

Mineral composition of antlers of three deer species reared in captivity

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Abstract

In order to study the mineral composition of antlers, nine fallen hard antler samples comprising three each of Barasingha (swamp deer, *Cervus duvaceli*), Chital (axis deer, *Axis axis*) and hog deer (*Axis porcinus*) reared in captivity were collected and analysed for various minerals. Dry matter, crude protein (31.99, 35.16 and 36.59%) and total ash (62.94, 62.54 and 60.27%) contents were similar among the three species, whereas the fat content was greater ($P < 0.05$) for swamp deer (5.08%) compared to axis deer (2.31%) but compatible with hog deer (3.14%). Concentrations of calcium (23.44, 23.43 and 22.05%), magnesium (0.73, 0.80 and 0.74%), cobalt (9.01, 8.04 and 7.67 ppm) and zinc (33.50, 32.14 and 35.81 ppm) were not different among species. However, the concentration of phosphorus was lower ($P < 0.05$) in axis deer (10.83%) in comparison to swamp deer (12.62%) and hog deer (12.23%). Concentration of copper was higher ($P < 0.05$) in hog deer (8.44 ppm) in relation to that of swamp deer (5.30 ppm) and axis deer (6.10 ppm). Concentrations of the heavy metals, lead and cadmium, were similar among the three species. It was concluded that the concentrations of various minerals in the fallen hard antlers of the three species of deer were similar to those reported for bones of domestic animals. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

Antlers are unique to most deer species, with the exception of musk deer and Chinese water deer, in the sense that these appendages are cast off annually and are replaced through regeneration. The growth of antler is regulated hormonally, especially under the

influence of testosterone (Fennessy and Suttie, 1985) and is related to male sexual behaviour. Antlers initially grow as soft tissues growing out with the mating season. The tissue of antler in velvet differentiates rapidly, showing a sequential development from tip to base (Kay et al., 1982). Eventually, just before rut, it becomes hardened as a dead bony tissue because of progressive mineralisation and finally owing to occlusion of blood vessels (Fletcher, 1986) with the dead skin fraying off to expose the hard antler. The basic principles of mineral metabolism and daily requirements applicable to domestic ruminants apply to free-ranging and captive exotic ruminants as well (Wallach

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and Hoff, 1982). But in the case of deer, it warrants special consideration during antlerogenesis because of the fact that the growth rate of antlers can be two to three times that of skeletal bone (Cowan et al., 1968). The role of minerals, therefore, are paramount in antler growth and mineral requirements increase during antlerogenesis (Adam, 1986).

Wild deer in their natural habitat can exercise a great deal of diet selectivity in order to meet their mineral requirements. This, however, may not be the case in farmed or captive-reared deer, which generally have fewer opportunities for selection of feedstuffs and, hence, may be more prone to mineral deficiencies and/or imbalances. Despite a good deal of research, knowledge concerning the nutritional requirements of deer is sparse (Shin et al., 2000), especially for mineral requirements (Adam, 1986). Keeping this in view, the present study was conducted to determine the concentration of some essential minerals in antlers of three deer species so as to aid in the establishment of mineral requirements for antlerogenesis and further, to compare the mineral composition of hard antlers of captive-reared deer to the bones of domestic animals considering the near similar management.

2. Materials and methods

2.1. Sample collection

Nine samples of fallen hard antlers, comprising three each of Barasingha (swamp deer, *Cervus duvauceli*), Chital (axis deer, *Axis axis*) and hog deer (*Axis porcinus*), were collected from the Wildlife Centre of the Indian Veterinary Research Institute. The animals were fed a standard maize–soyabean–wheat bran concentrate supplement which contained 0.70% Ca, 1.11% P, 0.39% Mg, 22.18 ppm Cu, 33.32 ppm Zn and 0.09 ppm Co on dry matter basis. The lead and cadmium concentration of the supplement was 0.40 and 0.15 ppm, respectively. The concentrate supplement was offered at approximately 1.0 kg/animal/day keeping in view the type of accompanying green forage being offered. The animals had year round access to ad libitum green forages (berseem, oats, maize and sorghum) depending upon season and availability. Green forages grown at the institute's farm section were harvested and fed to the animals.

The overall concentrations of Cu, Co and Zn, assayed in another study during the same period, ranged between 3.52–14.6, 2.10–7.25 and 30.17–36.04 ppm, respectively (Naresh et al., 2001).

2.2. Chemical analyses and statistics

The collected antlers were ground and representative samples were analysed for dry matter, crude protein, fat (ether extract) and total ash as per AOAC (1995). The acid extract of the ash were used for determination of calcium and phosphorus (Talapatra et al., 1940). Magnesium, copper, cobalt, zinc, lead and cadmium contents were estimated in the wet digested materials using atomic absorption spectrophotometry. The data were subjected to one-way analysis of variance. The treatment means were tested for significance using least significance difference. All the statistical procedures were as per Snedecor and Cochran (1980).

