Growth rate in early and late litters of the European hedgehog (*Erinaceus europaeus*)

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Abstract: European hedgehogs (*Erinaceus europaeus*) are thought to have two litters a year in Britain. Second or late litters would be expected to have a reduced chance of survival as they have less time available to gain sufficient weight to enable them to survive hibernation. Anecdotally, juveniles born late in the season have been reported to gain weight faster than their early counterparts. This study was conducted in order to determine whether there is any difference in the growth rate between young born to early and late litters of hedgehogs and between the sexes. The growth rate of all young hedgehogs (n=119) arriving at the author's sanctuary between 1998 and 2006 was determined. The overall growth rate of young born to late litters was found to be significantly higher than those born to early litters ($0.05>P>0.01$). There was no significant difference in growth rate between the sexes.

Keywords: hedgehog, *Erinaceus europaeus*, mammal conservation, growth rate, wildlife rehabilitation, mammal reproductive biology, animal welfare.

Introduction

During the winter months, in northern climates, some species of small mammals lower their body temperature, and also their metabolism, in order to reduce the rate at which fat is utilised (Young 1976). The extensive layer of subcutaneous fat that is formed during the autumn is used as insulation. Hibernating mammals must, of necessity, gain sufficient weight in the autumn to enable them to survive the winter. Raccoons (*Procyon lotor*) that spend part of the winter in a dormant state use fat deposited in the previous autumn to provide the energy required to maintain basal metabolism (Mugaas et al. 1993). Fat deposition therefore appears to be an important function for the survival of raccoons during the winter in northern climates (Gehrt & Fritzell 1999). In the Uinta ground squirrel (*Spermophilus armatus)* juvenile mass, prior to hibernation, has been associated positively with over-winter survival (Rieger 1996). Juveniles that are weaned when the season is well advanced, have less time to prepare for hibernation due to a decline in available food as the summer progresses. Yellow-bellied marmots (*Marmota flaviventris*) also show a positive association between early weaning and over-winter survival (Armitage et al. 1976). Rieger (1996) comments that juvenile marmots probably need to reach a threshold stage of development and a certain body fat content in order to survive hibernation. This is to be expected, as the longer an animal has to gain weight, prior to hibernating, the better chance it has of reaching an acceptable weight that will sustain it throughout the winter. Woodchucks (*Marmota monax*) are reported as having to deliver their young early enough in the season to allow them to lay down a sufficient layer of adipose tissue to enable them to survive hibernation (Young 1976). The ability to lay down an adequate fat layer, prior to the onset of winter, is particularly important to juveniles born late in the season.

In Britain and northern Europe, late litters of European hedgehogs (*Erinaceus europaeus*) are thought to be common and most likely to be born to females that have failed to successfully rear young earlier in the sea-

son (Reeve 1994). However, it has also been suggested that late litters are second litters, born any time from August onwards (Barrett-Hamilton 1911, Harrison Matthews 1952). Deanesly (1934) suggests that, as European hedgehogs are polyoestrous, under favourable conditions they could potentially raise two litters in a season. This is confirmed by Jackson (2006), who studied a population of introduced hedgehogs on a Scottish Island. Sexual behaviour was observed to commence in late April, shortly after most hedgehogs had emerged from hibernation. Two peaks of sexual activity were noticed, the first in mid-May and the second in late June or early July, giving rise to two distinct breeding periods. Jackson (2006) reported that at least 96% of adult females attempted to breed early in the season, resulting in litters born in June, while the greater majority (81%) bred again later in the season, resulting in litters born after mid-July.

Burton (1969) notes that while it seems certain that some females may have two litters in a year it is probably the females born in the previous year that supply most of the August and September litters, a female being ready to breed within ten months of birth. However, in New Zealand, where the introduced European hedgehog is abundant, there are thought to commonly be three litters a year (Burton, 1969). This would apply in particular to the North Island of New Zealand, where temperatures during the spring and summer are conducive to breeding. The mild climate in New Zealand means that European hedgehogs are sexually active for up to eight months of the year and may not hibernate (Reeve 1994). In these conditions, as in central and southern Europe, many late litters may be second litters (Wodzicki 1950, Brockie 1958, Parkes 1975).

