Variation in the weight, specific gravity and composition of the antlers of red deer (*Cervus elaphus* L.)

BY H. HYVÄRINEN* AND R. N. B. KAY
Rowett Research Institute, Bucksburn, Aberdeen AB2 9SB

AND W. J. HAMILTON
Hill Farming Research Organization, Bush Estate, Penicuik, Midlothian EH26 0PH

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1. Antlers were removed in September from 2–4-year-old red deer (*Cervus elaphus* L.). Both well-fed penned stags and less well-nourished grazing stags were studied.
2. For deer of the same age, both log antler weight and log antler specific gravity were related to body-weight in September and to body-weight gain between March and September. The antlers of 3- and 4-year-old stags were heavier and tended to be denser relative to body-weight and body-weight gain than those of 2-year-old stags.
3. For grazing stags of a given age, antler weight and specific gravity, and body-weight and body-weight gain, were progressively less in the three successive years of the study. This appeared to reflect increasing stocking rate over this period.
4. The composition of the antlers did not vary significantly between penned and grazing stags or with age. However the concentrations of ash, phosphorus and magnesium in dry matter showed significant positive correlations with specific gravity, that of zinc a significant negative correlation, while calcium, copper and manganese showed no significant correlation.
5. The antlers evidently provide a useful index of the changes in body-weight of the stags.

Goss (1963, 1970) and Chapman (1975) have provided a full description of the growth of the antlers of deer. They are bony structures which grow during the summer months when food is usually abundant. Minerals needed for their formation are mobilized from the skeleton under the influence of hormonal changes (Meister, 1956; Banks, Epling, Kainer & Davis, 1968; Cowan, Hartsook & Whelan, 1968; Phillippo, Lincoln & Lawrence, 1972) as well as being derived from the diet. In early autumn the skin covering the antlers, the velvet, is rubbed off at the approach of the breeding season, and from autumn to spring, when the animal's nutrition is often poor, the antler bone remains attached to the pedicle but is dead and inert. Scottish red deer (*Cervus elaphus* L.) cast their old antlers in May and begin to grow new ones immediately.

Huxley (1931) showed that there is a logarithmic relationship between antler weight and body-weight in mature red deer. It has been found that the size to which antlers grow and the number of 'points' they develop depend both on the age of the deer and on their nutritional state (Vogt, 1936; French, McEwan, Magruder, Ingram & Swift, 1955). The experimental development of the farming of red deer (Blaxter, Kay, Sharman, Cunningham & Hamilton, 1974) made it of importance to define convenient criteria for assessing the condition of deer. The size and composition of the antlers in relation to age has therefore been examined to see if these values supply indices of the size and growth rate of stags.

* Present address: Department of Biology, University of Joensuu, 8100 Joensuu, Finland.

EXPERIMENTAL

The antlers examined came from two groups of red deer: three stags housed in pens at the Rowett Research Institute, and nineteen stags grazing paddocks at an experimental deer farm at Glensaugh, Kincardineshire. The stags were between 1 and 4 years old. Some were examined in successive years.

Rowett stags. The stags were hand-reared indoors, and after weaning two of them were given a pelleted concentrate diet *ad lib.* together with a little dried grass (up to 100 g/kg food eaten). The third stag (J) was given dried grass *ad lib.* together with restricted amounts of a concentrate meal (Maloiy, 1968) which formed approximately half the food intake. The pelleted concentrate comprised (g/kg) 850 barley and 150 protein–mineral supplement and contained (g/kg) 27 nitrogen, 18 calcium, 9 phosphorus. The concentrate meal included grass meal and cereals and contained (g/kg) 24 N, 6 Ca, 7 P.

The deer were housed in pens measuring $1{\cdot}3 \times 3{\cdot}5$ m or 2×3 m and were bedded on sawdust. Some of them damaged their antlers during growth by knocking them against the walls of their pens.

Glensaugh stags. Most of these animals were also hand-reared indoors on a ewe-milk replacer and concentrates (Blaxter *et al.* 1974). They were transferred to the deer farm in September when approximately 3 months old. Supplementary food in the form of pelleted concentrates, with hay *ad lib.*, was given to the calves from September to March during their first winter. The daily ration of concentrates was 1·0 kg/calf during the winter of 1970–1, 0·9 kg during 1971–2, and 0·7 kg during 1972–3. A little hay was given to older stags in periods of storm but otherwise they depended entirely on grazing.

