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Timing of breeding and second litters in edible dormouse (*Glis glis*)

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Abstract. In temperate zone the edible dormouse (*Glis glis*) is an obligate hibernator with a relatively short activity season during the summer. Young are born in seed-masting years, mostly in early August and there is a time constraint as they have to reach independence and sufficient body mass prior to hibernation into which they enter from late September to October. Given the seasonal time constraints, only one litter per year is known to occur in this rodent. Here we report on the timing of breeding in a Czech population of edible dormouse and on two proven cases when females produced two litters per season. Both cases concern very early breeding females which had lost their first litters prior to weaning. The second (replacement) litters were born late in the season and they were successfully weaned. We discuss that probably several factors like female condition, field research design or current phenological trends in extended growing seasons could lead to multiple breeding events in this species.

Key words: breeding season, fat dormouse, multiple breeding, reproductive failure

Introduction

Rodents have on average two litters (mean 2.54 ± 1.76 SD, median = 2, n = 330 taxa) per season (Jones et al. 2009). The edible dormouse is an obligate hibernator and in contrast to other glirids with an unusually short active period and profound reproductive strategy. Its reproduction is tightly linked to the production of seeds of trees like beech and oaks and in non-masting years an entire population usually skips reproduction. Only one litter per season is produced (Kryštufek 2010). The births occur from mid July to mid September, with a peak in the first two weeks of August but rarely, late births were also reported in early September (Vietinghoff-Riesch 1960, Gaisler et al. 1977, Pilastro 1992, Pilastro et al. 1994, Schlund & Scharfe 1997, Burgess et al. 2003, but see Blohm & Hauf 2005).

Here we report on the timing of breeding in a Czech population of edible dormouse and on two proven cases when females produced two litters per season. Both cases concern very early breeding females which had lost their first litters prior to weaning.

Material and Methods

We conducted this study in Eastern Sudetes near Dlouhá Loučka (49°49′ N, 17°12′ E) in the NE Czech Republic. The study site represents a mosaic of managed mixed forest stands with an average age of 90 years and with the dominant tree species being sessile oak (*Quercus petraea*) and European beech (*Fagus sylvatica*). Since 2005 we have been regularly checking nest boxes throughout the entire vegetation period for a presence of dormice. All newly captured dormice were individually marked with subcutaneously injected PIT-tags (Trovan, ID 162 Isonorm). For details on field procedures see Kukalová et al. (2013) and Lebl et al. (2011). The study population does not live in close vicinity to urban areas which excludes the possibility that the dormice could feed on an artificial food supply. Since 2011 we tried to estimate exact parturition dates in our study population. Those females that looked to be close to their parturition day were more frequently monitored in nest boxes by quick daytime checks. However, due to logistic and time constraints we could not obtain parturition dates for all females. In addition, some females gave birth to young in natural cavities and later moved their young to the nest boxes. In 2011 we recorded exact parturition dates in 40 out of 137 litters. During 2013 we recorded 174 litters and out of them parturition date was exactly known for 91 litters. In 2015 we recorded exact parturition dates in

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68 out of 126 litters. As we tried to evenly spread the nest box checks throughout the study site and season we believe that the sub sample of exact parturition dates is not systematically biased from the pool of all reproducing females. In this study we considered only those litters for which we knew exactly their parturition dates. However, for one of the females with two litters per season we did not know her exact birth date of the second litter. In this case we estimated the parturition date based on the body mass of young (see details below). In all other cases the parturition dates were assessed based on intervals of nest box checks, external marks on young according to Koenig (1960), Vietinghoff-Riesch (1960) and our own experience gained over the years.

