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Jaw length and hind foot length as measures of skeletal development of Red deer (*Cervus elaphus*)

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(With 2 figures in the text)

Jaw length and hind foot length are compared, as indicators of skeletal development, using data from Red deer in three different populations. It is concluded that jaw length gives the best index of skeletal growth throughout the whole lifespan of Red deer, but it can only be measured reliably *post mortem*. Although the foot stops growing before some other parts of the skeleton, hind foot length is especially convenient for studies on young live deer.

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Introduction

Studies of growth and development depend on measurements of skeletal size as well as body weight, and the problem often arises as to which linear measurement gives the best index of skeletal size, or, indeed, which is most applicable for a given purpose. These studies have fallen into two categories, those where the length of the lower jaw was used as an indicator of skeletal development (Mitchell & Brown, 1974; Mitchell, McCowan & Nicholson, 1976; Staines, 1978) and those where the length of the hind foot was used (Flook, 1970; Blaxter, *et al.*, 1974; Simpson, 1976). Challies (1978) measured the total body length, hind foot length, jaw length and tooth row length of Red deer hinds shot in New Zealand. He concluded that jaw length was the best index of skeletal size as it was easily accessible after death, could be measured accurately, would be obtainable from most if not all animals killed and it showed a growth rate which was sensitive to small differences and changes in nutrition.

It is well known that skeletal development in domestic animals does not proceed at a constant rate and some bones, for example the metacarpus, ulna and fibula grow much faster

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and reach mature size earlier than others, such as the skull or the ileum (Wenham, Fowler & McDonald, 1973).

Unfortunately it is not possible to measure the jaw length of a live animal accurately due to the thick skin covering the lower jaw which prevents a tape measure reaching the bone. The hind foot length may, however, be measured accurately whether the animal is alive or not.

The aim of this study was to investigate the relationships among jaw length, hind foot length and age for Scots Red deer in order to assess the importance of each measure for studies of skeletal development in wild and captive Red deer.

Materials and methods

Data from three separate sources were analysed.

Source 1. Hinds shot in Glenfeshie, Invernesshire during the 1974–1975 stalking season. Jaw length was measured from the outer ridge of the incisiform-canine socket to the posterior edge of the mandible (Mitchell & Brown, 1974) and the dissected second and third fused metatarsi were measured with a steel tape measure as an index of hind foot length. Ages were assessed using a combination of two methods: tooth replacement and wear (Lowe, 1967; Mitchell & Youngson, 1969) and layers in dental cement (Mitchell, 1967).

Source 2. Hinds shot on the Isle of Rhum during the 1978–1979 stalking season. The measurements and assessments of age were made in the same manner as above.

Source 3. Yearling and 2-year-old stags shot at Glensaugh Deer Farm during September 1978, September and October 1979 and September 1980. Jaw length was measured as above but the hind foot length was measured from the top of the calcaneum to the junction between the second and third fused metatarsi with the phalanges, with the hoof flexed at right angles to the metatarsus. The animals were of known age at slaughter so there was no need to assess age from tooth wear or replacement as a check.

Results

The data from Glenfeshie and Rhum are given in Figs 1 and 2, respectively. It is clear from Figs 1 and 2 that the hind foot reached its maximum length at an earlier age than the jaw. There was no observable change in hind foot length after the animals had reached 3 years of age and growth might be complete before 2 years of age. In contrast the jaw continued to lengthen until the animals were at least 4–5 years old.

The mean jaw length of yearling stags shot at Glensaugh $\pm$S.E. was $23{\cdot}0 \pm 0{\cdot}16$ cm, whereas that of the 2-year-olds was $23{\cdot}9 \pm 0{\cdot}33$ cm (unpaired two-tailed t-test, $t = 2{\cdot}46$, $P < 0{\cdot}02$, $n = 51$). The mean hind foot length of the yearlings was $36{\cdot}6 \pm 0{\cdot}21$ cm and that of the 2-year-olds was $36{\cdot}9 \pm 0{\cdot}34$ cm ($t = 0{\cdot}73$, $P > 0{\cdot}05$). The jaw continued to lengthen between 15 and 27 months of age but the hind foot did not.

The mean jaw length of mature (5–10-year-old hinds) was $24{\cdot}0 \pm 0{\cdot}12$ cm on Rhum and $23{\cdot}3 \pm 0{\cdot}13$ cm at Glenfeshie ($t = 3{\cdot}70$, $n = 12$, $P < 0{\cdot}01$). The mean $\pm$S.E. hind foot length of these hinds was $23{\cdot}9 \pm 0{\cdot}13$ cm on Rhum and $23{\cdot}7 \pm 0{\cdot}24$ cm at Glenfeshie ($t = 0{\cdot}613$, $P > 0{\cdot}05$).