The stag herd was divided up to accompany the hinds in a number of different paddocks during the mating season (October–November), but during the rest of the year the adult stags (yearling and older) ran together in one of a group of paddocks of 7–9 ha (see Blaxter *et al.* 1974). These paddocks were of two types: moorland paddocks dominated by heather (*Calluna vulgaris*) with moderate amounts of grasses, and forest paddocks containing lodge-pole pine (*Pinus contorta*) and spruce (*Picea abies*) with little undergrowth and a fringe of heathery moorland. The number of adult stags (2 years or older) in these paddocks was increased from five in 1972 to nine in 1973 and nineteen in 1974.

Removal of antlers. The antlers were sawn off approximately 2–3 weeks after the velvet had been frayed off. At Glensaugh, the antlers were removed on 12 September 1972, 15 September 1973 and 27 September 1974. The 'Rowett' stags, which frayed a little earlier, had their antlers removed between 9 and 31 August in 1972–4. The cut was made about 20 mm above the pedicle.

Physical and chemical analysis of antlers. The length of the main shaft and number of 'points' were noted. Volume was determined from the difference in weight of the antlers in air and in water; the weight under water of the more porous antlers had to be recorded rapidly to prevent water displacing air from the internal spaces. The dry weight of the antlers was determined subsequently after drying for 48 h at 105°.

The specific gravity (g dry matter (DM)/ml) of the whole antler was estimated from the weight and volume measurements described previously. It was also measured separately on sections of antlers, 10–20 mm long, which were taken for chemical analysis. These were sawn from the antler shaft approximately 80 mm from its base. The area of each end of the section was measured by tracing the areas on paper then cutting out and weighing the tracings. The section volume was determined as mean area × length, and the dry weight was recorded after drying for 48 h at 105°.

These sections of antler were then heated in an oven at 550° for 16 h. The ash was weighed and dissolved in 5 ml concentrated hydrochloric acid. The solution was evaporated to dryness on a hot plate, redissolved in 5 ml concentrated HCl, then diluted appropriately. Ca and P contents were determined by the methods of Gitelman (1967) and Roach (1965) respectively using an autoanalyser. Magnesium was measured by atomic absorption spectrophotometry (Techtron AA5; Varian-Techtron Pty, Melbourne, Australia) using strontium (5 g/l) to suppress interference by phosphate.

Zinc, copper and manganese concentrations were determined in 10 mm long sections of antler sawn off adjacent to those described previously. The 'sawn' surfaces were cleaned with sand-paper to remove metallic contamination from the saw-blade and were washed carefully with distilled water. They were oven-dried and weighed. Each section was digested in 10 ml concentrated nitric acid–perchloric acid (1:4, v/v). Zn, Cu and Mn concentrations were then determined after suitable dilutions by atomic absorption spectrophotometry.

Radiographs were obtained of some sections cut for analysis to show the structure of the bone.

RESULTS

Body-weight, antler weight and antler specific gravity

In Table 1 the body-weight of the stags and the weight and specific gravity of their antlers are related to the age of stag and to the year in which measurements were made. The number of animals in each year and age-class varied greatly. To compensate for this imbalance mean values were fitted to each class by the method of least squares. For example, the four deer studied in 1972 were all 2 years old and their mean antler weight was 0·355 kg. Had there been an average mixture of ages in this year the mean antler weight for all ages, corresponding to 0·355 kg in the 2-year-old stags, would have been 0·417 kg, the value shown in Table 1.

The 3–4-year-old stags at Glensaugh were approximately 10 kg heavier than the 2-year-old stags but both age-groups made approximately the same average weight gain between March and September. The antlers of the 3–4-year-old stags were much heavier ($P < 0.001$) than those of the 2-year-old stags. This was more than could be accounted for by a simple relationship to body-weight since the relative weight of the antlers increased from 2·7 g/kg body-weight in the younger stags to 4·2 g/kg body-weight in the older stags. The specific gravity of the antlers was slightly but not significantly greater in the older stags.

With respect to the changes in successive years at Glensaugh, it is clear that the condition of the stag herd progressively deteriorated. Between 1972 and 1974 significant and marked decreases occurred in body-weight and summer weight gain, and in the weight and density of the antlers.

The well-nourished Rowett stags had grown to twice the size of the Glensaugh stags. Their antlers were massive and dense, with a relative weight of approximately 6·5 g/kg body-weight, and were impressive structures on such young animals. In one stag, the antlers increased from 100 g DM with two 'points' (both antlers) at 1 year old to 1558 g with ten 'points' at 3 years old. Another stag when 2 years old had antlers, misshapen through damage and therefore excluded from Table 1, weighing 3295 g and bearing twelve major 'points'.

