Is there a critical weight for oestrus in the ferret?

B. T. Donovan

Department of Physiology, Institute of Psychiatry, De Crespigny Park, London SE5 8AF, U.K.

Summary. Information concerning the weight at the onset of a period of oestrus, the timing of oestrus, the age at first oestrus and the lighting conditions was collected from the records of 1364 ferrets and reviewed for evidence indicating that the animals became sexually mature around a particular, critical, weight. None was found, but the results suggest that there is a minimum weight, around 420 g, below which oestrus does not occur.

Introduction

There is much evidence that in an individual rat or human a minimal weight must be reached before full reproductive activity can ensue (Donovan & van der Werff ten Bosch, 1965; Frisch, 1984). Less information is available for other species, and none to my knowledge for the ferret, for which photoperiodic influences are regarded as major factors in the control of reproduction (Donovan & Gledhill, 1981). If there were a minimal or critical weight for reproductive function in ferrets, then it would be futile to attempt to affect reproductive function by photoperiodic means in animals lighter than the critical weight. This consideration has prompted a search for information concerning the existence of a critical weight for sexual development in the ferret by a review of laboratory records extending over 30 years and 1364 animals, from which 1666 periods of oestrus have been recorded.

The ferret does not experience cyclic periods of oestrus during the breeding season, as do ewes or mares, but normally comes into oestrus in the spring and remains in oestrus until copulation induces ovulation, or, in the absence of a male, until shortening days bring the breeding season to an end.

Materials and Methods

Information concerning the weight at the onset of a period of oestrus, the timing of oestrus, the age at first oestrus, the lighting conditions, whether or not the animal was under experiment, and the life-history of the ferret, was abstracted for all of the females kept in our animal accommodation. The records covered ferrets weighing between 400 and 1730 g, and included observations on normal and experimental animals. For detailed analysis, the material on the occurrence of oestrus in normal animals weighing up to and including 600 g was used. There were 155 observations. In addition, the data from all animals born in our animal accommodation were scrutinized.

All animals had been examined and weighed weekly to the nearest 10 g on a spring balance and the occurrence of oestrus was determined on the basis of vulval swelling. The first observance of unequivocal swelling of the lips of the vulva was taken as the date of onset of oestrus. Commercial dog food was provided once daily, and water was always available.

Lighting was provided in windowless rooms by fluorescent, daylight-type, lamps switched on for 8 h (short days) or 16 h (long days) daily. In a few early experiments the short-day animals were exposed to daylight supplemented with artificial light for 8 h daily.

Student's t test was used to assess the statistical significance of differences in mean body weight.
Results

General observations

The incidence of oestrus at weights of 600 g and below for 180 ferrets is plotted in Fig. 1. Oestrus was never recorded in animals weighing less than 400 g, and was noted in 3 females of this weight. All were normal. One of the three had previously been in oestrus and had lost weight before coming into oestrus again at 400 g body weight, while the other two were in oestrus upon arrival from a dealer in May and July. Since ferrets show a marked loss of weight during lactation (see below), it is possible that the last two animals had given birth before shipment to us.

![Histogram showing the weight at onset of oestrus among 155 ferrets of 600 g body weight or less.](image)

Three animals weighed 420 g at oestrus. Of these, one (Ferret 221) was in oestrus upon arrival from the dealer, and was among a group of 15 females supplied in June, of which 4 delivered litters shortly after arrival, 3 were pregnant, and 3 were pseudopregnant, leaving 5 in oestrus. It may therefore be presumed that Ferret 221 was experiencing a post-partum oestrus. The other 2 females had been in oestrus earlier (at 480 and 520 g on arrival from the dealer) and had since lost weight. Neither subsequently gained weight in the manner of their companions.

Two females were observed in oestrus at 430 g; one on arrival from a dealer in July, and the other at 11 months of age after being born in our animal accommodation and housed under long-day conditions since then.

The female coming into oestrus at a weight of 440 g was born in July, and was housed under daylight conditions supplemented with fluorescent lamps between 09:00 and 17:00 h daily. She came into oestrus in April of the following year, later than the majority of her companions, but in company with 7 others weighing between 460 and 500 g.

There was an increasing incidence of oestrus at weights above 500 g.
Body weight and oestrus in ferrets

Animals of known age

The observations on animals born in our animal housing are of especial interest in view of the information available concerning growth rate and lighting conditions. Of the ferrets with vulval swelling at weights below 600 g, the youngest became oestrous at a weight of 570 g and at 22 weeks of age during exposure to long days, while the lightest animals weighing 430, 440 and 450 g were 56, 38 and 41 weeks old, respectively.

