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THE COPPER CONTENT OF THE LIVER OF SOME GAME ANIMALS IN KENYA

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SUMMARY

The liver copper levels of a number of game animals in Kenya were determined. It was found that the results fell naturally into two fairly distinct groups; for those with simple and those with complex stomachs respectively. The latter, generally speaking, had a higher mean content and a much greater range, with more individual variation. An exception to this was the hippopotamus which appeared to have a much higher content of liver copper than others in the simple stomach group.

INTRODUCTION

During the past few years, copper analysis has been carried out on some thousands of bovine and ovine livers by the Mineral Deficiency Disease Section of this laboratory, mostly with a view to giving advice on copper supplementation where deficiency was indicated, and also to confirm on odd occasions a clinical diagnosis of copper poisoning.

In the course of this work some game liver samples were obtained for comparison with levels found in domesticated animals, and with those described in vertebrates by Underwood (1956) and Beck (1956).

MATERIALS AND METHODS

Most of the liver samples were sent in by members of the Kenya Game Department during the course of game cropping, and some were also obtained from post mortem examinations carried out by officers of the Veterinary Department.

One ounce universal containers were chemically cleaned in the laboratory and half-filled with 10% formol-saline before despatch to officers in the field for collection of samples. The reason for inclusion of the fixative was to prevent putrefaction during transit. Preservation of samples for four days in 10% formol-saline in the laboratory was found to have no significant effect on the copper levels compared with those of fresh samples from the same livers.

Copper determinations were by the technique of Eden and Green (1940) as modified by Clare, Cunningham and Perrin (1945).

As no more than 15 grams of liver were obtained from any one animal the effect of uneven distribution of copper in the liver could not be taken into account. Beck (1956) found variation of up to 20% in duplicate samples taken from the same livers of various animals although the difference was usually less. In our own experience, however, the variation rarely exceeded 10% between duplicate samples taken from fairly large portions of liver.

RESULTS

The results for the liver copper content of the genera examined are given in Table I for simple stomachs and Table 2 for complex stomachs.

Except where there were less than four results, the mean, standard error and number of samples examined are given in each case. The nomenclature is after Stewart and Stewart (1963).

DISCUSSION

No attempt has been made in Tables 1 and 2 to differentiate between males and females of any one species as there were no obvious differences in the copper contents of the samples received. Seven male kongoni, for instance, had a mean liver copper level of 60ppm (range 15-155) while six females had a mean of 69 ppm (range 22-133). Beck (1956) found no evidence of sex differences in the species he examined with

TABLE 1

The liver copper content of simple stomach group

(Expressed as parts per million)
(on a Dry Matter Basis)

	No. of Observations	*Mean and Standard Error*	*Range*
Baboon (*Papio doguera* Elliot)	12	12.3 ± 1.4	(6-21)
Bush Pig (*Potamochoerus porcus* Linnaeus)	2	15	(14-16)
Elephant (*Loxodonta africana* Blumenbach)	18	16.6 ± 1.4	(10-30)
Hippopotamus (*Hippopotamus amphibius* Linnaeus)	5	364.8 ± 57.2	(212-489)
Rhinoceros (*Diceros bicornis* Linnaeus)	6	28.7 ± 3.5	(20-43)
Zebra (*Equus burchelli* Gray)	25	44.7 ± 4.9	(17-122)
Lion (*Panthera leo* Linnaeus)	4	36.3 ± 10.4	(15-64)
Hyena (*Crocuta crocuta* Erxleben)	3	68	(22-116)

TABLE 2

The liver copper content of complex stomach group

(Expressed as parts per million)
(on a Dry Matter Basis)

	No. of Observations	*Mean and Standard Error*	*Range*
Buffalo (*Syncerus caffer* Sparrman)	5	153.6 ± 9.4	(62-250)
Camel (*Camelus dromadarius* Linnaeus)	30	206.0 ± 16.0	(94-415)
Eland (*Taurotragus oryx* Pallas)	11	71.9 ± 24.3	(11-280)
Grant's gazelle (*Gazella granti* Brooke)	4	60.5 ± 22.4	(22-125)
Grant's gazelle, obtained from swayback area.	3	13.0	(12-15)
Impala (*Aepyceros melampus* Lichtenstein)	5	70.8 ± 19.0	(39-144)
Kongoni (*Alcelaphus buselaphus cokei* Günther)	25	50.3 ± 7.9	(12-155)
Waterbuck (*Kobus ellipsiprymnus* Ogilby)	14	122.4 ± 11.4	(66-186)
Wildebeest (*Connochaetes taurinus* Burchell)	16	29.3 ± 7.8	(9-123)
Oryx (*Oryx beisa beisa* Rüppell)	3	119.7	(67-212)
Thomson's gazelle (*Gazella thomsonii* Günther)	3	166.3	(135-220)

the exception of the Australian salmon (*Arripis trutta* Bloch and Schneider)

Underwood (1956) refers to the influence of age on liver copper, and as the author's own experience, particularly with bovine livers, also indicates much higher levels in the very young, liver samples were obtained from adult game only.