Fig. 1 shows log antler weight (kg; Y) *v.* log body-weight (kg; X). Regressions describing this relationship in the different classes (years combined) were as follows:

2 years old, Glensaugh	$Y = 1.94\ (\pm 0.51)\ X - 4.39$ (n 16),
3+4 years old, Glensaugh	$Y = 1.06\ (\pm 0.57)\ X - 2.51$ (n 10),
2+3 years old, Rowett	$Y = 2.89\ (\pm 0.44)\ X - 6.43$ (n 3),
all ages	$Y = 2.07\ (\pm 0.21)\ X - 4.59$ (n 29).

Table 1. *Body-weight and body-weight gain, antler weight and specific gravity of stags* (Cervus elaphus L.) *at Glensaugh deer farm and at the Rowett Research Institute*

(Mean values with their standard errors; the animals from Glensaugh deer farm have been classed by age or by the year in which the measurements were made)

		Body-wt (kg)				Both antlers			
		In September		Gain, March–September		Dry matter (DM) (kg)		Specific gravity (g DM/ml)	
	n	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Glensaugh stags									
2 years old, all years	16	85·3	2·1	15·0	1·0	0·233	0·015	0·98	0·015
3+4 years old, all years	10	94·9	2·7	14·0	1·3	0·396	0·019	1·02	0·019
		*		NS		***		NS	
1972, all ages	4	100·2	4·3	21·9	2·1	0·417	0·030	1·16	0·031
1973, all ages	8	93·7	2·9	18·1	1·4	0·308	0·020	0·96	0·021
1974, all ages	14	83·0	2·2	10·5	1·1	0·253	0·015	0·98	0·016
		**		***		***		***	
Rowett stags									
2+3 years old, all years	3	170·6	12·3	38·8	5·4	1·108	0·238	1·44	0·127

NS, not significant.
Mean values for different age- or year-classes were statistically significantly different $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

The slopes did not differ significantly between different age-classes, nor between different years. However, the mean antler weight, adjusted for the combined slope, that was associated with a given body-weight differed significantly ($P < 0.01$) between the age-classes. In 100 kg stags the values for the 2 and the 3+4-year-old stags at Glensaugh were 0·309 and 0·426 kg respectively. No such difference was found between the years, where differences in antler weight could be fully accounted for by differences in body-weight.

A similar relationship was found between log antler weight (kg; Y) and body-weight gain from March to September (kg; X). Regressions describing this relationship were as follows:

2 years old, Glensaugh	$Y = 0.0174\ (\pm 0.0044)\ X - 0.91$ (n 16),
3+4 years old, Glensaugh	$Y = 0.0078\ (\pm 0.0042)\ X - 0.53$ (n 10),
2+3 years old, Rowett	$Y = 0.0011\ (\pm 0.0170)\ X - 0.02$ (n 3),
all ages	$Y = 0.0168\ (\pm 0.0033)\ X + 0.00$ (n 29).

The slopes did not differ significantly between different age-classes, nor between different years. The mean antler weight, adjusted for the combined slope, associated with a given body-weight gain differed significantly between the age-classes ($P < 0.001$) but not between different years.

The relationship between antler specific gravity (g DM/ml; Y) and body-weight (kg; X) is shown in Fig. 2. There was no significant difference in the slopes of the regressions describing this relationship for different age-classes, so an over-all regression was calculated:

all stags $\quad Y = 0.00513\ (\pm 0.00067)\ X + 0.54$ (n 29).

A similar relationship existed between specific gravity (g DM/ml; Y) and body-weight gain between March and September (kg; X):

all stags $\quad Y = 0.0139\ (\pm 0.0020)\ X + 0.81$ (n 29).

