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Comments on reproduction of *Myotis dinellii* in San Juan, Argentina

Observaciones sobre la reproducción de *Myotis dinellii* en San Juan, Argentina

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Myotis dinellii forms groups of 3 to 80 individuals and inhabits natural and anthropic environments. Despite having a wide distribution in Argentina, the information available on its reproduction is scarce, so the aim of this paper is to provide information on its reproductive activity and fill some gaps in the knowledge of its biology. The reproductive activity of a colony of *M. dinellii* inhabiting a bridge (2.26 m high, 9.60 m long, 14 m wide) in the department of Ullum, San Juan, Argentina, was recorded. Two mist nets were placed on both sides of the bridge from 20:00 hr to 06:00 hr. Sex, age and reproductive condition were recorded for each specimen. From March 2018 to January 2020, with a sampling effort of 1,350 net-hr, 49 individuals were captured, consisting of 41 females (29 lactating and 12 non-lactating) and 8 males (4 with scrotal testes and 4 with abdominal testes). There were 29 births in the first days of December and lactation until the first days of January. The colony occupied the bridge from November to the beginning of March. These results constitute the first reproductive data of *M. dinellii* obtained from a systematic study of a colony. These studies are necessary to increase the general knowledge of the reproductive patterns of the species in Argentina.

Key words: Central western Argentina; colony; reproductive status; Vespertilionidae; yellowish bat.

Myotis dinellii forma grupos de 3 a 80 individuos y habita en ambientes naturales y antrópicos. A pesar de tener una amplia distribución en Argentina, la información disponible sobre su reproducción es escasa, por lo que el objetivo de este trabajo es proporcionar información referida a su actividad reproductiva y llenar algunos vacíos en el conocimiento de su biología. Se registró la actividad reproductiva de una colonia de *M. dinellii* que habita en un puente (2.26 m de alto, 9.60 m de largo, 14 m de ancho) en el departamento de Ullum, San Juan, Argentina. Se colocaron 2 redes de niebla en ambos lados del puente desde las 20:00 hr a 06:00 hr. De cada ejemplar se registró el sexo, edad y condición reproductiva. Desde marzo de 2018 a enero de 2020, con un esfuerzo de muestreo de 1,350 hr/red se capturaron 49 individuos, consistentes en 41 hembras (29 lactantes y 12 no lactantes) y 8 machos (4 con testículos escrotales y 4 con testículos abdominales). Se registraron 29 nacimientos en los primeros días del mes de diciembre y lactancia hasta los primeros días de enero. La colonia ocupó el puente desde noviembre hasta principios de marzo. Estos resultados constituyen los primeros datos reproductivos para *M. dinellii* basados en un seguimiento sistemático de una colonia. Estos estudios son necesarios para incrementar el conocimiento general de los patrones reproductivos de las especies en Argentina.

Palabras clave: Centro oeste de Argentina; colonia; estado reproductivo; murciélago amarillento; Vespertilionidae.

The reproductive cycle of bats is influenced by resource availability, rainfall and seasonality (Tuttle and Stevenson 1982; Racey and Entwistle 2000; Altringham 2011). Generally, species from temperate zones have one reproductive cycle with an annual birth peak (monoecious) and those from tropical zones have two annual cycles (polyesters), and may have a uni- or bimodal reproductive period with a long period of sexual inactivity, or they may reproduce continuously throughout the year (Racey and Entwistle 2000; Filho *et al.* 2007; Barclay and Fleming 2020).

Most vespertilionid bats from temperate areas display a seasonal monoestry, generally connected with hibernation (Krutzsch 2000; Araújo *et al.* 2013). They give birth from late spring to early summer, depending on insect

availability, which is in turn determined by rainfall patterns and increased temperature (Happold and Happold 1990; Hoying and Kunz 1998; Racey and Entwistle 2000; Burles *et al.* 2009; Araújo *et al.* 2013). However, resource availability and abundance do not always produce a positive energy effect on females, influencing their gestation stages and the end of the lactating periods (Marques-Aguiar 1986).