Beck (1956) suggested that with the exception of the sheep and cow, dietary copper was not an important factor in determining liver copper levels. He cited as an example sheep and kangaroos grazing on the same herbage with a high copper content (10-20 ppm DM) in the Wiluna area of Western Australia. Sheep grazing in these areas had a high liver copper value of up to 2,700 ppm, yet kangaroos grazing on the same areas had values of only 13-17 ppm. He commented further, however, that diets abnormally high or low in copper would cause corresponding changes in the concentration of copper in the liver of most, if not all, species; nevertheless, there was evidence that for some species the copper intake might vary within fairly wide limits without a corresponding change in liver levels. The last is apparently true of most of the genera examined in the simple stomach group as shown in Table 1. For instance, of the 18 samples of elephant liver analysed from various parts of Kenya, the range was only 10-30 ppm with a mean of 17 ppm (SE$\pm$1.4).

The comparatively high mean and wide range found for most of the animals in the group with complex stomachs (see Table 2) suggests that, in common with the sheep and cow, their liver copper content may vary within limits, and possibly according to dietary intake. This hypothesis is borne out to a certain extent by the samples obtained from Grant's gazelles: the four samples obtained from normal grazing areas contained between 22-125 ppm Cu (DM) with a mean of 61 ppm (SE$\pm$22) whereas three samples taken from the Lake Hannington area of Kenya where Swayback has recently been confirmed in lambs and kids by Hedger, Howard & Burdin (1964) had a mean of only 13 ppm (range 12-15 ppm). This difference is highly significant ($P<0.001$). No levels of more than 20 ppm Cu have been found in livers of goats, sheep or cattle in this area so far.

It might have been expected that grazing and browsing animals in the simple stomach group such as the elephant, rhinoceros, hippopotamus and zebra would have high means and wide ranges of liver copper content comparable to the ruminants. With the exception of the hippopotamus and possibly the zebra, however, this was not so. No explanation can be given for the high mean and wide range of the hippopotamus which was much greater than for any other animals tested.

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THE CHEMICAL COMPOSITION OF A DAY'S DIET OF AN ELEPHANT

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The plants browsed by elephants in the Tsavo Royal National Park (East) were described by Napier Bax and Sheldrick (1963), after some 14 months of careful observation. In order to supplement this knowledge, it was considered worth-while to observe in detail the browse acquired by one elephant in one day, during the hours of daylight. Accordingly, at 06.55 on 16 May, 1963 a 10-year old elephant 'Samson', of some 4,000 lbs bodyweight, was released from his stockade in the Tsavo (East) Park. Until he returned at 18.30 his behaviour was closely watched and the time he devoted to feeding and to other activities was recorded. Samples of the plants that Samson was seen to browse were obtained for identification and for chemical analysis.

Samson selected his diet from 28 botanical Families; he browsed 64 species and 59 of these were analysed. Some 74 per cent. of his entire browsing came from eight Families and these are given diagrammatically in Fig. 1.

Of the 11 h. 35 min. which Samson spent outside his stockade, 7 h. 13 min. were devoted to browsing, and periods of intensive browsing occurred between 07.00 and 09.40; 11.30 and 12.50; 12.56 and 13.50; 14.50 and 16.20 and 16.40 and 17.46 respectively. The time he allowed for feeding from each plant varied considerably. Thus, during the first 11 min. after leaving his stockade he fed from ten different species at approximately 1-min. intervals. On other occasions throughout the day he favoured a single species for a relatively long period. He spent as long as a ten min. period browsing *Panicum maximum* and *Cyperus articulatus* respectively; 11 min. browsing *Pavonia elegans;* 19 min. browsing *Ficus sycomorus* and 22 min. browsing a *Euphorbia* sp. He recurred to *Pupalia lappacea* on 32 different occasions and the time he allowed himself to browse this plant varied from 1-6 min. though in the aggregate, 45 min. of his browsing time were devoted to it.

Samson spent 4 h. 22 min. on purposes other than browsing, eg., on watering; travelling without eating; bathing; wallowing in mud; investigating the scent of other elephant and following their spoor; resting; eating a quantity of fresh faeces voided by other elephant and on defecating. He watered on six occasions; took a mud bath once; bathed twice and defecated on 14 occasions. The times of defecation and the amount of fresh faeces voided are given diagrammatically in Fig. 2, from which it is seen that the defecations become more frequent after midday.

Details of the Families and species browsed by Samson: the chemical composition of the plant parts eaten by him and the number of occasions that he recurred to the same species, are given in Table 1. The percentage distribution of the chemical components of the browse is given in Fig. 3.

Some 70 per cent. of the browse contained between 9 and 15 per cent. of crude protein in its dry matter; values ranged between 5 and 23 per cent. with a mean value of 12.56. Crude fibre ranged between 20 and 50 per cent. with a mean value of 32.26. Almost 70 per cent. of the calcium contained in the browse ranged between 1 and 3 per cent. of the dry matter, with a mean value of 1.5, and over 80 per cent. of the phosphorus ranged between .05 and .25 per cent. with a mean value of .19. Over 76 per cent. of the browse plants contained less than .06 per cent. of sodium. The mean sodium value for all records is .095 and it is .069 if *Pluchea dioscoridis* (1.668 per cent.) is omitted. The mean potassium content of the browse is 2.09 per cent. of the dry matter.