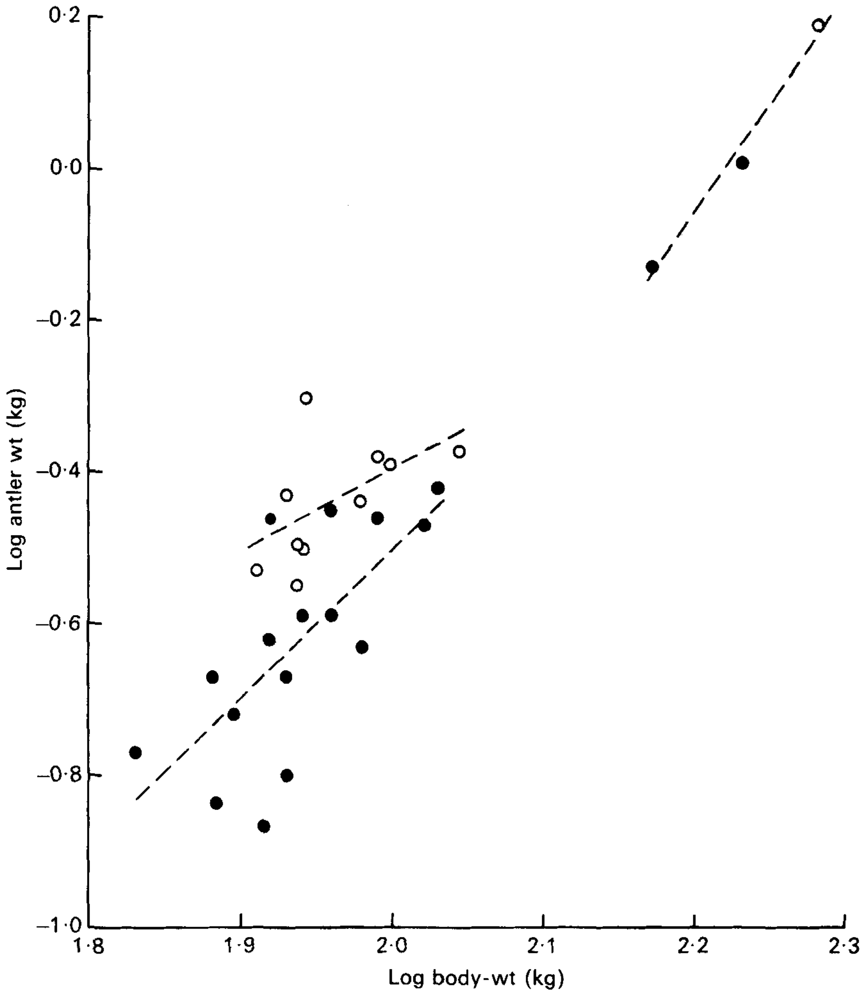


Fig. 1. The relationship between log antler weight (kg) and log body-weight (kg) of stags (*Cervus elaphus* L.) in September. The stags were grazing paddocks at Glensaugh deer farm or were hand-fed in pens at the Rowett Research Institute. The Rowett stags were the three heaviest animals. (●), 2-year-old stags; (○), 3- and 4-year-old stags. For details of regression lines shown for the 2-year-old Glensaugh stags, the 3- and 4-year-old Glensaugh stags, the Rowett stags, and all animals, see p. 303.

The mean values for specific gravity, adjusted for the relevant combined slope, that were associated with a given body-weight or body-weight gain, did not differ significantly between age-classes but did differ between years ($P < 0.001$). In these respects specific gravity contrasted markedly with antler weight. It should be noted that these relationships are very dependent on the comparison between years, and the association of specific gravity with body-weight and body-weight gain may therefore be spurious.

It was noticed that antlers that had been damaged during growth had an abnormally high specific gravity and they were therefore omitted from further consideration.