The genus *Myotis* includes 139 species distributed worldwide, except at the poles (Mammal Diversity Database 2020; www.mammaldiversity.org). Twenty-two of them are present in South America (Gardner 2008; Moratelli *et al.* 2011, 2013, 2019; Díaz *et al.* 2016), with 12 in Argentina (Barquez and Díaz 2020). In the Neotropics, the genus *Myotis* does not show a unique and constant reproductive pattern (Sosa *et al.* 1996). For instance, *M. keaysi* exhibits a seasonal monoestry, *M. oxyotus* a bimodal poliestry with 2 pregnancy events and *M. nigricans* has 2 or 3 reproductive seasons without postpartum estrus. Moreover, previous studies have reported random ovulatory events and pregnancy periods from 50 to 60 days in some species of this genus (Wilson 1971; Studier and O'Farrell 1972; Myers 1977; Wimsatt 1979; Krutzsch 2009).

Myotis dinellii (yellowish bat) is mainly distributed in Argentina, with scarce records in Bolivia and Brazil (Díaz *et al.* 2016; Barquez and Díaz 2020). This species is categorized as of Least Concern both by the UICN and at a national level (Díaz *et al.* 2013; Díaz and Barquez 2016). It lives in family groups of about 3 to 80 individuals and inhabits both natural and anthropic environments (Barquez and Díaz 2020). It was first described by Thomas (1902) but later, LaVal (1973) considered it as a subspecies of *M. levis*. Finally, Barquez (2006) adopted its traditional designation, considering its valid status as a full species, recognizing that both are in sympatry (Barquez 2006; Miranda *et al.* 2013). Even though it has a widespread distribution in Argentina, there is limited information about its biology, and particularly about its reproduction (Barquez and Díaz 2020). We provide new data about the biology of this species and hence contribute to improving our knowledge about these mammals.

The study area is a refuge located under a bridge over a drainage channel in the dock of Ullum Dam (31° 26′ 37.05″ S; 68° 39′ 31.90″ W; Figure 1) at Ullum department, 20 km northwest of San Juan city, Argentina. The bridge is used for drainage and overhead for the passage of vehicles, it has several cracks in the roof that are used as shelter by bats, the bridge measures: 2.26 m high, 9.60 m long and 14 m wide (Figure 2).

The area's landscape is typical of the ecoregion Monte de Sierras and Bolsones, characterized as an open xeric scrubland dominated by species of the Zygophyllaceae and legume families related to small sized shrubs, cacti and some herbaceous plants (Burkart *et al.* 1999). The climate