3. Results and discussion

3.1. Proximate composition

The chemical composition and macro-mineral contents of the antlers are given in Table 1. There were no differences ($P > 0.05$) in the dry matter, crude protein and total ash contents of the antlers among the three species, but the fat (ether extract) concentration of axis deer was lower ($P < 0.05$) than that of swamp deer. Ash concentrations of the antlers were similar to that reported for bones of adult bovine (57–64%) by Mello et al. (1978). Fat contents, on the contrary, were much lower than that of bovine bone (Mello et al., 1978). The crude protein contents were similar to that reported by Yartsev (1988) for pantokrine, a product from finely cut non-ossified antlers of Siberian stags and spotted deer. However, the total minerals (ash) and fat contents of the antlers were higher than observed values of 39.7 and 1.0%, respectively, for pantokrine found by Yartsev (1988). The differences are obviously because of the hard antlers used in this study, which might have undergone complete ossification. Bone ash contents depend on the extent of mineralisation (Pastrana et al., 1991). Our observations are closer to the value of $51.7 \pm 1.9\%$ total ash

Table 1
Chemical and macro-mineral composition of antler of three deer species^a

Particulars	Species of deer			S.E.M.	P-value
	<i>C. duvacei</i>	<i>A. axis</i>	<i>A. porcinus</i>		
Chemical composition (% in DM)					
Dry matter	90.48	91.80	91.05	0.32	0.072
Crude protein	31.99	35.16	36.59	1.15	0.073
Ether extract	5.08 a	2.31 b	3.14 ab	0.47	0.015
Total ash	62.94	62.53	60.27	1.31	0.362
Macro-minerals (% in DM)					
Calcium	23.44 (37.24) ^b	23.43 (37.49)	22.05 (36.54)	0.63 (0.71)	0.273 (0.642)
Phosphorus	12.62 a (20.03 a)	10.83 b (17.11 b)	12.23 a (20.32 a)	0.32 (0.69)	0.017 (0.031)
Magnesium	0.73 (1.17)	0.80 (1.27)	0.74 (1.22)	0.03 (0.04)	0.193 (0.234)
Ca:P ratio	1.87	2.17	1.81	0.13	0.176

^a Means with different letters in a row differ significantly at 0.05 level.

^b Figures in parentheses are concentrations as percent of total ash.

reported for hard antlers of red deer, *Cervus elaphus* (Kay et al., 1982).

3.2. Macro-mineral composition

The calcium and magnesium contents of the antlers did not vary significantly among the three species, whereas the phosphorus concentration was lower ($P < 0.05$) in antlers of axis deer compared with others. The overall Ca:P ratio of 1.95 ± 0.08 found in the present study was similar to the reported value of 2.0 ± 0.2 by Kay et al. (1982) for hard antlers, who observed that there was no difference in the Ca:P ratio of antlers among different stages of growth. This could be further explained by observations of Stephenson and Brown (1984) that deer may have mechanisms for conserving and mobilising calcium and possibly phosphorus (Ramirez et al., 1996) from bone to antlers. In fact, Banks et al. (1968) have suggested that deer go through a skeletal demineralisation to meet the increased demands of antler growth. The calcium and phosphorus values of antlers are similar to the values of 21–24 and 10–11%, respectively, reported for bones of adult cattle (Mello et al., 1978). Furthermore, the values obtained in the present study are apparently similar to the critical levels of bone calcium (24.5%) and phosphorus (11.5%) suggested for grazing ruminants by McDowell et al. (1984). The observations follow the same trend when the concentrations are expressed as percentages of total ash

(Table 1). The calcium contents are similar to the reported value of 36% for mammalian bone ash (Doyle, 1979) and it is known to vary little among species or bones except on very low calcium–phosphorus diets (Field et al., 1974). The overall phosphorus content as a percentage of total ash (19.12%) was also apparently similar to 17% reported for bones of domestic animals (Doyle, 1979).

3.3. Trace mineral composition

The trace mineral contents are listed in Table 2. Copper concentration of antlers of hog deer was greater ($P < 0.05$) than those of swamp deer or axis deer. However, values for cobalt and zinc were similar among the species. While there is little reported data on antlers to compare with the present findings, the values appeared to be more or less in the same range as the bones of conventional domestic ruminants (Doyle, 1979). Lead and cadmium are potentially hazardous environmental pollutants. Considering the location of the Wildlife Centre within the city limits, the animals were expected to have some degree of exposure to these toxic heavy metals especially with lead being largely airborne. Moreover, concentrations of both lead and cadmium have been shown to be inversely related to distance from heavy vehicular traffic (McDowell, 1992). Both these elements also happen to be among the most important toxic minerals associated with bone metabolism. The concentration of

Table 2
Some essential trace and toxic minerals contents of antler of three deer species^a

Particulars	Species of deer			S.E.M.	P-value
	<i>C. duvacei</i>	<i>A. axis</i>	<i>A. porcinus</i>		
Trace minerals (mg/kg DM)					
Copper	5.30 b (8.44 b) ^b	6.10 b (9.74 b)	8.44 a (13.94 a)	0.70 (0.94)	0.044 (0.014)
Cobalt	9.01 (14.26)	8.04 (12.93)	7.67 (12.78)	0.57 (1.10)	0.760 (0.590)
Zinc	33.50 (53.39)	32.14 (51.21)	35.81 (59.32)	6.10 (9.54)	0.913 (0.829)
Toxic minerals (mg/kg DM)					
Lead	2.51 (3.97)	2.16 (3.48)	2.84 (4.69)	0.59 (0.94)	0.735 (0.673)
Cadmium	2.12 (3.36)	1.58 (2.55)	2.18 (3.59)	0.53 (0.85)	0.695 (0.680)

^a Means with different letters in a row differ significantly at 0.05 level.

^b Figures in parentheses are concentrations as percent of total ash.

both these heavy metals were similar among the three species. The cadmium level found in our study is similar to the level observed in bones (2.1 ppm) of reindeer whereas the lead level was much lower than the value of 41.6 ppm (Medvedev, 1995). Bone lead concentrations are reported to be good indicators of exposure to lead (Milhaud and Mehennaoui, 1988). In the case of deer, bone, teeth and antlers are suggested to give reliable and sensitive indications of pollution in the forest eco-systems (Medvedev, 1995). The levels observed in the present study appeared to be below the threshold of toxic levels.

It is concluded that, overall, there is little or no differences in the mineral profile of hard antlers of the three deer species investigated. Moreover, the values of various minerals were apparently similar to the concentrations reported for bones of domestic animals.

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