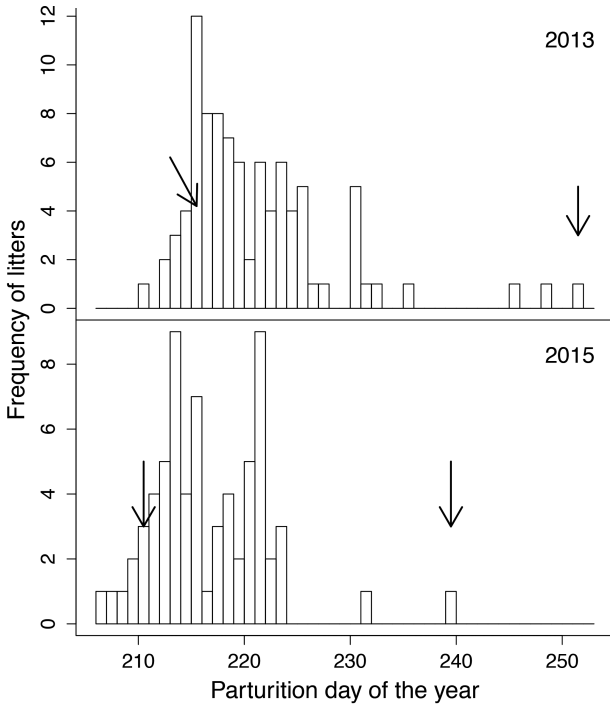


Fig. 1. Seasonal patterns of daily parturition dates in edible dormouse over two reproductive years. The arrows point at parturition dates for the two females which gave two births within one season. August 1 = day 213, sample sizes 2013 = 91, 2015 = 68.

Results

In 2011 the mean parturition date was 213.25 ± 3.4 SD (expressed as day of the year; median 214 = 2 August, range 204-223, n = 40). In 2013 the mean parturition date was 221.6 ± 7.3 (median 220 = 8 August, range 211-252, n = 91). In 2015 the mean birth date was 217.2 ± 5.5 (median 216 = 4 August, range 207-240, n = 68; Fig. 1). The seasons 2012 and 2014 were non-masting years, although locally some trees were weakly masting which resulted in 16 and 9 litters, respectively.

The first case of a second litter within one season refers to a female in 2013. She was caught for the first time as an adult on 12 June, then on 27 June, 10 July with body mass 101 g, 24 July when pregnant and body mass of 112 g. On 6 August she was with nine pups (average mass 5 g) born on 4 August and her body mass 115 g. Next encounter was on 4 September, pregnant with body mass 170 g. The interior of the nest box smelled of decaying pup bodies but the bodies were not found in the nest. On 19 September we found the female (mass 136 g) with nine pups with their average body mass 17.1 g. If we take the average birth mass in our population at 3.8 g and average daily mass gain 1.3 g (according to Bieber & Ruf 2004) the parturition date was probably on 9 September – hence for this female the second parturition date is only an estimate. On 30 September the female was with nine young. On 10 October there were nine young (average mass 32.3 g) with the female obviously in the process of weaning as only some tits showed signs of lactation. Last encounter was on 29 October when only one young (mass 84 g) was found in the nest box. One of the young survived hibernation and was recaptured on 5 September 2014.

Interestingly, in 2013 we recorded two more late litters with parturition dates on 3 and 6 September. Both females were one year old (after their first hibernation) and with low body mass but they successfully weaned young from these late litters.

The second case refers to a female in 2015. She was marked for the first time in 2008 as an adult. In 2015 we found her for the first time on 30 July 2015 right after the birth when she had five pups (mass 2.9 g) and her body weight 108 g. The female was encountered again on 12 August, obviously pregnant with body mass 131 g. Interior of the nest box smelled of decaying pup bodies but the bodies were again not found in the nest. Next check was on 24 August, female pregnant with body mass 156 g. On 1 September the female (mass 137 g) was with seven pups (mass 6.2 g) which were estimated to be born on 28 August. Next check was on 8 September when the female was with the young. On 12 October the female was with weaned young (average body mass 50.5 g) as there were no signs of lactation.

Discussion

We present detailed data on the timing of breeding in a central European edible dormouse population along with evidence for two litters per season in a species that is widely known, due to seasonal constraints, to have only one litter per year. In both documented

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cases the females lost their first litters and the second litters can be considered as replacement broods. Koenig (1960) reports, without further details, that when mortality occurs in the litters during the first two weeks of pups' life, the female is capable of two litters per season. However, it is not clear if Koenig was referring to wild dormice or those kept in captivity. Dormice kept in captivity have much longer breeding activity (Koenig 1960, Vietinghoff-Riesch 1960) which makes it difficult to compare with data on wild animals. To the best of our knowledge, only Blohm & Hauf (2005) reported on six cases of double or replacement litters (out of 184 litters) in a wild population of edible dormouse in beech-oak forest in NE Germany. However, the authors do not provide comprehensive details on their field methods and there is also absence of any remarks on adult female body masses and signs of lactation. We also cannot exclude the possibility of presence of artificial sources of food (e.g. in cottages or hunters' shelters) in their study which could alter the timing of breeding.

