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Age and sex differences in the timing of moult in the common seal, *Phoca vitulina*

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(With 2 figures in the text)

This study followed the progress of the annual moult within a population of common seals in Orkney, Scotland. Moulting seals were seen over a three-month period, from 7 June until 16 September. Yearlings were first to start moulting. Amongst older seals, females completed their moult an average of seven days earlier than immature males and 19 days earlier than mature males. Differences in the timing of moult appeared to be related to the age or reproductive status of the animals, and may be the result of differential changes in levels of the sex hormones.

Contents

Introduction

Common seals, *Phoca vitulina*, moult annually in late summer, shortly after the breeding season (Stutz, 1967; Bigg, 1981). It is believed that individual seals take one to five months to complete their moult, but this information is based on studies of only a small number of captive individuals (Scheffer & Slipp, 1944; Riviere, Engelhardt & Solomon, 1977; Ashwell-Erickson, Fay, Elsner & Wartzok, 1986) and little is known of the extent of the moulting period in wild populations.

Age and sex differences in the timing of moult have been suggested by several authors, but field data are anecdotal and sometimes ambiguous; yearlings are believed to moult first (Havinga, 1933), followed by females and then males (Millais, 1904; Rubertus, 1983). However, it has also

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been suggested that females may moult after males (Hewer, 1974), and in the only quantitative field study, no significant differences in timing were found between either age or sex classes (Stutz, 1967).

This study followed the progress of moult within a population of common seals in Orkney, Scotland. It aimed to describe the overall period of moulting and to investigate the possibility of age and sex differences in the timing of moult within that period.

Methods

Study area

The primary site used during this study was located on the north-east side of Eynhallow, an uninhabited island in Orkney, Scotland. As most seals using this site were males, additional observations were made at 2 other sites where females predominated. Both the latter sites were on the coast of Mainland Orkney, on the southern side of Eynhallow Sound. All 3 sites were within 3 km of each other, and the seals sampled were considered to be from the same population.

On Eynhallow, animals were observed from 2 hides mounted on 4-m high scaffolding towers, at a distance of between 10 and 250 m. At Mainland sites, groups of seals were observed from the top of the beach at similar distances.

Observational techniques

During 1985, the Eynhallow site was visited at least once a week, from the beginning of June until the end of September. Mainland sites were also visited weekly, from the beginning of July until the end of September.

On each visit, a 30×75 telescope was used to scan the group, noting where possible each individual's sex, age, presence or absence of recent neck wounds or scars from old wounds, and stage of moult.

It is difficult to sex common seals reliably in the field. Therefore, sex was determined only if the genitalia could be seen, if the animal was attended by a pup, or if the animal had previously been individually marked as part of a concurrent study.

Age is impossible to determine precisely, and seals were initially classified as either yearlings or 'adults', which included immature seals over one year old. Yearlings could be distinguished until the end of the moult by their very pale, unpatterned pelage. Once moulted, they could not be distinguished reliably from weaned pups of the year.

Mature male common seals often have wounds or scars around the neck region as a result of fighting during the breeding season (Bishop, 1968; Boulva & McLaren, 1979). The presence or absence of wounds or scars was used to subdivide further males into 2 broad categories; mature and immature.

Each seal was classified as being in pre-moult, moult or post-moult condition. Moulting was defined here as the period of hair loss, when patches of new pelage could be seen through the old coat. Prior to moult, the pelage was dull, brown and easily distinguished from the sleek, steely-grey pelage of newly moulted seals (Scheffer & Slipp, 1944; Stutz, 1967).

Data were recorded on a pocket tape recorder and later transferred to a computer database system.

Statistical methods

To test for differences in the timing of moult between groups of seals, we compared groups pairwise, in terms of the proportions of animals which had completed their moult by a given time. The method tested for a consistent difference in the proportions from several 2×2 contingency tables (Cox, 1977), where in the present application each table corresponded to a particular sampling occasion.

To measure differences, the pattern of the completion of moult was modelled for each group of seals. The times at which seals completed their moults were assumed to follow a normal distribution. Though these times could not be observed directly, information on them was available indirectly through the proportion of animals which had completed their moult by a certain time. For the assumed model, this proportion was determined by the cumulative normal distribution.

$$P_t = \Phi\left(\frac{t-\mu}{\sigma}\right)$$

P_t = the proportion of animals observed to have completed their moult by time t.
Φ = the cumulative normal distribution.
μ = mean time for completion of moult.
σ = standard deviation of the time for completion of moult.

Sightings of animals were assumed to be such that the individuals constituted a random sample from each group, and that being seen on one occasion did not affect an individual's chance of being seen again. It then followed that the variability in the observed proportion of animals which had completed their moult could be modelled as a series of independent binomial variates, with means given in the above equation. Estimates of the mean and standard deviation of the time of completed moult were obtained by fitting a Generalized Linear Model with a probit link function and binomial errors, using the statistical package GENSTAT (Alvey *et al.*, 1983).