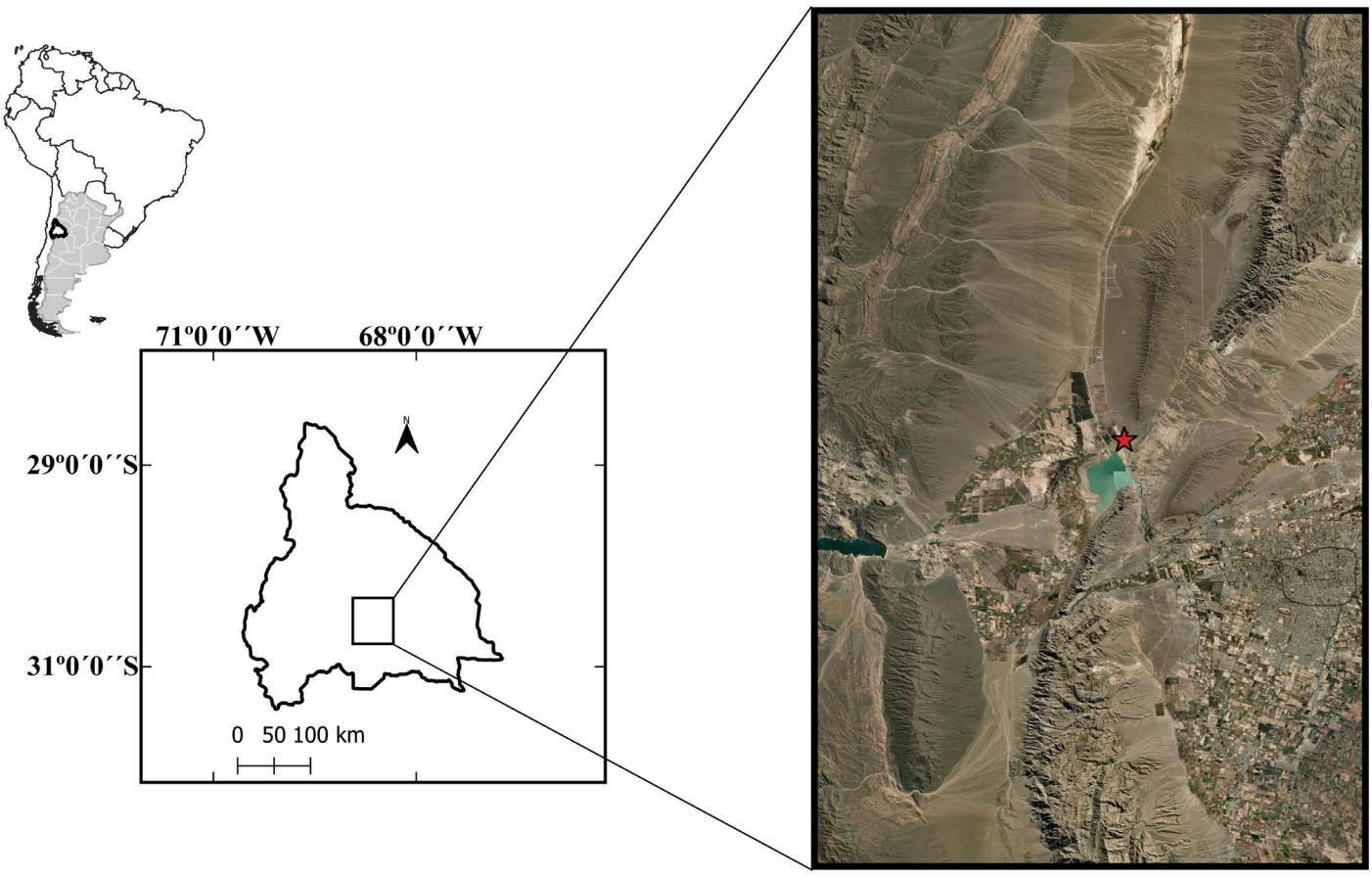

Figure 1. Geographical location of the *Myotis dinellii* colony studied (red star) in Ullum department, province of San Juan Argentina.

Figure 2. Bridge inhabited by *Myotis dinellii* colony in Ullum department, province of San Juan Argentina. Photography: E. G. Ruiz-Estebes.

is of the subtype BWwkb, typical of a hyper-arid desert, according to Köppen's phytoclimate model (Köppen 1931). About 72 % rainfall is concentrated in summer, with an annual average of 84 mm. The effect of water deficit is produced by not only low rainfall but also an annual average temperature of 20 °C, with a minimum average of 16 °C and a maximum average of 40 °C (Atlas Socioeconómico de la provincia de San Juan 1980; www.atlas.unsj.edu.ar).

The *Myotis dinellii* colony was surveyed between March 2018 and January 2020, observations were made once per month, completing a total of 23 days. The captured specimens were identified by comparing its external morphological traits with descriptions provided by Barquez and Díaz (2020) and with the assistance of the specialist Dr. M. Díaz. To determine the occurrence of specimens, we observed the cracks in the bridge at daytime and placed 2 mist nets (12 m x 2.30 m and 15 m x 3 m) on either side when we identified the presence of individuals. The nets were open from 20:00 hr to 6:00 hr and were checked every 30 min with a sampling effort was 1,350 net-hr. We registered sex, age and reproductive state of the captured individuals and one nail was dark-coloured to avoid duplicating information of the same individual. To classify them as juveniles or adults, we analyzed the degree of ossification of the phalangeal epiphyses and pelage colour and texture (Kunz and Parsons 2009). The reproductive state of females was determined by observation and abdominal palpation, identifying active or inactive females according to the presence or absence of milk in their mammary glands. Active females were classified as pregnant (by abdominal palpation) and lactating (by observation of mammary glands enlarged by milk production and nipples without fur around them; Kunz and Parsons 2009). In males, the reproductive state was assessed by the position of the testes. We defined as inactive those males exhibiting abdominal testes, and active those with scrotal testes (Kunz and Parsons 2009).