Information from 83 females of known birth date and subsequently kept under short-day conditions yielded no evidence for the existence of a critical (as opposed to a minimal) weight for the development of oestrus. The weights at oestrus ranged between 440 and 1340 g, but when attention was directed toward the smaller values with at least 3 animals in each category a spread from 460 to 700 g was evident (Fig. 2).

Environmental illumination unquestionably affects the onset of oestrus and the influence of this factor was examined by comparing the ferrets kept under short days or under long days up to the time of oestrus. Data on the age at the onset of oestrus are presented in Fig. 3; for the ferrets kept under short days (Fig. 3a) vaginal swelling was first recorded at 27 weeks but could be delayed until the females were 1 year old. One animal first came into oestrus after 63 weeks under short days, at a weight of 640 g.

Fig. 2. Histogram showing the weight at oestrus of 83 female ferrets of known age and housed under short-day lighting conditions.

Fig. 3. The age at the onset of oestrus of 75 ferrets kept under short-day lighting conditions (a) and of 25 females exposed to long-day conditions (b).
Exposure to long days (Fig. 3b) accelerated sexual development, in that 14 of 30 ferrets came into oestrus at 27 weeks or younger, with 3 showing vulval swelling at 22 weeks and at weights of 570, 630 and 760 g. There was no correlation between body weight and the age at puberty although the animals housed under long-day conditions tended to be lighter. Although the mean (± s.e.m.) weight at oestrus of 19 animals of 32 weeks or less kept under short days was 732·6 ± 35·9 g, and that for the 19 animals aged 32 weeks or less and kept under long days was 655·3 ± 19·8 g, the difference was not statistically significant. However, when the first 8 animals of the short-day group, reaching puberty at ages up to 29 weeks, were compared with 11 housed under long days and reaching puberty at 24 weeks or less, the mean ± s.e.m. weights at oestrus were 841·3 ± 155·1 g in short days and 670·9 ± 75·8 g in long days (P < 0·01). The lowest weight recorded for the animals reaching puberty at less than 1 year old after being housed under long days was 510 g, for a 30-week-old female, and for the short-day animals was 440 g for a 38-week-old individual.

The possibility of a link between body weight and the onset of oestrus can also be explored by examining the growth rates of young ferrets. When the weekly measurements of body weight were plotted over the 5 weeks before and 5 weeks after the onset of oestrus for 25 females kept under short days (Fig. 4), the mean weight reached a plateau at the beginning of the period, with a fall in body weight setting in during oestrus. The results from a group of 11 females exposed to long days differed slightly in that there was a slow increase in body weight up to the time of vulval swelling, followed by a fall which matched that observed with the females kept under short days. Sufficient sequential measurements have been collected from some animals to allow a longer perspective view and the weights for the 21 weeks preceding and 10 weeks after oestrus are plotted for 5 animals kept under short days (Fig. 5a) and 5 exposed to prolonged illumination (Fig. 5b). The graphs provide no evidence for the existence of a critical body weight for the attainment of oestrus, but reinforce the conclusion that body weight commonly declines after oestrus, with the fall being most marked in the heavier animals.

![Fig. 4. The changes in body weight over the 5 weeks before and 5 weeks after the onset of oestrus in 25 ferrets kept under short-day conditions (a) and in 11 ferrets exposed to long days (b).](image-url)
**Discussion**

The observations reported in this paper do not suggest that a critical weight for oestrus exists in the ferret. This conclusion is reinforced by the cross-sectional data summarized in Fig. 4, in which a plateau in weight was reached some weeks before oestrus developed, and by the individual body weight curves plotted in Fig. 5, where weights very close to, and sometimes above, those at oestrus were attained more than a month earlier.

While there is no evidence for the existence of a critical weight important in the timing of sexual development in the ferret, there are indications that a minimal weight of about 420 g may exist. This was the lowest weight recorded at the onset of vulval swelling amongst 115 ferrets followed from birth. It was not the smallest value noted, but the lesser weight of 400 g came from those of a larger study group of 1364 animals of unknown age and included animals experiencing a post-partum or post-nursing oestrus.