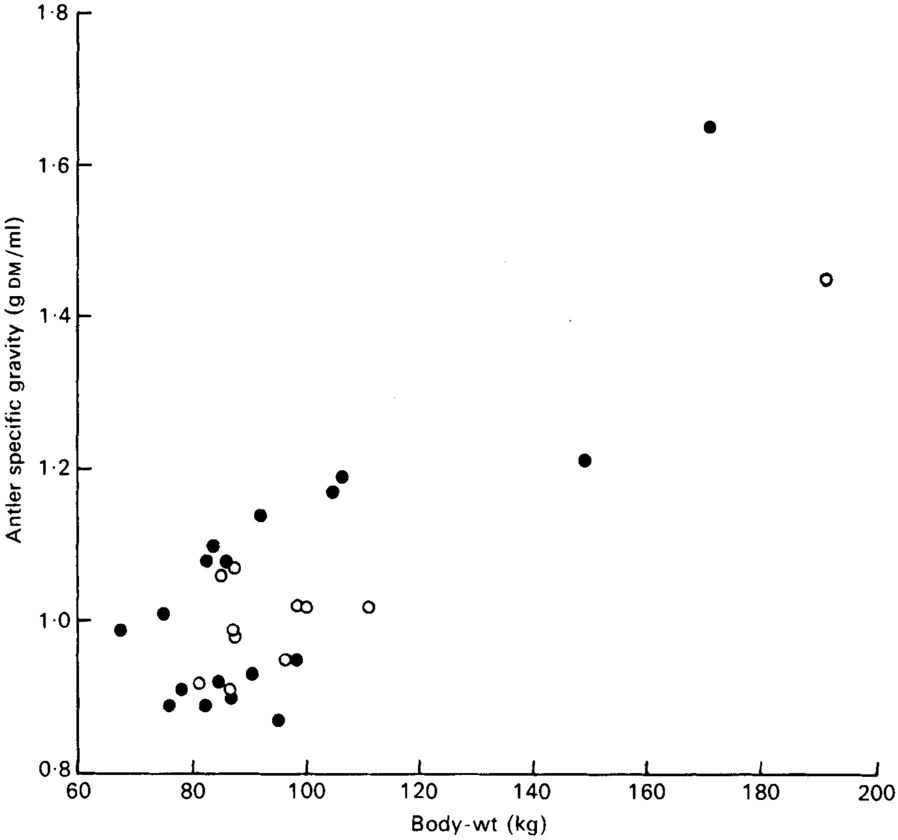


Fig. 2. The relationship between antler specific gravity (g dry matter DM/ml) and body-weight (kg) of stags (*Cervus elaphus* L.) in September. The stags were grazing paddocks at Glensaugh deer farm or were hand-fed in pens at the Rowett Research Institute. The Rowett stags were the three heaviest animals. (●), 2-year-old stags; (○) 3- and 4-year-old stags.

Antler structure

Radiographs of antler sections (Plate 1) clearly show the marked structural differences in antlers of varying density. The shafts of the Glensaugh antlers had a spongy core formed of trabecular bone, the specific gravity reflecting the relative width of the low-density core. On the other hand the shafts of the Rowett antlers were largely composed of compact bone.

In 1972 the base of the Glensaugh antlers was well-mineralized and there was no bleeding when the antlers were sawn off. In 1973 and 1974, however, the base had a more open, trabecular structure and in most stags a small amount of blood was released from the cut surface of the antler stump for a few minutes. This suggested that even 2 or 3 weeks after the velvet has been frayed off a little blood was still being supplied to the base of these poor antlers. One 1-year-old stag accidentally struck his head against a post at the September gathering in 1973, breaking off its right antler complete with its pedicle and a fragment of frontal bone. In the next 3 years it grew only its left antler. Plate 1(D) is a radiograph of the right antler and pedicle, cut longitudinally. This shows that a trabecular core runs without interruption through from the pedicle into the antler. Evidently the compact bone which renders the burr (the base of the cast antler) solid can be deposited after the velvet has frayed.

Table 2. *The specific gravity SG; (g dry matter* (DM)*/ml), and the composition of sections of the antlers of* 2–4-*year-old stags* (Cervus elaphus L.) *at Glensaugh deer farm and at the Rowett Research Institute*

(Mean values with their standard errors)

		SG		Content (mg/g DM)								Content (μg/g DM)					
				Ash		Ca		P		Mg		Zn		Cu		Mn	
	n	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Glensaugh																	
1972	5	1·37	0·05	590	8·4	231	6·3	109	2·2	3·21	0·10	75·2	7·5	3·48	0·18	9·20	3·24
1973	6	1·09	0·03	553	16·2	221	6·8	105	3·5	3·09	0·09	79·6	5·5	3·58	0·38	7·81	1·29
1974	5	0·98	0·06	562	13·3	227	7·6	105	2·9	2·97	0·09	82·1	6·0	3·68	0·27	8·95	1·32
Rowett																	
1972–3	3	1·38	0·08	591	21·7	227	10·9	106	2·8	3·11	0·11	67·5	1·4	3·23	0·42	2·05	0·08

No significant difference was found between years at Glensaugh, nor (except for Mn concentration, $P < 0·01$) between Glensaugh and Rowett stags.

Chemical composition of the antlers

The antler sections analysed, being cut from the lower part of the shaft, tended to be denser than the whole antler because the ratio, compact bone:core was usually greater towards the base. Results given in Table 2 indicate that there were only small differences between years in the composition of the antlers from the Glensaugh stags. Ash content tended to be higher in 1972 than subsequently but the difference was not statistically significant. Between years the Ca:P value ranged only from 2·10 to 2·16. The dense antlers of the Rowett stags had much the same composition as the Glensaugh antlers. The only notable difference was in Mn, for which the concentration in the Glensaugh antlers was approximately four times that found in the Rowett antlers.

With the rather small ranges of mineral concentrations in antler DM, significant correlations with antler specific gravity were found only for ash (r 0·67, $P < 0·01$), P (r 0·48, $P < 0·05$), Mg (r 0·65, $P < 0·01$), and Zn (r −0·56, $P < 0·05$).

DISCUSSION

In his classic study of antlers, Huxley (1931) recorded measurements from 527 European red deer and found a logarithmic relationship between antler weight (Y) and clean (eviscerated) body-weight (X_c), $Y = 0·00162\ X_c^{1·6}$.

