First Notes on the Life History of Eupithecia tarapaca Rindge (Geometridae) on the Western Slopes of the Andes of Northern Chile

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FIRST NOTES ON THE LIFE HISTORY OF *EUPITHECIA TARAPACA* RINDGE (GEOMETRIDAE) ON THE WESTERN SLOPES OF THE ANDES OF NORTHERN CHILE

Additional key words: *Balbisia microphylla*, Florivory, Larentiinae, Vivianiaceae, Pupal diapause

The life histories of the Lepidoptera from the Atacama Desert and the Andes of northern Chile are in general poorly studied. However, as already shown for some butterflies inhabiting these arid environments, data dealing with biology and host ranges are essential to understand their abundance and distribution patterns, and also provide useful tools to assess adequately their conservation status (Despland 2014).

Eupithecia tarapaca Rindge (Lepidoptera, Geometridae, Larentiinae) is a little known geometrid moth originally described based only on the holotype male collected in Timar, a narrow ravine situated on the western slopes of the Andes of northern Chile (Rindge 1987, 1989). All aspects of its biology are presently unknown, mostly due to the scarce sampling for geometrid moths in these arid environments. However, some adults of this species were recently reared from larvae collected on a native plant close to the type locality. Accordingly, the objective of this contribution is to provide the first notes on the life history of *E. tarapaca*, including the first host plant record and the first record of facultative pupal dormancy for this desert moth.

Sampling was performed in the area around Socoroma village (18°16' S, 69°35' W), Parinacota Province, at about 3,300 m elevation on the western slopes of the Andes of northern Chile (Fig. 1). The site is characterized by a tropical xeric bioclimate with a highly seasonal vegetation cover that generally reaches higher levels in March–April after the summer rains (Luebert & Pliscoff 2006). The larvae were collected between March 2011 and July 2015 on flower buds of *Balbisia microphylla* (Phil.) Reiche (Vivianiaceae) (Fig. 2–3). They were placed in plastic vials and kept in the laboratory. Additional flowers of the same plant were provided daily until the larvae finished eating and started to prepare for pupation. Pupae were periodically observed until adult emergence. Adults were pinned, spread, and dissected following standard procedures in order to provide a taxonomic identification. Voucher specimens are deposited in the Colección Entomológica de la Universidad de Tarapacá (IDEA), Arica, Chile.

Seventeen adults of *E. tarapaca* were reared, twelve males and five females. The identification was based on comparisons with the original description (Rindge 1987) and photographs of the genitalia of the holotype deposited in the American Museum of Natural History (AMNH).

Balbisia microphylla is the first host plant recorded for *E. tarapaca*. Furthermore, this is the first mention of the association of *Eupithecia* with Vivianiaceae (Robinson et al. 2010). At the local level, previous host plant records for *Eupithecia* of northern Chile mostly included Fabaceae, with only one species, *E. atacama* Vojnits, associated with Chenopodiaceae, and another, *E. yubitzae* Vargas & Parra, with larvae being able to feed on Anacardiaceae as well as Fabaceae (Vargas et al. 2015).

Detailed knowledge of host ranges of geometrid larvae is useful to understand the ecology of these organisms in these arid environments, either in their role as herbivores or as prey (Méndez-Abarca et al. 2014, Vargas et al. 2014). Although this study did not aim to determine the host specificity of *E. tarapaca*, it must be noted that other plant species, mostly of the Asteraceae and Fabaceae, have been surveyed for florivorous caterpillars for more than seven years in the study site, but no additional hosts have been detected for *E. tarapaca*, suggesting a close association with *B. microphylla*. Monophagy and oligophagy have been reported for other Neotropical representatives of the Larentiinae (Strutzenberger et al. 2010, Seifert et al. 2015), including *Eupithecia* (Parra & Ibarra-Vidal 2002, Bodner et al. 2010). However, polyphagy has been reported for several florivorous Nearctic and Palearctic *Eupithecia* (Bolte 1990, Mironov 2003, 2014). Further field and laboratory studies are required to assess better the host specificity of *E. tarapaca*. Since other species of *Balbisia* have distribution ranges close to *B. microphylla* both in northern Chile and southern Peru (Weigend 2005, 2011), it should be interesting to survey them for *E. tarapaca* larvae.