Results

Extent of the moult period

The change in the proportion of seals hauled out on land which were unmoulted, and fully moulted, throughout the study period is shown in Fig. 1. Moulting seals were seen over a three-month period, from 7 June until 16 September. At the beginning of moult, it was sometimes difficult to tell whether hair had started to fall out, whereas the end of moult, when the last of the old hair had been shed, was more clearly defined. Sample sizes in the latter half of the study were also much larger; during June and July a mean of 86 seals were sampled on each visit, compared with 305 during August and September. Therefore, data on moult completion have been used to compare the timing of moult in different age and sex classes.

Time taken for individual seals to moult

Marked animals were not seen regularly enough to estimate accurately the time that it took individual seals to complete their moult. However, repeated observations on six adults gave maximum estimates for the period of moult of from 19 to 33 days. No realistic minimum estimates could be made.

Age and sex differences in the timing of the moult

From 7 June until 7 July, all except one of the seals seen moulting were yearlings. However, moulting yearlings were occasionally seen as late as the last week in August.

To determine whether there were age- or sex-related differences in the timing of the moult amongst 'adults', the change in the proportion of animals having completed their moult was compared in five different groups of seals:

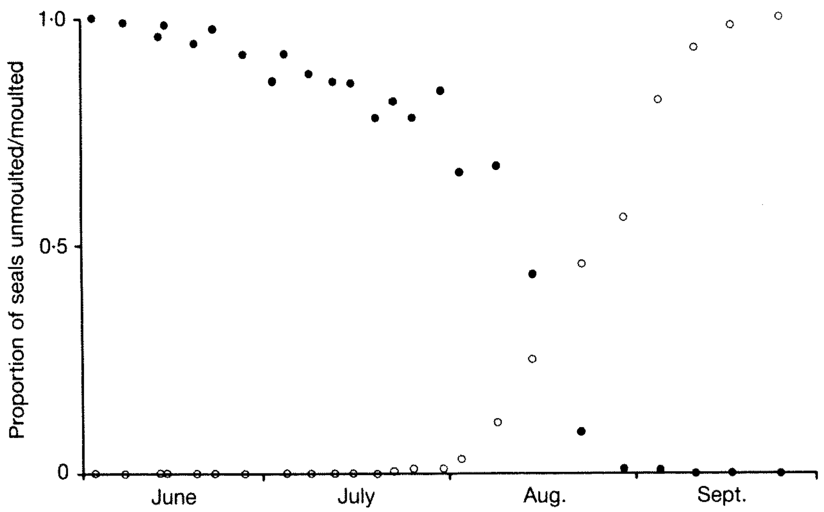

FIG. 1. Changes in the proportion of seals hauled out on Eynhallow which were unmoulted (●) or completely moulted (○) through the study period.

(1) mature males (males which had neck wounds or scars)
(2) immature males (males which had no neck wounds or scars)
(3) other males (males whose necks were obscured during sampling)
(4) females from Eynhallow
(5) females from Mainland sites

Significant differences occurred amongst all groups on Eynhallow ($P<0{\cdot}01$). No significant differences were detected between Eynhallow and Mainland females ($P>0{\cdot}1$).

Fitted curves, and observed patterns, for the proportion of mature males, immature males and Mainland females which had completed their moult are shown in Fig. 2. Table I gives the model's parameter estimates for all five groups, together with approximate standard errors and deviances. These deviance values can be used as an approximate test of the model's validity. In two groups, immature males and females from Eynhallow, there is a significant lack of fit. This could reflect a departure from the assumed curve, some additional component of sampling variation, or possibly both. Differences between observed data and the predicted curve (Fig. 2) fail to suggest how the model could be improved, and for the purposes of these comparisons, these complications have been ignored.

Females completed their moult first, followed by immature males and finally mature males (Table I). The estimated mean date for moult completion was similar for females on both Eynhallow and Mainland. The synchrony of moult, as measured by the standard deviation, was also similar for both groups. Amongst males, the mean date of moult completion was approximately 12 days later for mature animals than for immatures (Table I). The respective standard deviations show that mature males were also more synchronized in the timing of their moult than immatures. Results for those males whose reproductive condition could not be determined fell between those for matures and immatures.

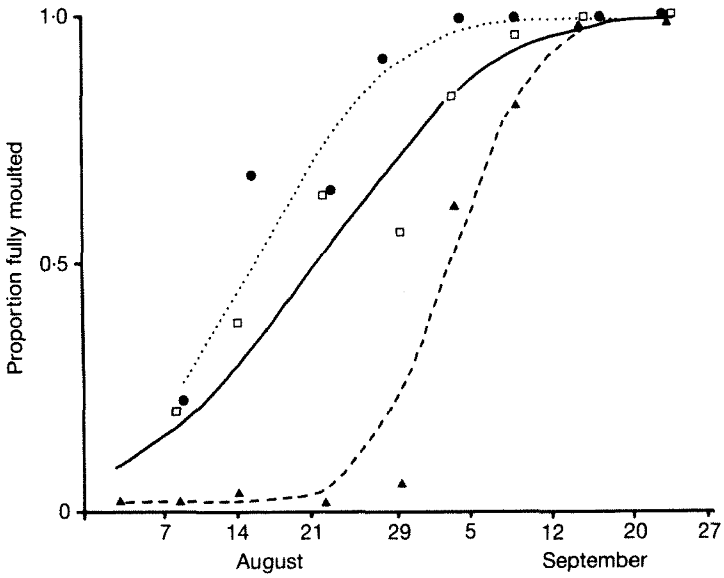

FIG. 2. Fitted curves, and observed proportions, for the proportion of Mainland females (· · · · ● ·), immature males (——□–) and mature males (– – –▲–) hauled out which had completed their moult.

