Appearance of antler pedicles in early foetal life in red deer

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SUMMARY

The primordial antler pedicles of red deer show a transitory enlargement in early foetal life in the male while no similar change occurs in the female. Observations on the growth rate of the reproductive tract, pituitary and adrenal glands and the content of testosterone in the gonads, indicate that the precocious development of the pedicles occurs during a phase of increased testicular activity and probably reflects a surge in testosterone secretion following sexual differentiation.

INTRODUCTION

It is possible to sex a red deer foetus (Cervus elaphus) at an early age by close inspection of the animal's forehead. In the male foetus a pair of conspicuous swellings develop on the skull which are not found in the female. These structures represent the primordial antler pedicles, and following this early development they become inconspicuous until puberty when they resume growth and give rise to the antlers.

It is well established that the development of antler pedicles in deer at puberty is stimulated by the secretion of testosterone by the testis (Wislocki, Aub & Waldo, 1947). The question arises as to whether the precocious development of the antler pedicles in the foetus is also the result of increased testosterone secretion. It has been established in a number of other mammals that the testis is active in early foetal life and is responsible for the differentiation of the male reproductive tract as well as influencing the form of the external genitalia (Burns, 1961). The present study attempts to find an explanation for the early growth of the antler pedicles in red deer by comparing the development of the reproductive system of the male foetus with that of the female.

MATERIALS AND METHODS

Ninety-six red deer foetuses weighing between 0.5 g and 525 g were collected between 1968 and 1971 from hinds shot by Nature Conservancy stalkers on estates in Scotland. They were stored in 10% formalin and later sexed and

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weighed. The gonads, accessory glands, pituitary and adrenal glands were removed under a dissecting microscope and weighed. The ano-genital distance, neck girth and the appearance of the pedicles was also recorded. When the foetuses were too small to be sexed on morphological grounds only the gonads were weighed.

For simplification the animals of approximately the same size were grouped together and the organ weights expressed as a mean for the group. Testosterone was extracted from pooled samples of gonads from each group by the method of Mann, Rowson, Short & Skinner (1967), purified by thin layer chromatography on Silica gel/CT (Reeve Angel Scientific), and measured by radio immuno-assay using anti-sera raised to a testosterone conjugate (P. Rowe, unpublished, Unit of Reproductive Biology, University of Liverpool). The maximum sensitivity of the method was 50 pg of testosterone per animal. The age of the foetuses was estimated from a regression line relating the cube root of body weight to gestational age (Mitchell & Lincoln, in preparation) using a mean gestation length for red deer of 233 days.

RESULTS

(a) Growth of the pituitary and adrenal glands. The weight of the pituitary and adrenal glands increased steadily in relation to gestational age from 50 to 120 days (1 g to 600 g foetal weight) and there was no sex difference in the weight of the glands at any stage (Fig. 1).

(b) Growth and testosterone content of the gonads. At 38–40 days of age (0·5 g wt) the gonads were elongated bodies lying along the medio-ventral surface of the enlarged mesonephric kidney and morphological separation of the sexes was impossible at this stage. This distinction became possible by the 42nd day (1·5 g wt) when the testes became larger, rounder and firmer than the ovaries.

From 45 to 95 days of gestational age the gonads of both sexes continued growing rapidly with the testes remaining larger than the ovaries until about the 87th day (Fig. 6a). Over this period the gonads of both sexes moved slightly posteriorly as the mesonephric kidney regressed and was replaced anteriorly by the functional kidney of the adult. The testes reached a peak in weight in foetuses of about 80 days of age (80 g wt) before becoming slightly reduced in size during the period that they migrated from the posterior border of the kidney to the neck of the inguinal canal (Figs. 4 and 5). In the females the ovaries retained their abdominal position and reached maximum weight about 16 days after the initial peak found in the growth of the testes (Fig. 6a). After this period of growth the ovaries underwent rapid involution and at 100 days of foetal age weighed less than half that of the testes at a similar stage.

Testosterone was not detected in pooled samples of gonads from foetuses before 55 days of gestation, although it was possible to sex the animals at this
stage. The hormone was detected in pooled samples of testes from animals of 55 to 65 days of age (10–30 g wt) and in all groups until 105 days. Testes from animals between 105 and 120 days of age contained no detectable testosterone as did extracts of ovaries at all stages (Fig. 6c).