In Fig. 3 Huxley's (1931) results are compared with our results. The body-weights of our stags have been converted to clean body-weights by multiplying by 0·75, the factor used by Huxley (1931). It can be seen that the slopes of the lines, the 'growth coefficients', are very similar but the relative antler weights differ greatly. Huxley (1931) comments on the magnitude of the regional variation, evident in Fig. 3 in the difference between Huxley's (1931) Scottish stags and his European population as a whole. Our stags showed a significant effect of age, 3- and 4-year-old stags having relatively heavier antlers than 2-year-old stags. This indicates that the mechanisms determining relative antler size in mature stags operate somewhat differently in young animals; allometric growth of antlers is evidently age-dependent. However, this effect of age could account for only a small part of the difference between the antlers of our young stags and those of Huxley's (1931) mature animals. Other factors contributing to the relative lightness of our antlers are that they were cut off above the burr, and were then oven-dried. However, this would decrease their weight by only approximately 20 %, therefore much of the difference shown in Fig. 3 remains to be explained.

Gould (1974) has recently re-examined information on antler growth from various sources and showed that the positive allometric relationship between antler and body size in red deer also describes that seen in other species. Deer carrying antlers range from the little Chinese muntjac (*Muntiacus reevesi*) with antlers only approximately 40 mm long to the enormous Irish elk (*Megaloceros giganteus*) whose antlers had a span of up to 4 m.

It is clear that the weight and specific gravity of the antlers of stags of a particular age provided a good index of their body-weight in September and, less precisely, of their gain in weight between March and September. At first sight it seems surprising that the antlers should more closely reflect September body-weight, representing net growth over the animal's lifetime, than the gain in weight over the shorter period, March to September, which indicates the stag's nutritional status during the period within which the antlers developed. One explanation is that antler growth depends not only on the stag's nutrition and weight gain during the summer months but also on the size and state of maturity it had attained at the beginning of this period. Thus a well-grown stag that is poorly fed

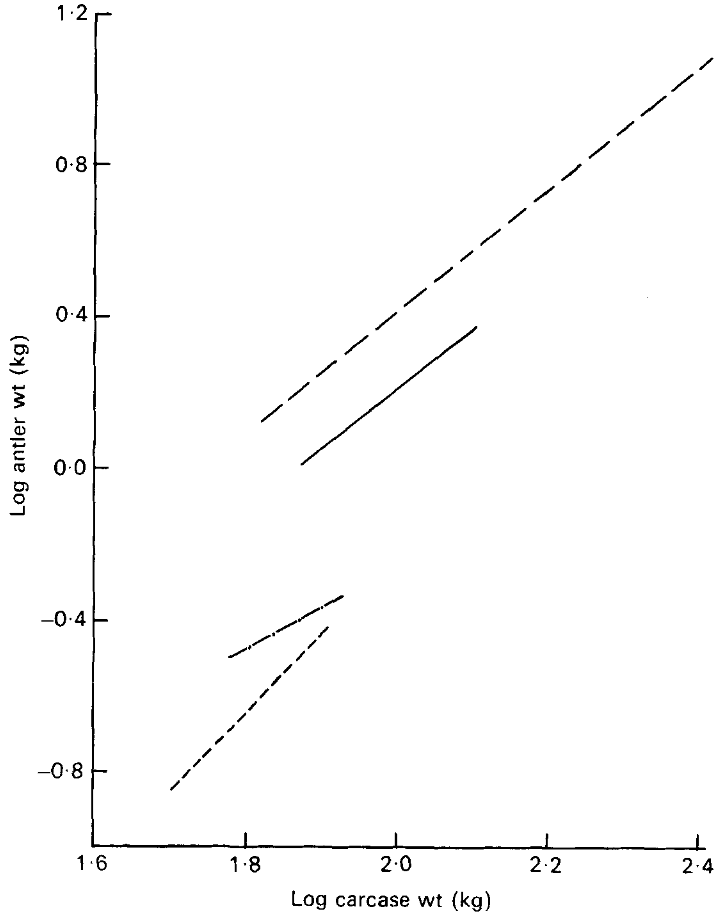


Fig. 3. The relationship between log antler weight (kg) and log carcase weight (kg) in different populations of stags (*Cervus elaphus* L.). The stags were grazed in paddocks at Glensaugh deer farm: (- - - -), 3- and 4-year-old stags (*n* 10); (—·—), 2-year-old stags (*n* 16). The values of Huxley (1931) are calculated from his Table 2 (Scottish stags; *n* 108) (——), and from his Fig. 3 (European stags; *n* 527) (– – –) where antler weight (kg; *Y*) is related to carcase-weight (kg; *X*) by: $Y = 0{\cdot}00162\ X^{1{\cdot}6}$, or $\log Y = 1{\cdot}6 \log X - 2{\cdot}79$.

during summer may grow as good a set of antlers as a stunted but subsequently well-fed animal of the same age.