Reeve (1994) comments that if a female that had borne a litter in early June was to conceive again immediately, birth of a second litter in mid-August, with subsequent independence in mid-September, would leave no more than one or two months for the young to prepare for hibernation. Also, Morris (1984) considers that young born after September probably have insufficient time to achieve a weight that would enable them to survive hibernation. He therefore thinks it is likely that comparatively few of these late-born young survive. It follows that it is uncertain how many late litters can be successfully raised second litters. It has been suggested that the particular abundance of hedgehogs in some years, in Britain, may occur when conditions are suitable for a significant proportion of the population to rear second litters successfully (Jefferies & Pendlebury 1968).

Anecdotal evidence from hedgehog carers, and data collected by myself over seventeen years of running a hedgehog sanctuary, suggested that young born to late litters gain weight more rapidly than their counterparts born to early litters. It was decided to put this theory to the test. The study attempts to establish whether there is any difference in growth rate between young born to early and late litters, and between the sexes.

Material and methods

Since 1992, a sanctuary for hedgehogs has been run in York, UK, solely by the author. The sanctuary operates under the supervision of the Royal Society for the Prevention of Cruelty to Animals (RSPCA). Any necessary veterinary treatment was provided by the Minster Veterinary Practice, York, UK. Most of the hedgehogs (90%) presented at York RSPCA are taken to the sanctuary for the purpose of rehabilitation and eventual return of the survivors back to the wild.

On arrival, young hedgehogs were fed Esbilac®, a milk substitute for puppies. As they grew, they were gradually introduced to Pedigree® Chum Complete Puppy dog food and dried biscuits specifically manufactured for hedgehogs or kittens. Food was made available ad libitum. Animals that required handfeeding were dropper fed Esbilac® at regular intervals. The feeding regime used was identi-

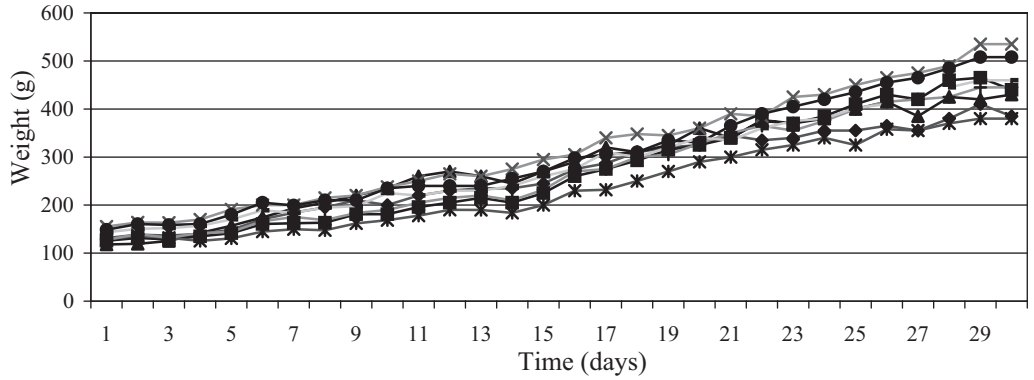

Figure 1. Growth of eight healthy siblings.

cal for animals born to early and late litters.

For the purpose of this study, early litters are defined as all young hedgehogs, weighing no more than 255 g, that arrived at the sanctuary between June and the end of August in the same year.

Late litters are defined as all young hedgehogs that arrived at the sanctuary between the beginning of September and the end of January in the following year. Young hedgehogs were brought to the sanctuary having been identified by members of the public as being in need of care. The reasons included being found in the open during daylight hours, the nest having been disturbed by domestic animals (in particular dogs), and the absence of an adult hedgehog for more than two days in a garden where a nest was known to exist. The latter usually resulted in the young hedgehogs emerging from the nest in search of food.

Data collected during a nine-year period (1998-2006) included daily weight recordings for all hedgehogs admitted for treatment. This enabled the growth rate of all young hedgehogs (n=119) to be determined from the point of their arrival onwards. The weights of young hedgehogs arriving at the sanctuary ranged between 43 g and 255 g in the early litters (n=81) and between 90 g and 275 g in the late litters (n=38). When young hedgehogs reach 250 g they are mostly weaned and largely dependent on non-milk foods for their survival.