The edible dormouse strictly relies, both for reproduction and pre-hibernation fattening, on tree seeds (beech nuts and acorns) which are not fully ripen before midsummer (Kager & Fietz 2009, Lebl et al. 2010). Hence, they are tightly adapted with their timing of reproduction to coincide with available seeds. Having the young too early in the summer carries the risk for mothers of not having enough ripe seeds for milk production. Hence we think that the species evolved its timing of breeding to coincide with seasonal seed production and its ripeness. Currently there is strong evidence that due to ongoing climate change the plant growing seasons are extending (Linderholm 2006). Theoretically, this might be beneficial for those mammals who time their activity seasons with the available green vegetation. In central Europe we have also good evidence that both oak and beech are also advancing the dates when their fruits are available. Kolářová et al. (2014) documented that both tree species advanced their seed ripening dates by more than 8 to 9 days during 1976-2010 (phenological shifts: –0.24 day per year in beech and –0.27 day per year in oak). Hence, it is possible that the seasonal shifts in available food might mirror in advanced timing of reproduction. This could lead to a broader time window for dormice to rear their young and in the case of a failed attempt a second replacement litter might be produced. Therefore, we suggest that it might be the combination of shifting plant phenology and early breeding females that might lead to second litters within the same season. In fact, climate-induced shifts in hibernation phenology have been documented in this species in central Europe. The timing of dormice spring emergence after hibernation has been advancing at our and a German study site (Koppmann-Rumpf et al. 2003, Adamík & Král 2008). Thus birth date could be another trait that plastically mirrors changing external stimuli (Boutin & Lane 2014).

Other factors like female condition or age, territory quality but also an intensity of field work might explain the occurrence of replacement litters in this species. It might be the case that only females in good condition or those close to their last investment (one case refers to an extremely old female) could afford to produce a second brood. Also it is possible that the occurrence of replacement litters is more common but depending on the field research design (e.g. frequency of field checks) it might be overlooked. One issue that remains unclear is whether a monoestrous species is physiologically capable of a switch to polyestrous cycle. According to Airapetyants (1983) edible dormouse is a monoestrous species. Hence, this issue calls for further research.

While the edible dormouse has only one litter per year, other dormice species were reported to be more variable. Especially southern populations of garden *Eliomys quercinus* and forest dormouse *Dryomys nitedula* were found to have two to three (in the latter species) litters per season and the timing of breeding is shifted towards climatologically favourable conditions outside the hot summer (Nevo & Amir 1964, Moreno 1988, Gil-Delgado et al. 2006). In contrast, northern populations have usually one litter per year and very short breeding period (Juškaitis et al. 2015). The common dormouse *Muscardinus avellanarius* has one to two litters per season and in exceptional cases even three litters (Juškaitis 2014). The length of its breeding season, but not the number of litters per year, seems to be latitudinally driven. Interestingly, the occurrence of late litters in Lithuanian common dormice was associated with their low population densities (Juškaitis 2003). For edible dormouse the available studies report a range of parturition dates between mid July until mid September (Pilastro 1992, Pilastro et al. 1994, Schlund & Scharfe 1997, Burgess et al. 2003, Kager & Fietz 2009, Juškaitis & Augutė 2015). The widest range was recorded in Turkey from 14 July until 16 September (Özkan 2006), while the narrowest from 28 July until 13 August at the northern limit of its distributional range in Lithuania (Juškaitis & Augutė 2015). When reviewing the reported breeding dates we found an inconsistency across

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studies in reported statistics. Some studies provided only the range of dates and others report detailed measures of the breeding period. Hence, as has been suggested by Juškaitis & Büchner (2013), we encourage that further studies on dormice should pay attention to the occurrence of late-born young and to the length of the breeding season. Detailed reports on timing of breeding could be useful for assessments of latitudinal or climate-driven clines in breeding traits.

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