Osteophagia in the Cape porcupine *Hystrix africaeaustralis*

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Two groups of porcupines (*Hystrix africaeaustralis*) were maintained for a period of 23 weeks on a diet containing high levels of Ca^{2+} and PO_4. Parallel to this another two groups were maintained on a diet containing low levels of these minerals. All groups were provided with defatted bovine bones during weeks 18 to 23 of the experiment. Plasma Ca^{2+} and PO_4 levels were determined at intervals throughout the experiment. The amount of osteophagia that occurred was determined by weighing the bones at two-weekly intervals. No significant differences in the plasma Ca^{2+} and PO_4 levels of the porcupines on the high diet and those on the low diet were detected. Osteophagia by porcupines on the low diet was twice that of porcupines on the high diet.

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Twee groepe ystervarke (*Hystrix africaeaustralis*) is vir 23 weke 'n dieet bevattende hoë vlakke Ca^{2+} en PO_4 gevoer en twee ander groepe 'n dieet bevattende lae vlakke Ca^{2+} en PO_4. Tydens weke 18 tot 23 van die eksperiment is alle groepe van ontvette beesbene voorsien. Plasma Ca^{2+} en PO_4 is op verskeie stadiums in die verloop van die eksperiment vasgestel. Die hoeveelheid osteofagie wat plaasgevind het is elke twee weke bepaal deur die bene te weeg. Geen betekenisvolle verskille in die plasma Ca^{2+}- of PO_4-vlakke van die ystervarke op die hoë dieet en die op die lae dieet is gevind nie. Ystervarke op die lae dieet het twee keer soveel osteofagie getoon as ystervarke op die hoë dieet.

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Cape porcupines *Hystrix africaeaustralis* have long been known to accumulate bones in their lairs in certain regions and to practise osteophagia as evidenced by gnawing marks on these bones (Pitman in Shortridge 1934). These behaviours are important palaeontologically and were described by Maguire (1976) and Brain (1981). The reasons for osteophagia in porcupines, however, remain obscure and a subject of some speculation. De Graaff (1981), for example, states that it is the need to hone the incisor teeth that induces porcupines to gnaw bones while Kingdon (1974) and Skinner, Davis & Ilani (1980) believe that bones are gnawed for the minerals, particularly calcium and phosphorus, which they contain.

The former explanation for osteophagia can be discounted as attrition of the open-rooted incisors of rodents occurs naturally when the upper incisors rub against the lower pair (De Blasé & Martin 1982). Furthermore Skinner *et al.* (1980) note that osteophagic behaviour in porcupines is unique amongst species similar in size and mass and with similarly structured incisor teeth.

The porcupine diet consists of roots, bulbs, tubers, rhizomes and fruit (De Graaff 1981). These plant parts are known to be poor sources of calcium and phosphorus (McDonald, Edwards & Greenhalgh 1973). Thus it is possible that unless their digestive systems are adapted to extract adequate quantities of these minerals, porcupines may experience deficiencies in calcium and phosphorus and as a consequence, resort to osteophagia.

The objective of the present study was to investigate the relationship between dietary levels of calcium and phosphorus, and the incidence of osteophagia.

Materials and Methods

Four groups of adult porcupines were constituted as follows;
High diet groups — four males and four females
Low diet groups — two groups of one male and three females.
The mean body masses of these groups were the same.

The porcupines were housed in pens with cement floors. Half of this area was under cover and the rest exposed to sunlight. Two daily rations containing approximately the same amounts of crude protein (45 g and 42 g) but different amounts of Ca^{2+} (4 g and 0,2 g) and phosphorus (1,75 g and 0,8 g) were formulated using 0,45 kg calf starter pellets [Epol (Pty) Ltd, Johannesburg] and 2,0 kg potatoes (Table 1). Drinking water was provided *ad libitum*.

Plasma was collected from animals immobilized following van Aarde (1985) at intervals over 19 weeks. These samples were analysed for PO_4 following Henry, Cannon & Winkelman (1974) and for Ca^{2+} by absorption spectropho-

Table 1 The amount of each constituent of two rations fed to porcupines each day in the present experiment

Constituent	High diet (g) Calf starter pellets 0,450 kg	Low diet (g) Potatoes 2,0 kg
Protein	45,00	42,0
Calcium	4,00	0,2
Phosphorus	1,75	0,8
Fat	6,25	2,0
Fibre	15,00	8,0

tometry according to the Varian-Techtron manual (1972).

Defatted bovine bones were provided to all the experimental groups during weeks 18 – 23 after drying at 80°C for 4 h and mass determination. New bones were provided every two weeks and the old bones removed and weighed after scrubbing and drying as above.

The results were analysed using Student's *t* test.

Results and Discussion

The effects of growth, old age, pregnancy and lactation on calcium and phosphorus absorption were excluded from the experiment. For practical reasons sex did not apply.

Protein levels of the two diets were similar while calcium and phosphorus levels of the high diet exceeded those of the low diet by factors of 20 and 2,18, respectively. The fibre and fat content of the high diet were, respectively, two and three times those in the low diet. Fat only affects calcium absorption in cases of steatorrhea (Agnew & Holdsworth 1971).

The blood plasma Ca^{2+} levels (Figure 1) of both the high and low groups varied but remained within the range of 9 – 11 mg 100 ml^{-1} which is 'normal' for most animals (Martin 1976). PO_4 plasma levels (Figure 1) were inclined to vary more widely but remained close to levels for humans of 2,4 – 4,4 mg 100 ml^{-1} (Vaughan 1975). Differences between the values of the high and low groups were not significant for the duration of the experiment ($P \leq 0,05$).

