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NATURAL HISTORY NOTE

Observations and comments on demographic features of the Mediterranean horseshoe bat (*Rhinolophus euryale* Blasius, 1853)

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ABSTRACT

Lifespan is a fundamental demographic parameter that we can seldom measure in animals with elusive behaviour like bats. Even more useful parameters for modelling the life history are survival or reproduction by age and sex. However, in practice there are substantial obstacles to achieve information of that kind and, regretfully, we often rely on longevity records. This paper provides new records on long-lived *Rhinolophus euryale* individuals, including one female more than 25 years old. We also discuss the evidentiary support for the widely accepted age at first reproduction in that species.

RESUMEN

La esperanza de vida es un parámetro demográfico que en pocas ocasiones se logra estimar en animales con comportamientos esquivos. La supervivencia y reproducción por edad y sexo son otros parámetros aún más convenientes para modelizar la historia vital de las poblaciones. No obstante, existen considerables limitaciones para obtener este tipo de información y, desafortunadamente, a menudo nos conformamos con registros de longevidad. Este artículo presenta nuevos registros de murciélagos mediterráneos de herradura longevos, entre ellos alguna hembra de más de 25 años de edad. Igualmente, se discute el sostén evidenciario de la tan aceptada edad de primera reproducción de esta especie.

The estimation of bats' basic demographic features is challenged by the difficulties to observe over the long-term fundamental biological traits of most members of these mammals. Their secretive life, the extreme sensitivity to disturbances caused by capture and handling, or the recognition, avoidance of trapping devices and injuries from the marking methods reduce the feasibility of long-term studies (Dietz 2007, Kunz & Weise 2009). Besides, note that the ability to determine age by identifying individuals or cohort membership is a prerequisite to build up a life table. In most bats, traits as longevity, reproductive success, and age-specific mortality rate are frequently guessed. Hopefully, the number of species whose survival rate has been estimated has risen considerably in recent years (e.g. Chauvenet et al. 2014, Arlettaz et al. 2017, Bailey et al. 2017, Fleischer et al. 2017, Law et al. 2018). Less has been uncovered on the reproductive success or mortality rate by age (but see Hoyle et al. 2001, Schaub et al. 2007, O'Shea et al. 2011, Arlettaz et al. 2017, Fleischer et al. 2017) .

Even where individuals have been sampled at great numbers, resighting of marked animals is occasional. Consequently, the number of individuals in any given age drops dramatically so that most estimates are clumped into broad age classes (young *vs* adults). Even today, the registered variables are often just the time lapse between the two capture events (considered as the minimum age) or observed ontogenetic changes (reproduction at a given age). As a result, longevity records of bats sprout from time to time from the scientific literature, sometimes extending the known lifespan of a bat species or sex of a species (e.g. Caubère et al. 1984, Arlettaz 2002, Florko et al. 2017). The present paper is no exception.

One of the consequences of the uncertainty about the demographic information gathered so far is the hurdle in applying the criteria A (reduction in population size), C1 (continuing decline) and E (probability of extinction) of the IUCN guidelines to assess extinction risk in bats, since the turnover rate of breeding individuals must be calculated, if possible, from a life table (IUCN Standards and Petitions Committee 2019). Such a parameter is called "generation length" and may also be defined as the average age of parents of the current cohort. In order to obtain a reliable estimate of it, information on survival and fecundity is required, preferably stratified by age and sex. Biased estimation of

the generation length implies that the time for a predicted population crash may be wrong. Underestimation is of particular concern and the calculation of the generation length must not incur in it. The lack of reliable information on these fundamental parameters increases the chances of a biased estimation (Bird et al. 2020). In *Rhinolophus euryale*, different generation time estimates are used in different assessments: for instance, the Italian assessment of *R. euryale* considered ten years (Agnelli et al. 2013), whereas it was six years in the global assessment (Juste & Alcalde 2016). That inconsistency indeed reflects a lack of grounded evidentiary information on this parameter.

This paper aims to gain insight into the survival of the Mediterranean horseshoe bat, seeking, ultimately, to improve the accuracy of the calculations of the generation length.

