermo Fisher Scientific), the concentration of K was determined by an AAS-flame (AA240; Varian), and the concentration of Cu was determined by a GF-AAS (Spectra AA220Z; Varian) with a Zeeman correction.

Statistical analyses were performed using the TIBCO® STATISTICA™ package (StatSoft). The small sample size suggested a non-parametric approach, without need of normality testing. A comparison of mineral concentrations between two localities was performed using the non-parametric Mann-Whitney U test. Serum mineral relationships were tested by Spearman's correlation.

The values of the WDE serum mineral concentrations (Table 1) were lower in almost all elements compared to the blood parameters of other Tragelaphineae, zebu or cattle (Table 2). The only detected correlations between minerals were those of Ca with Mg ($r_s = .96$, $p = .05$) and Ca with P ($r_s = .96$, $p = .05$) in Bandia reserve animals.

The serum mineral levels were comparable for males and females with the exception of Mg concentrations, which were lower in males (U = 3, $p = .035$) without any obvious reason, which was

TABLE 1 Concentration of minerals (mean ± *SE*, range) in the blood serum of Western Derby elands (*n* = 11) in the Bandia and Fathala reserves, Senegal

	Total *n* = 11	Bandia *n* = 7	Fathala *n* = 4	Males *n* = 6	Females *n* = 5
Ca, mmol/L	1.87 ± 0.14 (0.95–2.39)	1.77 ± 0.54 (0.95–2.39)	2.03 ± 0.34 (1.54–2.27)	1.75 ± 0.53 (0.95–2.27)	2.00 ± 0.41 (1.31–2.39)
P, mmol/L	2.12 ± 0.13 (1.36–2.76)	2.17 ± 0.52 (1.36–2.76)	2.04 ± 0.27 (1.77–2.38)	1.96 ± 0.37 (1.36–2.38)	2.31 ± 0.46 (1.55–2.76)
Mg, mmol/L	1.55 ± 0.10 (1.09–2.05)	1.68 ± 0.33 (1.09–2.05)	1.32 ± 0.18 (1.15–1.49)	1.36 ± 0.26* (1.09–1.75)	1.78 ± 0.24* (1.39–2.05)
Cu, µmol/L	10.87 ± 2.78 (6.55–38.50)	12.14 ± 11.65 (6.86–38.50)	8.66 ± 1.47 (6.55–9.95)	8.58 ± 1.20 (6.55–9.95)	13.62 ± 13.91 (6.86–38.50)
Fe, µmol/L	22.35 ± 1.21 (16.80–31.30)	24.2 ± 3.73* (19.2–31.30)	19.13 ± 2.11* (16.8–21.9)	20.92 ± 3.33 (16.80–25.80)	24.08 ± 4.46 (19.20–31.30)
Zn, µmol/L	11.51 ± 0.40 (10.60–14.90)	11.34 ± 0.84 (10.70–13.10)	11.80 ± 2.07 (10.60–14.90)	11.55 ± 1.67 (10.60–14.90)	11.46 ± 0.97 (10.70–13.10)
Se, µmol/L	1.75 ± 0.17 (0.87–2.92)	1.62 ± 0.49 (0.87–2.34)	1.97 ± 0.66 (1.43–2.92)	1.73 ± 0.68 (0.87–2.92)	1.78 ± 0.43 (1.26–2.34)
K, mmol/L	5.21 ± 0.11 (4.70–5.75)	5.40 ± 0.26* (5.11–5.75)	4.87 ± 0.23* (4.70–5.20)	5.00 ± 0.27 (4.70–5.26)	5.46 ± 0.30 (5.11–5.75)
S, mmol/L	27.23 ± 0.50 (24.00–30.00)	26.54 ± 1.61* (24.00–29.30)	28.43 ± 1.05* (27.90–30.00)	27.90 ± 1.15 (26.70–30.00)	26.42 ± 1.95 (24.00–29.30)

*Significant ($p < .05$) differences tested by Mann-Whitney *U* test according to locality and sex.

TABLE 2 Overview of blood (serum/plasma) mineral concentrations (mean, range) of different ruminant species