All larvae of *E. tarapaca* included in this study were collected in flower buds of the host. They mostly fed on the reproductive structures of the floral buds during rearing, eventually also eating the petals. Although leaves were also offered to the larvae, these organs were never consumed, suggesting a florivorous habit. Florivory appears to be the predominant feeding habit of the *Eupithecia* from the Atacama Desert, although

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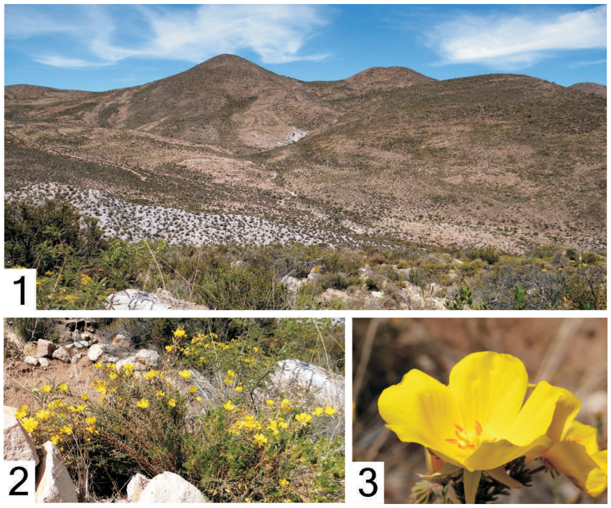

FIGS 1-3. Habitat and host plant of *Eupithecia tarapaca*. **1**) Study site near Socoroma village (18°16' S, 69°35' W), Parinacota Province, at about 3,300 m elevation on the western slopes of the Andes of northern Chile; **2**) the host plant *Balbisia microphylla*; **3**) open flower of *B. microphylla*.

larvae of *E. yubitzae* are able to eat leaves of Anacardiacaeae and flowers of Fabaceae (Vargas et al. 2015). Florivory is also the most important feeding habit in most species of *Eupithecia* globally (Mironov 2014).

The duration of the pupal stage of *E. tarapaca* was strikingly variable, ranging from about three weeks to more than two years. The most common duration of the pupal stage was 20–30 days (n = 13), but some pupae (n = 4) lasted 13–27 months in this stage, suggesting that *E. tarapaca* has facultative pupal dormancy with the possibility of an extremely prolonged duration of the pupal stage.

Many of the Nearctic and Palearctic species of *Eupithecia* overwinter as pupae with many cases of pupal diapause recorded (Bolte 1990, Mironov 2003, 2014). The northern populations of the Palearctic *Eupithecia abietaria* Goeze have biennial life cycles with a prolonged pupal diapause (Mironov 2014). Powell (1987) recorded 21 months of diapause for one pupa of the Nearctic *Eupithecia dichroma* McDunnough. Among the Neotropical *Eupithecia*, obligatory diapause was described for *E. tamarugalis* Vargas & Parra, whose larvae feed on flowers of *Prosopis tamarugo* (Fabaceae) in the Atacama Desert (Vargas & Parra 2005) about 300 km southwest of the study site. This strategy enables *E. tamarugalis* to synchronize its life cycle perfectly with the flowering of its host plant; adults and larvae are active only during the season with higher availability of flower buds and flowers for egg laying (female adults) and feeding (larvae).

Facultative diapause can have profound effects on the ecology and evolution of species (Liu et al. 2010, Mironov 2014). It has been recognized as a useful strategy to overcome adverse conditions in phytophagous Lepidoptera (Pessoa-Queiroz et al. 2008). Powell (1987) highlighted that extended diapause mostly occurs in species of Lepidoptera inhabiting areas with seasonal drought and with erratic food abundance. Studies dealing with the flowering phenology of *B. microphylla* were not found in the literature. However, in accordance with the patterns described for three other species of *Balbisia* in southern Peru (Weigend 2005), preliminary observations performed in the study site suggest that the main flowering of *B. microphylla* occurs following the summer rains, approximately in March–April, while additional flowers occur during the remainder of the year. The abundance of flowers produced outside the main flowering period appears to be extremely variable temporally and also highly clustered spatially. Thus based on the life history notes described here for *E. tarapaca*, it appears that this moth fits the bet-hedging strategy (Venable 2007, Rajon et al. 2014), characterized in this case by a variable duration of the pupal stage which enables *E. tarapaca* to use a highly variable resource. Further field and laboratory studies are required to understand the adaptive significance of the facultative pupal dormancy of *E. tarapaca* on the arid western slopes of the Andes of northern Chile.

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