The values obtained refer to antlers removed shortly after the velvet had been frayed off. Antlers are naturally cast in May, 7 or 8 months later, and for these the relationships would probably be slightly different as there is evidence that some loss of structure may take place in antlers before casting (Bélanger, Choquette & Cousineau, 1967). The persistence of a slight supply of blood to the base of the poorer antlers, and the incomplete development of the burr, also suggest that the bone does not die completely as soon as the velvet is frayed, perhaps allowing limited changes in mineralization to continue for a few weeks longer.

The concentrations of ash and minerals in the DM of the antlers was remarkably constant compared with the wide ranges of weight and density (cf. Bernard, 1963). This indicates the prime importance of the organic structure in determining the extent of mineralization, as in other bones (Dallemagne & Richelle, 1973).

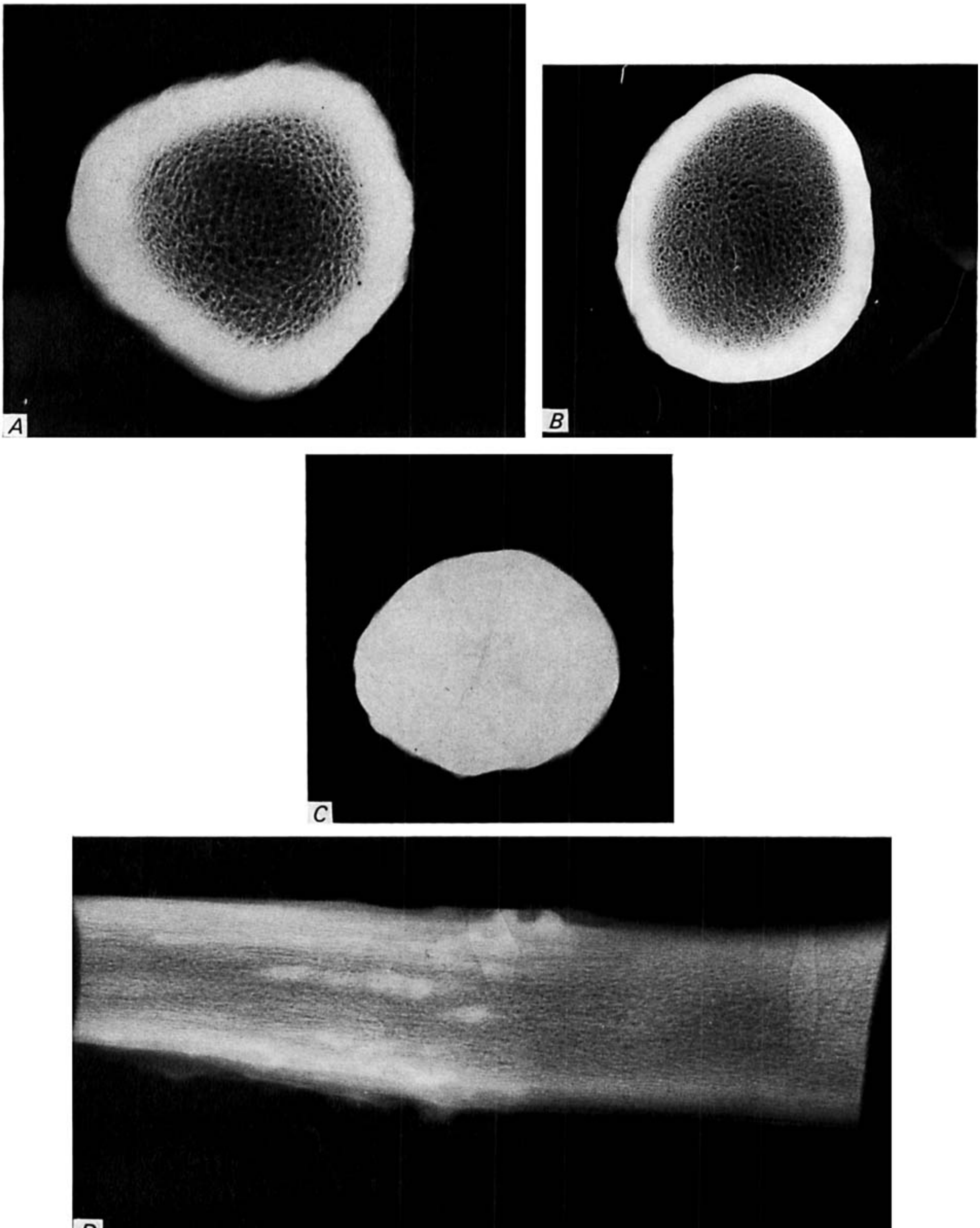
Antlers closely resemble bone in the concentrations of all minerals except Mn. Surprisingly, Mn was approximately four times more concentrated in the Glensaugh antlers than in the Rowett antlers, which resembled mature bone in this respect (Guggenheim & Gaster, 1973). The concentations of Cu and Mn did not vary with the size or density of the Glensaugh antlers, but Zn was found to show a weak but significant relationship with specific gravity. The relatively high Zn content of the less dense antlers suggested that they may be somewhat immature. It is known that in developing antler tissue the activity of alkaline phosphatase (*EC* 3.1.3.1), which is involved in bone formation, is much higher than in other developing bones (Kuhlman, Rainey & O'Neill, 1963). This enzyme contains Zn and, for example in the tibia of female sparrows, there are closely correlated seasonal cycles of Zn concentration and alkaline phosphatase activity which correspond to changes in mineralization (Ojanen, Haarakangas & Hyvärinen, 1975).