TABLE I

Estimated mean date of moult completion (with standard error) expressed as days from 1 August and standard deviation of moult completion dates, for the five different groups of seals. * = *significant lack of fit (P < 0·05)*

Sex	Group	Estimated mean	Estimated standard deviation	Deviance	Degrees of freedom
F	Eynhallow	14·5 (1·3)	10·0 (1·5)	17·6*	7
F	Mainland	15·8 (1·6)	10·0 (2·1)	4·7	6
M	Mature	34·0 (1·0)	6·4 (0·9)	13·3	7
M	Immature	21·5 (1·2)	13·1 (1·4)	17·3*	7
M	?	28·9 (1·5)	11·4 (1·5)	10·9	7

Discussion

Length of the moult period

During this study, individuals appeared to moult in a shorter period than the five weeks noted for two captive adults described by Scheffer & Slipp (1944) and Ashwell-Erickson *et al.* (1986). It is important to remember that all these estimates refer only to the period of hair loss and that this is just the final stage of a whole series of physical and anatomical changes constituting the pelage cycle (Ling, 1970). Working on captive common seals and spotted seals, *Phoca largha*, Ashwell-

Erickson *et al.* (1986) suggested that the entire period of shedding and regeneration lasted about four to six months, with considerable variation between individuals. Due to the small sample sizes in all these studies, it is not possible to suggest whether the shorter moulting period found in this study was a result of real differences between wild and captive seals, or simply of a high degree of individual variation.

Age and sex differences in the timing of the moult

In agreement with Havinga's (1933) findings, the first individuals to moult during the present study were yearlings. However, it does not necessarily follow that all yearlings moult early, as a few individuals were seen moulting in late August. It may simply be that the moulting period is less synchronous, or that individual animals take longer to moult when young. Newly moulted yearlings are easily confused with weaned pups and data on yearlings' moult completion times were not collected in this study. Therefore, it is not possible to suggest which of the above suggestions is most likely.

The significant differences in the timing of the moult between different age and sex classes in this study are in contrast to the findings of Stutz (1967). Stutz's work was based on collections of skins from *Phoca vitulina richardsi*, the sub-species of common seal found along the coast of the north-east Pacific. These skins were obtained from commercial fur companies and originated from sites as far apart as western Alaska and the Puget Sound, Washington. Along the Pacific coast, there is great variation in the timing of the annual cycle of common seals (Bigg, 1973). Differences, similar to those found between age and sex classes in this study, could have occurred in *P. v. richardsi* at specific localities, but in Stutz's heterogeneous sample, those differences would have been masked by variation between sites.

Comparisons between males and females, and between mature and immature males, were made using moult completion times. Therefore, it is possible that there could be age or sex differences in the time that it takes an individual seal to moult (for example if females moulted faster than males) which we could not test for. Whilst such differences could exist, we feel that they are unlikely to be the main factor producing the differences in moult completion times found in this study. A larger number of marked animals, of known age and reproductive status, would be needed in order to test whether there are age or sex differences in the length of the moult.

Sex differences in the timing of the moult have been found in other species of phocid seals such as the grey seal, *Halichoerus grypus*, and the southern elephant seal, *Mirounga leonina* (Laws, 1956; Hewer, 1974). Within the phocids, there seems to be a close relationship between the annual moult and the reproductive cycle, with females moulting during the period of delayed implantation (Ling, 1970). Thus, sex differences in the timing of moult may be the result of constraints of the reproductive cycle, which could affect the timing of the moult through sex differences in either body condition, or levels of sex hormones.

It has been suggested that animals in poor condition may delay their moult (Ling, 1970). For example, immature southern elephant seals have a delayed moult, which is thought to be due to their poor body condition (Ling, 1965). However, this would not explain why common seal females moulted before the males, as it would be the females that would be expected to be in relatively poor condition after lactation.

Oestrogen and testosterone are both believed to have an inhibitory effect on hair growth (Spinner, 1940; Ling, 1970), and it has been suggested that age differences in the timing of moult may be the result of an animal's reproductive status (Ashwell-Erickson *et al.*, 1986). No data on changes in testosterone levels are available for common seals, but they are likely to decline soon after the end of lactation, as both testes and epididymis tubule diameter have been shown to decrease at this time (Boulva & McLaren, 1979). Females' oestrogen levels decrease markedly at parturition, about three weeks earlier than this (Raeside & Ronald, 1981). It may be coincidental, but the delay in the mature males' moult completion time, compared with the females', was approximately the same length as the lactation period. Therefore, if oestrogen and testosterone have a similar inhibitory effect on the moult, changes in the levels of these hormones may contribute to the observed sex differences in the timing of the moult.

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