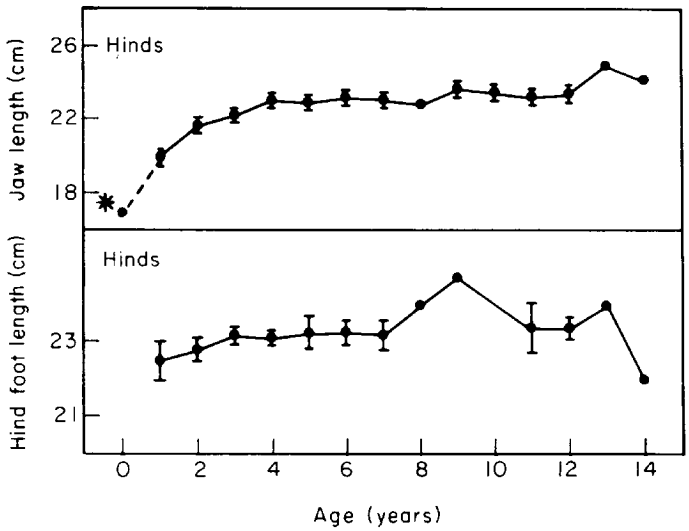

FIG. 1. The relationship between jaw length, hind foot length, and age for hinds from Glenfeshie. The values presented are mean ± S.E. The asterisk indicates a data point taken from Mitchell, Staines & Welch (1977) and therefore not part of the series of data examined for the present study. This was because no calves were shot during the 1974–1975 stalking season.

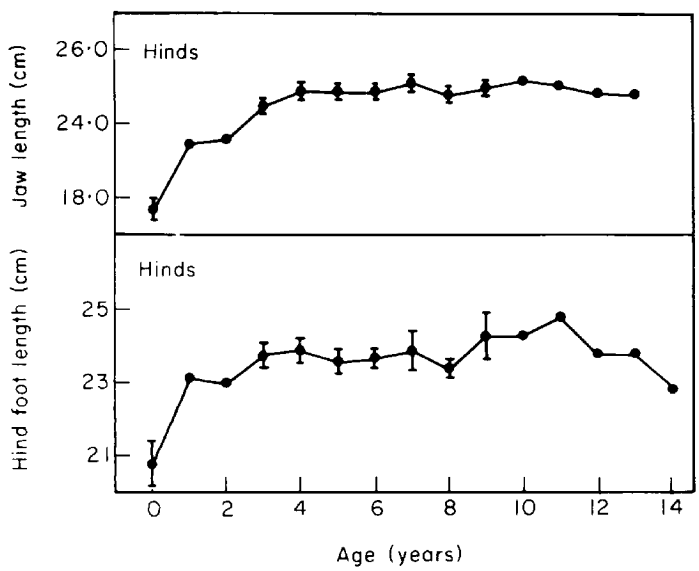

FIG. 2. The relationship between jaw length, hind foot length and age for hinds from Rhum.

Discussion

Clearly the hind foot of both hinds and stags stopped growing much earlier than the jaw. For long term studies jaw length is undoubtedly superior to hind foot length as a measure of skeletal development, because it continues to grow for longer but can only be measured *post mortem*. The data from Rhum and Glenfeshie further indicate that jaw length may be a more sensitive indicator of life time nutritional status.

It is known that in general Rhum is a more favourable environment for deer than

Glenfeshie (Mitchell & Lincoln, 1973; Mitchell & Crisp, 1981) and this is reflected in differences in jaw length between the populations but not in hind foot length.

However, hind foot length is also a useful indicator of skeletal development, particularly when short term studies on young animals is undertaken (Suttie, 1981), and studies on living animals in which the jaw length cannot be measured accurately.

The present studies agree well with Flook (1970) who found that hind foot length stopped increasing before body weight in North American Wapiti (*Cervus elaphus canadensis*).

It should be pointed out that different authors measure both jaw and hind foot length differently. Challies (1978) measured the jaw from the distal end of the dentary to the proximal edge of the mandibular condyle diagonally across the jaw; this method would tend to overestimate length compared to the one used in the present study. Staines (1970) measured hind foot length to the tip of the hoof rather than the junction of the second and third fused metatarsi with the phalanges; this also would tend to overestimate length. Care should be exercised in interpretation of results depending on the measuring methods used. It is considered that the methods used in the present study are optimal as artefacts due to worn or damaged teeth or long short hooves often a function of hard or soft terrain are eliminated.

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