	Cape eland	Greater kudu	Lesser kudu	Bongo	Zebu	Horro cattle	Cape eland (free)
Ca, mmol/L	2.44 (1.91–2.81)	1.84 (0.99–2.23)	2.27 (2.09–2.62)	1.73 (1.14–2.47)	5.40 (4.10–12.30)	3.82	2.87
P, mmol/L	2.44 (1.91–2.81)	2.70 (1.36–4.60)	2.32 (1.24–3.37)	2.21 (1.94–2.74)	3.30 (1.80–4.60)	4.56	1.29
Mg, mmol/L	0.84 (0.50–1.06)	0.53 (0.30–1.07)	0.75 (0.62–0.95)	0.71 (0.33–1.12)	1.90 (1.40–2.30)	0.71	0.78
Cu, µmol/L	22.55 (17.20–30.80)	27.80 (17.20–46.90)	21.35 (19.60–23.10)	25.5 (7.60–34.40)	6.00 (0.80–18)	10.38	14.10
Fe, µmol/L	39.60 (15.90–50.50)	35.48 (8.40–56.60)	53.94 (39.60–69.80)	39.55 (23.90–58.60)	143 (75–1,200)	24.35	
Zn, µmol/L	103.3 (29.20–198)	91.36 (48.60–137)	71.15 (53.70–86.60)	117.60 (114.50–120.70)	46 (24–107)	13.92	
K, mmol/L	5.86 (5.39–6.25)	4.55 (4.01–5.24)	5.72 (4.34–8.35)	6.19 (4.88–7.40)	4.40 (2.70–6.60)		
S, mmol/L					37 (22–47)		

Source: For captive Cape eland ($n = 8$–10), Greater kudu ($n = 3$–20), Bongo ($n = 4$–8) and Lesser kudu ($n = 2$–8) (Váhala et. al., 1989), domestic zebu ($n = 90$) (Dermauw et al., 2013), domestic Horro cattle ($n = 10$–14) (Gizachew et al., 2002), and free-ranging Cape eland ($n = 4$–12) (Drevemo et al., 1974).

similar to the findings in the plasma of captive zebu (*Bos indicus*) in Ethiopia (Dermauw et al., 2013). We recorded higher serum levels of Fe ($U = 1.5$, $p = .023$) and K ($U = 1$, $p = .018$) in the Bandia reserve compared to the Fathala reserve. Higher serum level of S ($U = 3$, $p = .046$) was recorded in the Fathala reserve compared to the Bandia reserve. Higher serum levels of Fe and K in the animals living in the Bandia reserve correspond to the higher concentrations of these minerals in the soil in the Bandia reserve (Stoklasová, 2016). Other tested minerals in soil (Ca, P, Cu, Fe, Zn, K) were higher on the Bandia reserve compared to the Fathala reserve as well. Animals from the Fathala reserve had slightly, but not significantly higher concentrations of Ca, Cu and Zn in the blood, thus not corresponding to soils in reserves. Soils in both reserves are generally very low in mineral concentrations compared to other localities (Stoklasová, 2016). Regarding the animals from the Bandia reserve, there was more mineral content variability in the blood serum among individual animals with no specific pattern.

Predominantly low concentrations of minerals in WDE's blood serum might indicate mineral deficiency; however, the animals were all in a good condition without any obvious clinical issues. Recorded mineral levels may reflect most likely an adaptation of the WDE to a specific environment that is poor in minerals. Considerably low concentrations were recorded for Cu, Fe and Zn. The low Cu concentration could be explained by copper-containing serum proteins that are incorporated into the clotting during the serum extraction, making the Cu levels rather variable (Laven & Smith, 2008). The low Zn could be linked to either low Zn levels in the mature forages or to an antagonistic relation to the P in phytates (Suttle, 2010). Cu and Zn are susceptible to so called "herd effect" which influences the concentrations of minerals in serum independently on diet, and more animals must be tested for convincing results (Herdt & Hoff, 2011). Regarding low number of individuals involved in the study, our results might be partly affected by a small sample size.

A low concentration of Cu matches a low concentration of Fe, since Cu is essential for absorption and transport of Fe (Tuormaa, 2000). The serum Ca:P ratio of WDEs in the reserves (mean 0.88 ± 0.13 *SD*) was inverted compared to the ratio values for ruminants considered clinically normal (1.5–2 for domestic cattle, see Gizachew, Hirpha, Jalata, & Smit, 2002; for wild antelopes, see Drevemo, Grootenhuis, & Karstad, 1974). This shows the same phenomenon commonly observed in non-domesticated bovids bred in captivity, for example greater kudu *(Tragelaphus strepsiceros)* and bongo *(Tragelaphus eurycerus)* (Table 2) (Miller et al., 2010; Váhala, Pospíšil, Špála, & Kaše, 1989). Considering diet selection of WDE, the Fathala reserve appears unfavourable for WDE in terms of macro-elements' content and fibre fractions of local plants (Hejcmanová, Miřejovská, Homolka, & Hejcman, 2019), and similar conditions in the Bandia reserve can be expected. Combined findings of soil and our serum analyses suggest that WDEs might benefit from mineral supplementation, for example mineral licks. Effects of such a supplementation would have to be evaluated.

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CONFLICT OF INTEREST

All authors state no conflict of interest.

ANIMAL WELFARE STATEMENT

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to. The authors confirm that the study was performed within the frame of conservation translocation of the animals with approval of Senegalese conservation authorities, namely the Directorate of National Parks of Senegal, and the study has followed EU standards for the protection of animals used for scientific purposes.

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