Of 119 young hedgehogs that arrived between 1998 and 2006, 88 were healthy during their development and 31 were sick. Animals were considered to be healthy when they exhibited no ailments of any kind, produced faeces that exhibited normal gross morphology and texture (Bunnell 2001b), fed normally, and gained weight at a normal rate. The growth rate of eight siblings from one litter who remained healthy throughout their development was determined and individuals shown to follow a similar pattern (figure 1).

Animals from early litters (n=81) accounted for 61.3% of the sick animals (n=19) while those from late litters (n=38) accounted for 32.3% (n=12). Of the early litters, 23.5% were sick, compared with 31.6% of late litters. When comparing the growth rates of young from early litters with those from late litters, only healthy animals were included in the analysis. Also, all data refer to animals that survived and were released back to the wild. The data were analysed using the Mann Whitney Test for unrelated data. Two-tailed probability values $P \leq 0.05$ were considered statistically significant.

Results

Young hedgehogs arrived at the sanctuary over an eight month period, the numbers varying between the months and different weight categories (figure 2). The weight and numbers

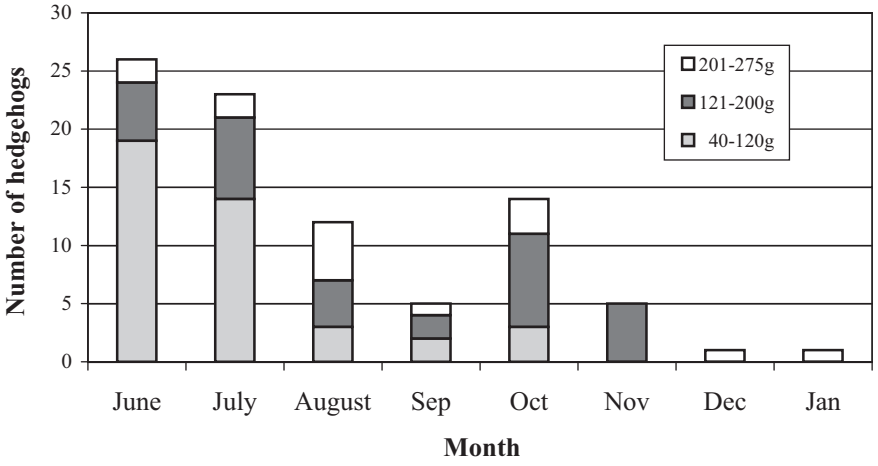

Figure 2. The number and weight of young hedgehogs on arrival, between 1998 and 2006.

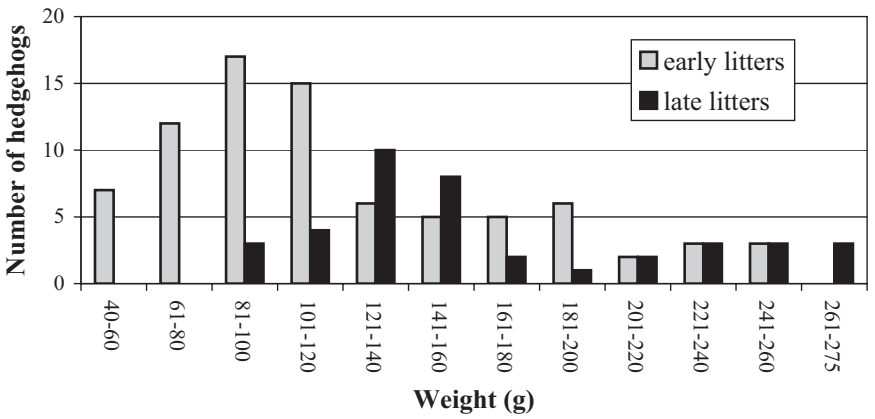

Figure 3. Weight of young hedgehogs from early and late litters on arrival at the sanctuary.

of young hedgehogs from early litters differed from those of late litters (figure 3).

The daily growth rate (g day^{-1}) was determined for all healthy young hedgehogs (n=88) born to early and late litters between 1998 and 2006. This enabled the overall rate of growth from time of arrival of each hedgehog to maturity or release status to be determined.