(c) Growth of the external genitalia, accessory glands and secondary sexual characters. While it was possible to determine the sex of a foetus on the appearance of the gonads at 42 days of gestational age (1·5 g wt) it was not until about 7 days later (4·5 g wt) that sex differences were clearly visible in the form of the external genitalia. After 50 days of age the male foetuses showed a rapid increase in the ano-genital distance compared with the females (Fig. 6b) and
Fig. 2. Male red deer foetus of about 97 days of age (204 g wt) showing conspicuous antler pedicles on the forehead (indicated), and expanded neck girth. × 1.5.

Fig. 3. Female red deer foetus of about 94 days of age (170 g wt) for comparison with Fig. 2. × 1.5.

Fig. 4. Male red deer foetus of about 63 days of age (15 g wt) dissected to show the reproductive tract about 3 weeks after sex differentiation. Externally the scrotum is just visible, the ano-genital distance is 17 mm, and the antler pedicles are just apparent on the forehead. a, adrenal; b, metanephric kidney; c, mesonephric kidney; d, testis; e, penis. × 2.

Fig. 5. Male red deer foetus of about 88 days of age (121 g wt) showing the testes during their descent towards the inguinal canal. At this stage the antler pedicles are most conspicuous. × 1.
Fig. 6 (a). Weight of testes (●), ovaries (■) and seminal vesicles (○) of red deer foetuses related to gestational age. Mean value and s.d. for groups of animals are shown.

(b) Ano-genital distance of male (●) and female (■) foetuses related to age.

(c) Testosterone content of testes (●) and ovaries (■) related to age. Mean value for groups of animals is shown.

(d) Period of enlargement of the antler pedicles in the male, and the clitoris in the female; the double hatched area indicates when the organs were particularly conspicuous.
the penis assumed a more ventral position. The scrotum was apparent by 60 days (15 g wt) and the seminal vesicles were identifiable by 70 days (40 g wt, Fig. 6a).

The antler pedicles first became apparent in male foetuses at about 60 days of age (15 g wt) and from 75 to 100 days (60 g to 240 g wt) they were particularly conspicuous (Figs. 2 and 3). Later they became less obvious apparently due to differential growth of the surrounding tissue (Fig. 6d). The female foetuses often showed opaque, slightly raised areas in the position of the antler pedicle but these did not expand as in the male. In addition to this difference in the development of the antler pedicles, there was also a sex difference in the growth of the neck musculature in early foetal life. In the male foetuses the neck girth increased markedly over that found in the female, and this difference was most apparent from 70 to 100 days of age. The mean neck girth of male foetuses at 62, 82 and 100 days of age was 36 mm, 53 mm and 97 mm respectively, while the corresponding measurements for the female foetuses were 35 mm, 46 mm and 93 mm (Figs. 2 and 3).

While the female foetuses showed no changes in the antler pedicles and neck musculature comparable to that of the male it was interesting that over the same period they showed very pronounced hypertrophy of the clitoris. At about 70 days of age (40 g wt) the clitoris began to enlarge and between about 80 and 90 days of age (80 g to 150 g wt) it was most conspicuous (Fig. 6d).

**DISCUSSION**

During foetal development the gonads of red deer undergo a period of rapid growth initiated prior to sex differentiation at 42 days of age and continuing until about mid-gestation. In the male testosterone is present in the testes at an early age, and it seems probable that the hormone is responsible for the masculinizing changes which occur in the reproductive tract following sex differentiation. In addition, it is likely that the hypertrophy of the antler pedicles and the expansion of the neck musculature of the male foetuses which occurs between 50 and 100 days is also the direct result of a surge in testosterone secretion which accompanies the period of increased testis activity. In adult life both the antler pedicle and the neck musculature represent secondary sexual characters which develop in response to testosterone (Lincoln, 1971), and the present observations indicate that this androgen sensitivity acquired in early foetal life. Sex differences in the neck musculature of foetuses have also been noted in the wapiti, *Cervus canadensis* (Retsfalvi, 1969).

While both the foetal testis and ovary show a period of activity or growth during the first half of gestation in the red deer, it is striking that testosterone disappears from the testis, and the ovary becomes involuted after about the 110th day. This is of interest for it may indicate the development of a functional negative feedback system from gonad to hypothalamus soon after the sex differentiation changes have occurred in the reproductive system. Whether the hypothalamus itself is sex differentiated at this early age is not known.
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REFERENCES


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