It is important to highlight that the identification of these external morphological traits does not provide evidence to detect an early pregnancy or the occurrence of spermatogenesis or oogenesis processes. Moreover, information about sperm storage, delayed implantation, embryonic development and some other reproductive events is necessary to determine the reproductive pattern of a species and to describe its reproductive biology (Miotti 2020).

We found no specimens occupying the bridge crevices between early March and late November 2018, in February 2019 and from early April to November 2019. We only recorded specimens during the calving and lactation sea-

son, 8 individuals (2 males with scrotal testes, 1 male with abdominal testes and 5 lactating females) were captured in December 2018, 4 females (1 lactating and 3 non-lactating) in January 2019, 1 lactating female in March 2019, 22 females (21 lactating and 1 non-lactating) in December 2019, and 14 individuals (2 males with scrotal testes, 3 males with abdominal testes, 2 lactating females and 7 non-lactating females) in January 2020 (Table 1). It was confirmed that the specimens occupy the refuge during the last period of pregnancy (end of November) and remain there until lactation ends and the young can fly (beginning of March).

Bats inhabit a wide variety of refugees, both natural and artificial. They can use them temporally, for sheltering, mating or other social interactions, or permanently, for sheltering, reproduction, gestation and care of their offspring until they become independent (Kunz 1982; Kunz and Fenton 2005; Torres-Flores *et al.* 2012). The analyzed *M. dinellii* colony temporally used the bridge cracks to give birth and parental care of offspring development until their independence (Figure 3).

Table 1. Frequency and monthly distribution of the reproductive status of females and males captured at the bridge, Ullum department, province of San Juan Argentina.

Reproductive state	Number of individuals	Month and year
Lactating females	5	December 2018
Males with scrotal testes	2	December 2018
Male with abdominal testes	1	December 2018
Lactating females	1	January 2019
Non-lactating females	2	January 2019
Lactating females	1	March 2019
Lactating females	21	December 2019
Non-lactating females	1	December 2019
Males with scrotal testes	2	January 2020
Male with abdominal testes	3	January 2020
Lactating females	2	January 2020
Non-lactating females	7	January 2020