Overall growth rates of young born to late litters were shown to be significantly higher than young born to early litters ($0.05>P>0.01$). No significant difference in growth rate was found to exist between the sexes, for either the early or late litters considered separately or combined. The mean values for overall growth rates for early and late litters, and for males and females, were determined (table 1). The mean growth rate for each month that young hedgehogs arrived at the sanctuary was determined and shown to be lowest in July and highest in September (figure 4).

Discussion

Hedgehogs delivered to wildlife sanctuaries often present with many ailments in need of treatment (Boag & Fowler 1968, Smith 1968,

Table 1. Mean values for overall growth rate in early and late litters and for males and females.

	Early litters	Late litters	Females	Males
Mean value (g/day)	10.87	12.55	10.87	11.57
Standard Deviation	4.06	3.39	2.90	4.28
n	61	26	40	47

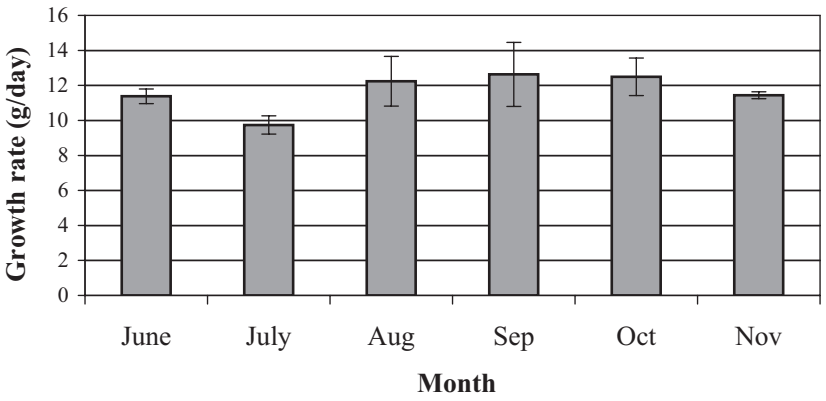

Figure 4. Mean growth rate from June until November, between 1998 and 2006, including standard error bars.

Morris & English 1969, Stocker 1987, Majeed et al. 1989, Keymer et al. 1991, Sykes & Durrant 1995, Reeve & Huijser 1999, Robinson & Routh 1999, Bunnell 2000, Bunnell 2001a, Bunnell 2001b, Bunnell 2001c). Attempts are being made to increase the body of knowledge accumulated in these centres, which could help to ensure optimum chances of survival following release back to the wild (Morris et al. 1993, Morris & Warwick 1994, Sykes & Durrant 1995, Bunnell 2002). Survival during hibernation is a particular challenge in Europe where it can last for five months (Herter 1963).

The hypothesis formulated is that young European hedgehogs born in the autumn gain weight more rapidly than their counterparts born early in the season. This, in turn, might serve to increase the survival probability of late litters, if survival probability is improved by a relatively high growth rate. It has been suggested that growth rate is adaptively flexible and affects optimal size and development times in a seasonal environment, the most likely effect being that growth rate becomes faster with less time available (Abrams et al. 1995). A lagomorph, the collared pika (*Ochotona collaris*), is thought to use two strategies to cope with the short and unpredictable seasons typical of northern latitudes. It appears to adjust to seasonal uncertainty by varying the breeding season as well as exhibiting faster growth rates (Franken & Hik 2004). Seasonal differences in weight change, with males in particular gaining weight in autumn, has been observed in New Zealand hedgehogs and thought to be due to endogenous rhythms of fat deposition (Parkes 1975).

Whether young hedgehogs born to late litters are first or second litters does not detract from the fact that the juveniles need to obtain a satisfactory weight/size relationship in order to survive hibernation. This relationship has been defined in terms of an index, which needs to be a minimum of 0.80, with an associated weight of at least 650 g, for an optimal chance of survival during the winter months (Bunnell 2002).