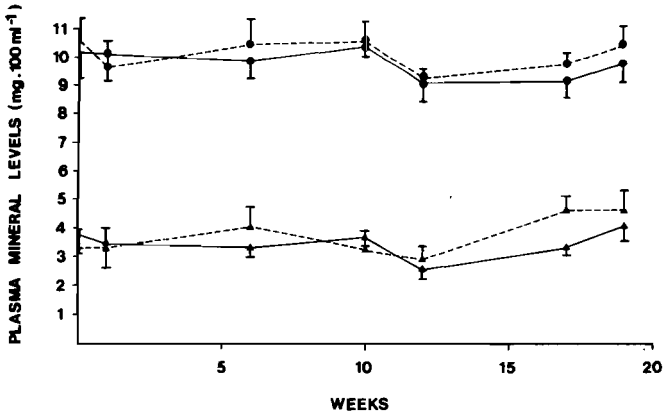

Figure 1 Blood plasma calcium (●) and organic phosphate (▲) levels of porcupine on high (– – – –) and low (——) mineral diets. Differences not significant ($P \leq 0,05$).

The physiological mechanisms controlling plasma Ca^{2+} are more effective than those influencing plasma PO_4 and levels of the former only become depressed in cases of gross deficiency (Underwood 1966), thus these results do not exclude the possibility of lesser, undetected deficiencies.

Observations on porcupines gnawing bones indicated that bone shavings are taken into the mouth. It was therefore assumed that these were ingested as none were found on the cage floor. Porcupines on the low diet gnawed approximately twice as much bone as those on the high diet during weeks 18 and 19 (Figure 2). During weeks 20 and 21 these levels of osteophagia declined slightly followed by a considerable decline during the final two weeks of the experiment. The reason for the latter could be that food was provided *ad libitum* during the final two weeks and that prior to this porcupines were not fed over weekends. Nevertheless, although food was provided *ad libitum*, the relative difference between the amount of gnawing remained the same. The difference between the amount of bone gnawed by the high and low groups from week 18 – 21 was significant ($P \leq 0,05$, pooled data). The difference from week 22 – 23 was not significant ($P \leq 0,05$). This is probably attributable to the smaller sample size (i.e. $n = 2$).

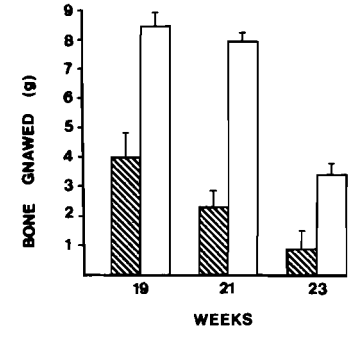

Figure 2 The amount of bone gnawed per day by two groups of porcupines on high ▨ and low □ mineral diets. Difference from week 18 – 21 significant. Difference from week 22 – 23 N.S. ($P \leq 0,05$).

Although differences were significant, conclusions from these results are compromised by shortcomings in the diet constitution which did not take into consideration differences in protein quality, calorific content or volume of ration. They do, however, indicate that *H. africaeaustralis* will osteophage even when dietary calcium levels are high. Here cognizance should be taken of the fact that porcupines are Africa's largest rodents which like other rodent species probably have an innate tendency to collect and gnaw objects of any size and description (Alexander 1956; Maguire 1976; Brain 1981).

That such large percentages of natural porcupine accumulations should comprise bones (e.g. 94% in the Nossob lair, Brain 1981) could be related to their relative availability, portability and colour attraction as compared to other objects in the environment.

References

AGNEW, J.E. & HOLDSWORTH, C.D. 1971. The effect of fat on calcium absorption from a mixed meal in normal subjects, patients with malabsorptive disease, and patients with partial gastrectomy. *Gut* 12: 973 – 977.

ALEXANDER, A.J. 1956. Bone carrying by a porcupine. *S. Afr. J. Sci.* 52: 257 – 258.

BRAIN, C.K. 1981. The hunters or the hunted? An introduction to African cave taphonomy. The University Press, Chicago.

De BLASÉ, A.F. & MARTIN, R.E. 1982. A Manual of Mammalogy with keys to the families of the world. Wm.C. Brown, Dubuque, Iowa.

De GRAAFF, G. 1981. The rodents of southern Africa. Butterworths, Durban.

HENRY, R.J., CANNON, D.C. & WINKELMAN, J.W. 1974. Clinical Chemistry : Principles and Techniques. Harper & Row, New York.

KINGDON, J. 1974. East African Mammals. Vol. II, Pt B (Hares & Rodents). Academic Press, London.

MAGUIRE, J. 1976. A taxonomic and ecological study of the living and fossil Hystricidae with particular reference to southern Africa. Ph.D. thesis, University of the Witwatersrand, Johannesburg.

MARTIN, C.R. 1976. Endocrine Physiology. Oxford University Press, New York.

McDONALD, P., EDWARDS, R.A. & GREENHALGH, J.F.D. 1973. Animal Nutrition. Longman, New York.

SHORTRIDGE, E.C. 1934. The Mammals of South West Africa. Vol. I. Heinemann, London.

SKINNER, J.D., DAVIS, S. & ILANI, G. 1980. Bone collecting by striped hyaenas, *Hyaena hyaena*, in Israel. *Paleont. afr.* 23: 99 – 104.

UNDERWOOD, E.J. 1966. The mineral nutrition of livestock. Bourne Offset Ltd, Iver.

VAN AARDE, R.J. 1985. Husbandry and immobilization of captive porcupines *Hystrix africaeaustralis*. *S. Afr. J. Wildl. Res.* 15: 77 – 79.

VARIAN-TECHTRON. 1972. Analytical methods for flame spectroscopy. Varian-Techtron, Victoria.

VAUGHAN, J.M. 1975. The physiology of bone. 2nd edn. Clarendon Press, Oxford.