The concentration of Ca and P in the antlers was such that the 3- and 4-year-old stags at Glensaugh were depositing about 80 g Ca and 40 g P in their 400 g antlers. Well-grown stags in Scotland have antlers weighing approximately 2 kg, and therefore need to absorb from their food or mobilize from their skeleton approximately 400 g Ca and 200 g P for antler growth. These are approximately the same quantities as are secreted in the milk of a hind, 370 g Ca and 300 g P (Arman, Kay, Goodall & Sharman, 1974), which is in full lactation during the same season of the year. Continental red deer are still larger and have heavier antlers (Huxley, 1931).

The antlers of the Glensaugh stags decreased progressively in weight during the years 1972–4 to an extent which reflected the reduction in body-weight. They also decreased in density to an extent which was not fully accounted for by the reduction in body-weight. Three factors may have contributed to poorer condition of the stags: slower development as calves, increased stocking rate, and mineral deficiency. The decreasing level of supplementary feeding of the calves in successive winters was associated with slightly reduced growth rate, for the 1972-born stags weighed 6 kg less at 9 months of age than the 1971-born stags. However, this gap had narrowed to 1 kg by the time the animals were 15 months old, so this factor was probably of little subsequent importance. On the other hand, the increased number of stags in successive years, and the consequent increase in grazing pressure, may well have led to a reduction in the quantity and quality of forage available in 1973 and 1974.

One must also consider whether deficiency or imbalance of P and Ca might have affected appetite or mineralization of skeleton and antlers. French *et al.* (1955) found that while stags of the white-tailed deer (*Odocoileus virginianus*) had a good appetite and normal antler growth when given a basal diet supplemented with Ca and P (g/kg air-dry weight; 6·4 Ca, 5·6 P), appetite and antler growth were poor when an unsupplemented diet was given (g/kg air-dry weight; 0·8 Ca, 2·6 P). However, restriction of the supplemented diet to approximately the voluntary intake of the deficient diet led to a similar reduction in appetite and antler growth. There was thus no evidence from these experiments that deficiency or imbalance of Ca and P influenced antler growth other than by reducing appetite.

Heather was the dominant herbage in the paddocks grazed by our stags. It contains moderate amounts of Ca but is notably deficient in P; heather leaf contains (g/kg DM) approximately 4·2 Ca and 1·2 P (Grant & Hunter, 1966). An experimental diet that was similarly imbalanced and deficient in P was found to cause severe inappetance in lambs (Field, Suttle & Nisbet, 1975) and moderate inappetance in stag calves (R. N. B. Kay & E. D. Goodall, unpublished results). During the summer months heather formed only approximately 30 % of the rumen contents of stags grazing a heathery pasture similar to that at Glensaugh (Staines, 1970), and at Glensaugh itself heather comprised only 11–32 %



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of the vegetation grazed by two hinds during June and July (Blaxter *et al.* 1974). This does not suggest that a mineral imbalance is likely in the summer diet of freely-grazing stags, yet the decrease in the specific gravity of the antlers beyond that accounted for by reduced body-weight indicates that mineral deficiency may have been present in our stag herd.

In conclusion, our observations show that the size and composition of antlers may provide a useful and convenient way of monitoring the growth and condition of a herd of stags.

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EXPLANATION OF PLATE

Plate 1. Radiographs of sections of antler shafts (A, B, C) and of the antler-pedicle junction (D) for stags (*Cervus elaphus* L.) at Glensaugh deer farm and at the Rowett Research Institute. A, Glensaugh, 1972 (specific gravity 1·20 g dry matter (DM)/ml; B, Glensaugh, 1974 (specific gravity 0·80 g DM/ml); C, Rowett, 1973 (specific gravity 1·50 g DM/ml); D, Glensaugh, 1973. In D, there is continuity of the core between pedicle (right) and antler (left); the light spots are caused by 'knobs' on the surface of the antler.

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