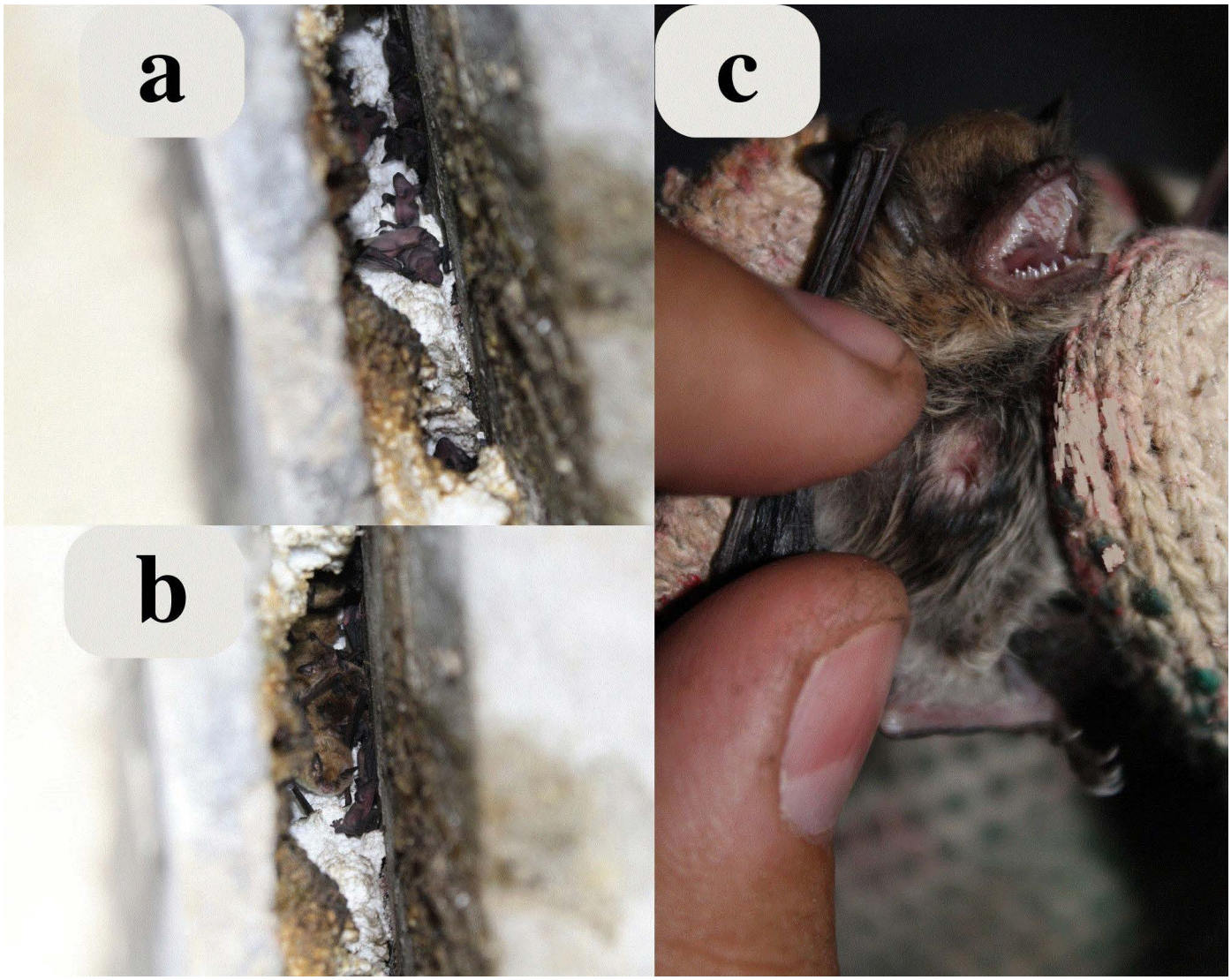

Figure 3. Specimens found in Ullum department, province of San Juan Argentina. a) Juveniles in the shelter. b) Adults and juveniles. c) A lactating female, with a developed mammary gland, shown in detail. Photography: E. G. Ruiz-Estebes.

Some *Myotis* species present in Argentina, such as *M. chiloensis*, *M. levis* and *M. riparius*, display a seasonal monoestry as reproductive pattern (LaVal and Fitch 1977; Pearson and Pearson 1989; Miranda *et al.* 2010; Araújo *et al.* 2013; Farias *et al.* 2015) while others (*e.g.*, *M. albescens*) are polyestric (Myers 1977; Wilkinson and McCracken 2003). Previous studies of *M. dinellii* from other regions of Argentina have provided information about the reproductive season, ranging from spring to summer (Barquez *et al.* 1999). They have reported the occurrence of females with open vaginas in January, February and March, females with closed vaginas in January, February, March and October, males with abdominal testes January, March and October, and males with scrotal testes in March (Alurralde *et al.* 2017).

The colony analyzed in this study comprises a few males and several females sheltering from the end of gestation, when giving birth until the completion of the lactation period of their offspring. Females gave birth in early December and lactation was recorded until early January. Usually, the average lactation length is 40.9 days, a variable condition among species as it depends on the time to grow and become independent required by offspring (Kunz and Fenton 2005). For instance, *Myotis velifer* females have been observed nursing their babies after they have developed the flight ability (Bishop *et al.* 1992; Balmori 1999).

The colony is in an area with high tourist activity, as it is located at the bottom of a bridge at the entrance of a nautical complex. Motorcycles and quad bikes often pass under the bridge, and there have also been attempts to destroy the refuge by setting fires under the bridge near the crevices where the colony lives. To generate protection measures for this colony, it was recently declared a SICOM (Site of Importance for the Conservation of Bats) endorsed by RELCOM (Latin American and Caribbean Network for the Conservation of Bats).

Based on gathered information and considering our study area has a marked seasonality with estimated temperature and rainfall (dry and rainy seasons), we found that *M. dinellii* displays a seasonally monoestrous reproduction, with a short reproductive cycle. Such a pattern, influenced by climate and food resources, is typical of insectivore bats (Bernardi *et al.* 2014).

These results constitute the first reproductive data of *M. dinellii* obtained from a systematic study of a colony. We highlight the importance of carrying out similar studies to improve research methods and increase knowledge about the reproductive patterns of most species in different environments in Argentina.

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