*Journal of the Lepidopterists' Society*
60(4), 2006, 101–102

# EGG VIABILITY AND LARVAL CONTRIBUTION TO FECUNDITY OF *PARNASSIUS SMINTHEUS* DOUBLEDAY (PAPILLIONIDAE)

**Additional key words**: life history, reproduction, Rocky Mountain Apollo

Fecundity and egg viability are important components of life history affecting population dynamics and persistence as well as being a central factor in evolution. Despite its basic nature, estimates of fecundity for Lepidoptera are not common (Hunter 1995). Here we briefly present estimates of egg viability and fecundity primarily due to larval resources for the Rocky Mountain Apollo butterfly *Parnassius smintheus* Doubleday, 1847.

We collected 146 female butterflies from two large meadows (sub populations P & Q, see Matter *et al.* 2000) along Jumping Pound Ridge, Kannanskis, Alberta, Canada (51°57'N, 114°54'W, ~2100 m). All *P. smintheus* encountered were removed on six occasions (July 20, 23, 30, 31 and August 11, 19) during the adult flight season of 2005 (~18 July–24 August). We collected ten additional females from nearby Powderface Ridge (Matter and Roland 2002) on August 6th 2005. The removals on Jumping Pound Ridge are part of a larger experiment examining spatial population dynamics. Upon capture, we placed individual butterflies in a glassine envelope and took them to The University of Calgary's Barrier Lake Field Station (~1400 m) where they were kept in the envelopes at ambient conditions. After the female's death, we counted the number of eggs laid by each butterfly. Because butterflies were removed from meadows frequently, each was captured fairly shortly (1–10 d) after its emergence. *Parnassius smintheus* continues to develop eggs in the adult stage (C. Guppy, personal communication). Thus, the number of eggs produced here should largely represent fecundity based on larval resources, rather than total fecundity including additional eggs produced from nectar resources during the adult stage. Additionally, the mating status of females was assessed by the presence or absence of a sphragis which males affix to females during copulation to prevent additional mating by other males (Bird *et al.* 1995).

We examined egg viability for a subset of females and compared viability among mated and unmated females. Eggs from all females were kept at ambient temperature until September 4. After that they were refrigerated in a humid relaxing chamber at ~5 ˚C until use in mid December. Between 3 and 28 eggs (X = 12.2) from 32 females (25 mated and 7 virgin) were placed on wetted filter paper in individual Petri dishes and kept at room temperature (~25 ˚C). Although some larvae began to eclose immediately upon the addition of water, most hatched after 4–5 days. To ensure that hatching was complete, we kept the filter paper moist and waited 3 weeks to examine number of larvae that eclosed.

We compared egg production among the three populations and between mated and unmated females using one-way analysis of variance. To assess any effect of the time between captures on the number of eggs produced we used linear regression.

Populations differed in the number of eggs produced by females ($F_{2,153}$ = 5.52, P = 0.01). Likely due to differences in phenology and our frequent removals, the mean numbers of eggs produced by females from the two Jumping Pound Ridge sub-populations (19.3 ± 2.1 (Std. Error, here and throughout) and 10.8 ± 2.3) were much greater than butterflies from Powderface Ridge (1.1 ± 0.7). All further analyses exclude the Powderface Ridge butterflies. There was no difference in the mean number of eggs laid by mated (18.0 ± 2.1) or unmated females (15.2 ± 2.8; $F_{1,144}$ = 0.52, P = 0.47), indicating that male-donated nutrients likely play little or no role in female fecundity for this species (Boggs 1990, 1997). The number of eggs laid by butterflies collected on different dates showed significant variation ($F_{5,140}$ = 4.93, P < 0.01). The greatest numbers of eggs were produced by females collected on July 30 and 31. Surprisingly, the number of eggs laid increased with the number of days between butterfly removals ($F_{1,141}$ = 16.16, P < 0.01). Thus, the observed number of eggs produced by females did not decrease due to prior oviposition by older females collected after longer intervals. In contrast, this result suggests that longer access to adult nectar resources may increase egg production (see below).

Across all butterflies from the two Jumping Pound Ridge populations, the mean number of eggs produced was 17.1 ± 1.7 (Figure 1). The distribution was highly skewed, ranging from 35 butterflies that produced no eggs to one female that produced 95 eggs. If the data are limited to mated females the mean number of eggs produced increases slightly to 18.0 ± 2.1. The number of eggs produced by *P. smintheus* was much lower than estimates for *Euphydryas editha* and *Melitaea cinxia* (Boggs and Nieminen 2004). Watanabe and Nozato

(1986) reported a similar mean of 17.8 ± 4.9 mature eggs from dissections of 17 newly emerged spring generation *Papillio xuthus*. Newly emerged butterflies from later generations and from *P. machaon* showed over twice as many mature eggs. The low reproductive output seen for *P. smintheus* relative to other Papillionids is likely a function of the lack of adult nutrition (nectar) provided in our study combined with continued egg maturation by adults. Lack of adult nectar resources may limit both lifespan and egg maturation (Boggs 1997). Thus, the reproductive output seen here largely represents the contribution due to larval resources, and is not an estimate of total potential fecundity. This result further emphasizes the importance of adult nectar resources for population processes (Matter and Roland 2002).

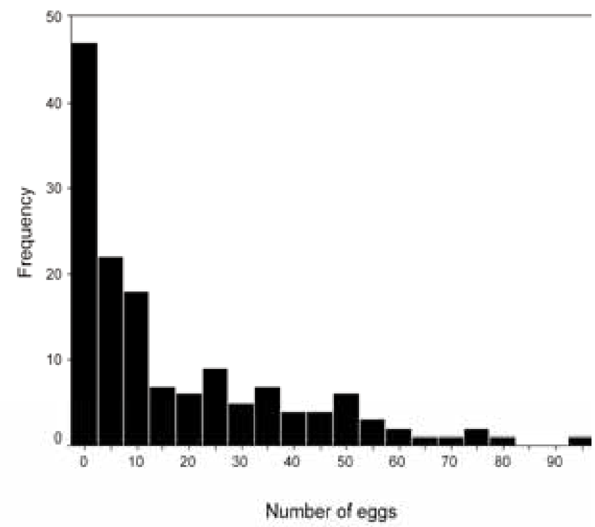


FIG 1. Frequency distribution of the number of eggs laid by female *Parnassius smintheus* from two populations along Jumping Pound Ridge.

A mean of 46.3 ± 8.2 % of the eggs from mated females produced larvae (range 0–100%). No larvae were reared from eggs from females without a sphragis. This result confirms that the sphragis generally is not lost, and the presence of a sphragis can be used to confirm mating status. Dissection of 5 eggs from one mated female revealed 3 live pharate first instar larvae and 2 incompletely developed larvae. As these butterflies overwinter as pharate first instars (Guppy and Shepard 2001) the fate of the incompletely developed eggs is unclear. These eggs, presumably produced later in the season, either die or overwinter. The incomplete development may have been due to some eggs being subjected prematurely to a cold environment. It is unclear to what degree this incomplete development occurs under natural conditions.

This research was supported by NSF grant DEB-0326957 to SFM and an NSERC operating grant to JR. We thank Chris Garrett and Alison Winkelar for assistance with the field work and Crispin Guppy for critical comments.

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*Received for publication xxxxxxxxx revised and accepted xxxxxxx.*