Undernutrition is known to delay puberty in sheep, possibly by reducing the frequency of pulses of LH secretion (Foster & Olster, 1985), just as modest undernutrition can depress spermatogenesis in a manner that is species specific (Blank & Desjardins, 1984), but there was no indication of a
poor nutritional state in those of our animals that reached puberty rather later than others. Indeed, it was clear that oestrus was not inhibited by the low body weight of the mothers experiencing the nutritional drain of lactation. The lowest weights at the onset of oestrus were most frequently encountered amongst such females. The original critical weight concept (Frisch & Revelle, 1971) has been amended by Steiner, Cameron, McNeill, Clifton & Bremner (1983), who suggest that blood-borne signals based on metabolic parameters such as amino acids may be influential, because the chronic infusion of a solution of carbohydrate and amino acids markedly increased the plasma LH concentration of juvenile macaque monkeys.

The hormonal changes underlying the onset of sexual maturation in the ferret remain unknown (Donovan & Gledhill, 1981; Ryan, 1984), although Ryan & Robinson (1985) have shown that the exposure of immature ferrets to long days caused a marked increase in the frequency of episodes of LH secretion. Paradoxically, the plasma concentrations of gonadotrophin in circulation during anoestrus may be higher than during oestrus, although the gonadotrophin assayed radioimmunologically may not be biologically active (Donovan & Gledhill, 1984). It remains possible that pituitary hormones other than the gonadotrophins may be concerned in the process of sexual development, with growth hormone being a likely candidate: B. T. Donovan, C. P. M. Broekman, M. A. de Bruin & E. Buskens (unpublished) have found that growth hormone acutely increases the ovarian secretion of androstenedione in anoestrous ferrets.

Current information does not indicate that exposure to long days accelerates weight gain in ferrets, because the animals exposed to long days were lighter at oestrus than those illuminated for short periods daily. Tucker, Petitclerc & Zinn (1984) have addressed this question with regard to sheep, cattle and deer and concluded that increasing exposure to light exerted anabolic effects in sheep independently of the presence or absence of gonads, whereas short days favoured the deposition of fat in fawns. The hormonal basis of the changes remains unclear, and the situation is complicated in ferrets because of the need for exposure to a period of short days before long days can advance the onset of oestrus (Donovan, 1967).

Study of the changes in body weight around the time of the onset of oestrus has shown that body weight declines during oestrus (Donovan & Harris, 1956; Hammond, 1974). This is presumed to be due to the action of oestrogen, although the plasma oestradiol concentration of oestrous ferrets (157–357 pmol/l) overlaps with that prevailing during anoestrus (101–357 pmol/l) (Donovan, Matson & Kilpatrick, 1983), and oestrogen is generally regarded as promoting the accumulation of adipose tissue. While oestrogen implants into gonadectomized ferrets may produce a transient gain in body weight, Hammond (1974) concluded that the weight loss evident at natural oestrus is due to oestrogen. The fact that marked falls in plasma androstenedione, dihydrotestosterone and testosterone occur in anoestrous ferrets exposed to long days to induce oestrus (Donovan et al., 1983) could be taken to suggest that the fall in body weight of the oestrous ferret arises at least in part from the withdrawal of the anabolic effect of the androgens. The decline in body weight was particularly marked in the heaviest females, and could indicate that adipose tissue in particular is lost. This finding does not argue in favour of the view that the relative degree of fatness is directly related to both the quantity of circulating oestrogen and its biological effectiveness so that the acquisition of a certain percentage of fat serves as a timing factor for puberty (Frisch, 1984).

Alternatively, the decline in body weight during oestrus could simply reflect a greater degree of energy expenditure by the oestrous female. Donovan (1985) has shown that wheel-running in the ferret is considerably increased during oestrus, although Stockman, Albers & Baum (1985) found that the administration of oestradiol to gonadectomized animals did not increase the activity recorded within the test cage. The apparent discordance in result probably arises from the use of different measures of activity.

Our work with ferrets has been supported by grants from the Medical Research Council, the Population Council and the Research Fund of the Bethlem Royal and Maudsley Hospitals. Mrs M. Kibble helped greatly in this study.
References


Hammond, J., Jr (1974) The ferret: some observations on photoperiod and gonadal activity, and their role in seasonal peli and bodyweight changes; the synergistic effect of oestrogen and progesterone on weight gain; and a comparative study of the corpus luteum of the ferret and rabbit. W. Heffer: Cambridge.


Received 15 July 1985