We report several observations on the age of individuals banded as yearlings during September in a nursery colony of the Basque Country (latitude 43.2, longitude -3.4, WGS84). We banded 31 individuals in 1995 (11 males, 20 females), 11 in 2003 (6m, 5f), 70 in 2005 (39m, 31f) and 30 in 2006 (13m, 17f). Aluminium rings of 4.2 mm of diameter provided by the former Spanish Institute of Nature Conservation were used. The lack of ossification of the epiphyseal plates of the phalanges of the fourth finger was used to classify the individuals as young born that year.

Banded individuals have been recaptured on several occasions (Table 1). The eight recaptured individuals were more than 14 years old, and among them, five were more than 15 y, two more than 17 y and the oldest was more than 25 y. Six out of eight of the recaptured observations were males despite the balanced sex ratio in banded batches. Tooth wear was appreciable in one individual, and the rings were gnawed in three cases. Besides, we recovered another individual whose ring was severely gnawed, and as a result, its code was unreadable. We detached the ring of that animal.

The oldest *R. euryale* female previously reported in the literature is an individual ten years and nine months old from the Carpathian Mountain range (Uhrin et al. 1996). Our record reveals a female individual more than twice older, who was still lactating at 22 y according to the inspection of the nipples.

The new lifespan records are similar to other recent estimations corresponding to a male Mediterranean horseshoe bat (Ibáñez et al. 2018) and fits a lifespan ranging 20-30 years as anticipated by Gaisler (2001). Adoption of this new longevity value may increase the generation length estimate up to a minimum of 10 years, which is almost twice the value used nowadays for this species by the IUCN (Juste & Alcalde 2016), and would likely increase the extinction risk assessed under criteria A, C1 and E. However, we must note that the demographic meaning of these observations will remain unclear as long as we are unable to estimate the annual survival rate (Krementz et al. 1989).

The population dynamics of *R. euryale* would also be more precisely modelled if the evidence on the age at first reproduction of females were unequivocal. It has been assumed to be two-to-three years in several reviews (Gaisler 2001, Arthur & Lemaire 2009, Dietz et al. 2009). Dietz et al. (2009) also referred to their own observations, although the data were not shown. The first and hitherto only data on the age at first reproduction in *R. euryale* were allegedly published by Crucitti (1976) and Dinale (1963). Dinale (1963) banded and resighted *R. euryale* during the winter of subsequent years, determining females' sexual maturity by the presence of pubic nipples. However, he did not record all individuals' age class of the first capture, hampering the precise characterization of age at sexual maturity. The only individuals classed as subadults when captured were resighted again as subadults the next winter, but subsequent recaptures were lacking. Dinale (1963) concluded that females probably give birth for the first time at two and three years old, but he did not asseverate that unambiguously (p7, sic: *…però contiene alquanti punti dubbi…*). Crucitti (1976) reports the time-lapse between banding and the last resighting of one of the females banded by Dinale (1963), but he did not report any new data on the age at first reproduction. Other papers of Dinale (1967, 1968) have also been cited to refer to the age of first reproduction in *R. euryale* (e.g. Gaisler 2001), although they only state opinions of the author based on the original data (presented in Dinale 1963). As long as reliable studies on this issue are not carried out, we suggest a cautionary use of this value when calculating the species' generation length.

Table 1 - Records on individual Mediterranean horseshoe bats indicating data (month/year) of banding and recapture, sex and additional remarks.

Banded	Recaptured	Sex	Remarks
09/1995	08/2017; 01/2021	Female	Lactating in 2017. Little tooth wear
09/2003	01/2021	Male	N/A
09/2005	01/2021	Male	Tooth wear
09/2005	02/2021	Male	N/A
09/2005	09/2020; 01/2021	Female	Sharp teeth
09/2005	02/2020	Male	N/A
09/2005	02/2020	Male	N/A
09/2005	02/2020	Male	Sharp teeth

The inconsistent link between tooth wear and age of the observed bats strengthens the view already expressed by other authors (Brunet-Rossinni & Wilkinson 2009) about the unreliability of tooth wear to estimate age.

Similarly to demographic parameters, evidence on other fundamental biological traits of this species are weak or circumstantial, e.g. the mating system (De Paz et al. 1986, Uhrin 1992). Altogether, the information available so far reflects the difficulties to the study of any parameter on the biology of this species that requires careful observation in the long term (Dietz 2007). Consequently, caution is advised whereby the assessment of the extinction risk of this and similar bats uses biological information with little evidentiary support.

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