With the exception of a solitary animal in December and January, young hedgehogs arrived at the author's sanctuary between June

and November (figure 2). Very young animals, weighing between 40 g and 120 g appeared every month between June and October, inclusive. It would therefore appear that European hedgehogs breed from June onwards, over a five month period, with the greater majority of young being born in June. Two distinct peaks, the first in June and the second in October (figure 2) suggest two breeding periods (Bunnell 2001c) or, at the very least, an extended breeding season. This agrees with the findings of Jackson (2006) who reported two breeding seasons, the first being in June. Reeve (1994) comments that in Britain and northern Europe, late litters are common. Such litters may result from a female reaching reproductive maturity late in the year, the loss of a first litter, or a very mild autumn, the latter increasing food availability and the increased incidence of females breeding twice during the season.

Regardless of whether a late litter is the first or second born to any particular female, it can be speculated that young hedgehogs born to late litters have a reduced chance of surviving the winter. However, if all the young were to succumb during the first cold spell of winter this would mean a great waste of resources on the part of the female hedgehog giving birth to late litters. In terms of conserving resources, it would seem more beneficial to an adult female hedgehog not to produce a late litter for two reasons. Firstly, the female would be less likely to survive hibernation if she has had to sacrifice some of her body reserves to feed her young. Indeed, only female marmots that have had young late in the season seem unable to always gain adequate weight in time for the onset of hibernation (Armitage et al. 1974). Secondly, if the suggestion that late litters have a poor chance of survival is true (Reeve 1994, Morris 1984), the adult female will have decreased her chances of surviving the winter for no apparent reason. However, this study has shown that late litters might not have a poor chance of survival, due to their increased weight gain during the autumn. While this may be at the expense of the survival of the mother, it would result in possibly more than one of the late juveniles surviving hibernation, as opposed to one adult female. This possible sacrifice of the mother hedgehog would, in evolutionary terms, then be justified, as the hedgehog population would have increased.

This study has shown that, in northern England, European hedgehogs born to late litters gain weight significantly faster than those born to early litters. The reasons for the significantly faster growth rate seen in juveniles from late litters can be speculated upon. External factors such as temperature and day length appear to determine how many litters are born in any one year, the onset of hibernation and the end of hibernation, all of which depend on the country of origin in question. It is possible that decreased day length, accompanied by falling ambient temperatures, serves to alter the physiology of hedgehogs born later in the year. An increase in appetite, supposing sufficient food supplies to be available, would result in a more rapid weight gain in late juveniles compared with their counterparts born to early litters. As the hedgehog in Britain is able to forage and obtain its own food when it has a body weight of 200 g or less, the ability to gain weight depends on the efforts of individual animals and the availability of food, in terms of quantity and quality, and not solely on parental care. In New Zealand, on the North Island, European hedgehogs have been observed foraging at a weight of 100 g (Bunnell, personal observation 2003).

The tendency of young from late litters to gain weight at a faster rate than young from early litters increases the chance of late juveniles reaching an acceptable weight prior to hibernation. These findings dispel previous suggestions that all young hedgehogs born late in the year are automatically doomed to die due to a failure to achieve a satisfactory weight which would allow them to survive hibernation. In terms of physiological resources this makes good sense, both for the females who produce late litters and for the resulting young.

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Samenvatting

Groeisnelheid bij vroege en late worpen van de egel (*Erinaceus europaeus*)

Verondersteld wordt dat egels (*Erinaceus europaeus*) in Groot-Brittannië twee worpen per jaar hebben. Het is te verwachten dat jongen van tweede of late worpen een geringere overlevingskans hebben, omdat ze minder tijd hebben om voldoende in gewicht toe te nemen en daardoor een kleinere kans hebben om de winterslaapperiode te overleven. Er zijn enkele losse waarnemingen van laat in het seizoen geboren egels die sneller in gewicht toenamen dan egels die vroeg in het seizoen werden geboren. Deze studie werd uitgevoerd om vast te stellen of er bij egels een verschil is in groeisnelheid tussen vroege en late worpen of tussen die van mannetjes en vrouwtjes. De groeisnelheid werd gemeten van alle jonge egels (n=119) die tussen 1998 en 2006 aangeboden werden in het opvangcentrum van de auteur. De groeisnelheid van jongen van late worpen bleek significant hoger te zijn dan die van vroege worpen ($0{,}05>P>0{,}01$). Er bleek geen significant verschil in groeisnelheid tussen de beide geslachten.

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