

**Larval morphology and life history of the little-known
winter moth *Agriopis budashkini* KOSTJUK, 2009,
based on new records from Crete
(Lepidoptera: Geometridae)**

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Abstract

Larvae of the little-known winter moth species *Agriopis budashkini* KOSTJUK, 2009, have been collected in Crete Island and successfully reared in captivity. The biology of this species is presented and experiments with various potential host plants are reported. The larva was found on *Acer sempervirens* and reared successfully on *Acer pseudoplatanus*, *Quercus robur* and *Quercus petraea*. Colour variation of larvae and adults are illustrated and/or briefly described. Several other geometrid species, which were collected on *Acer sempervirens* are listed.

Introduction

The term ‘winter moths’ refers to species reproducing in winter in temperate regions and having a univoltine life cycle (YAMAMOTO & SOTA 2007). In the family Geometridae, the females of many winter moth species are brachypterous (wings are lost or shortened) and quite often have a degenerated proboscis (SCOBLE, 1995). Due to their pest status some species of winter moths (e.g. *Erannis defoliaria* CLERCK, 1759, *Operophtera brumata* LINNAEUS, 1758) are economically important (MINET & SCOBLE 1999; RAJAEI et al. 2010).

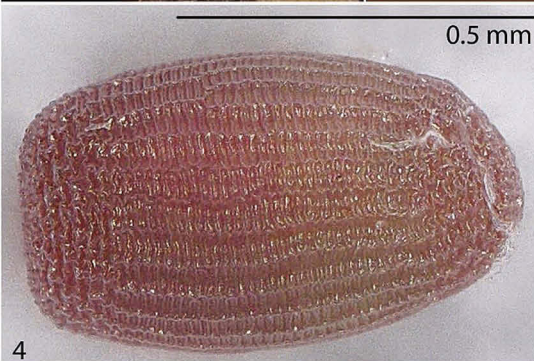
From Crete Island (Greece), several winter moths are known, e.g. *Erannis defoliaria* CLERCK, 1759, *Agriopis marginaria* FABRICIUS, 1776, *A. bajaria* DENIS & SCHIFFERMÜLLER, 1775 and *A. budashkini* KOSTJUK, 2009. Diagnostic characters of these species on the wing patterns and genitalia are presented by MÜLLER et al. (2019). During several expeditions since 2004, the first author (M.L.) collected numerous larvae of geometrid moths. From rearing of these larvae multiple geometrid species records resulted for Crete, including *Agriopis budashkini* KOSTJUK, 2009 (MÜLLER et al. 2019). Although this species seems to be not rare in Crete (depending on the distribution area of its food-plant) it remained undiscovered until recently (RUCKDESCHEL 2007; MÜLLER et al. 2019). The reason is possibly due to its flight time (mid of December until early February, see breeding experiments), when very few lepidopterists were visiting the type locality.

Here the variation of the wing pattern as well as the morphology of larva and the diet of this little-known species is presented.

Material and Methods (collecting data and localities)

Numerous larvae of geometrids (including larvae of *Agriopis budashkini*) were found in the following localities in western Crete (Greece):

- eastern part of Levka Ori Mts., between Kallikratis and Asfendos, altitude: 800 m. 12.-26.v.2004, and 12.-25.v.2005 (fig. 1).
- eastern part of Levka Ori Mts., between Petres und Goni, altitude: 700 m. 12.-25.v.2005.
- western part of Levka Ori Mts., Omalos, 2 km South of Omalos, altitude: 1150 m. 12.-25.v.2005.
- eastern part of Levka Ori Mts., Asfendos, altitude: 700 m, 5.-15.v.2012.



Figures 1–5. *Agriopsis budashkini*: Habitat and eggs.
 1. Habitat in the eastern part of Levka Ori Mts., between Kallikratis and Asfendos, altitude, 800 m;
 2. Freshly laid eggs are green; 3. Eggs turn to beige-brown to red-brown after 7 to 12 days;
 4–5. Morphology of eggs (4, lateral view; 5, view from micropyle area).

All these localities are open valleys covered with grassland. The small streambed in Omalos was dried-up. The moderately steep slopes were partially interstratified by large limestones. All habitats were strongly overgrazed by goats. In all habitats there were single trees and shrubs, predominantly of the following species: Cretan Maple (*Acer sempervirens*), Kermes Oak (*Quercus coccifera*), Evergreen Oak (*Quercus ilex*), Cretan Barberry (*Berberis cretica*) and Hawberry (*Crateagus* sp.). The lower branches of trees and other small shrubs were extremely overgrazed. The following smaller plants were noted: *Asphodelus tenuifolius*, *Arum* sp., *Dracunculus vulgaris*, *Poterium spinosum* and *Iris unguicularis*.

In the upper listed localities, numerous larvae of Geometridae were collected, most of them on *Acer sempervirens*, but also on *Crataegus* sp. and *Quercus coccifera*, by knocking and shaking the trees. The larvae were transferred to a small Polyethylene box (7.0×4.5×3.0 cm) and the data of the associated plant noted on each box. As the main food-plant (*Acer sempervirens*) of the target larvae is absent in Germany, different other plant species were offered to the larvae (see below). After the second or third moulting, the breeding was continued in a cage (12×12×25 cm), which was covered with a screen-printing mesh, with the food plant in a small jar of water. The larvae were kept and fed at room temperature (22°C) in order to complete their larval stages and to facilitate pupation.

Results

Food-plants

For confirmation of the favorite food-plant the following food-plants were offered to the larvae (Table 1):

Table 1. Feeding reactions of *Agriopis budashkini* KOSTJUK, 2009 to different offered plant species under rearing conditions (botanic nomenclature according to The Euro+Med Plant Base: <http://www.emplantbase.org/home.html>).

Family	Tree species	Result
Sapindaceae	<i>Acer pseudoplatanus</i>	Well accepted
Sapindaceae	<i>Acer monspessulanum</i>	Accepted, but not preferred
Sapindaceae	<i>Acer campestre</i>	Accepted, but not preferred
Fagaceae	<i>Quercus robur</i>	Well accepted
Fagaceae	<i>Quercus petraea</i>	Well accepted
Rosaceae	<i>Prunus spinosa</i>	Accepted, but not preferred

Preimaginal stages

Ovum (figs 4 & 5).

Elliptical, length about 0.7 mm, width about 0.4 mm. Ornamented by longitudinal ribs and multiple transverse micro-grooves (figs 4 & 5). Freshly laid eggs are blue-green (see fig. 2), becoming beige-brown to red-brown after 7 to 12 days (see figs 3-5). Two to five days before hatching the eggs turn to dark brown or black.

Larva (figs 6 – 13).

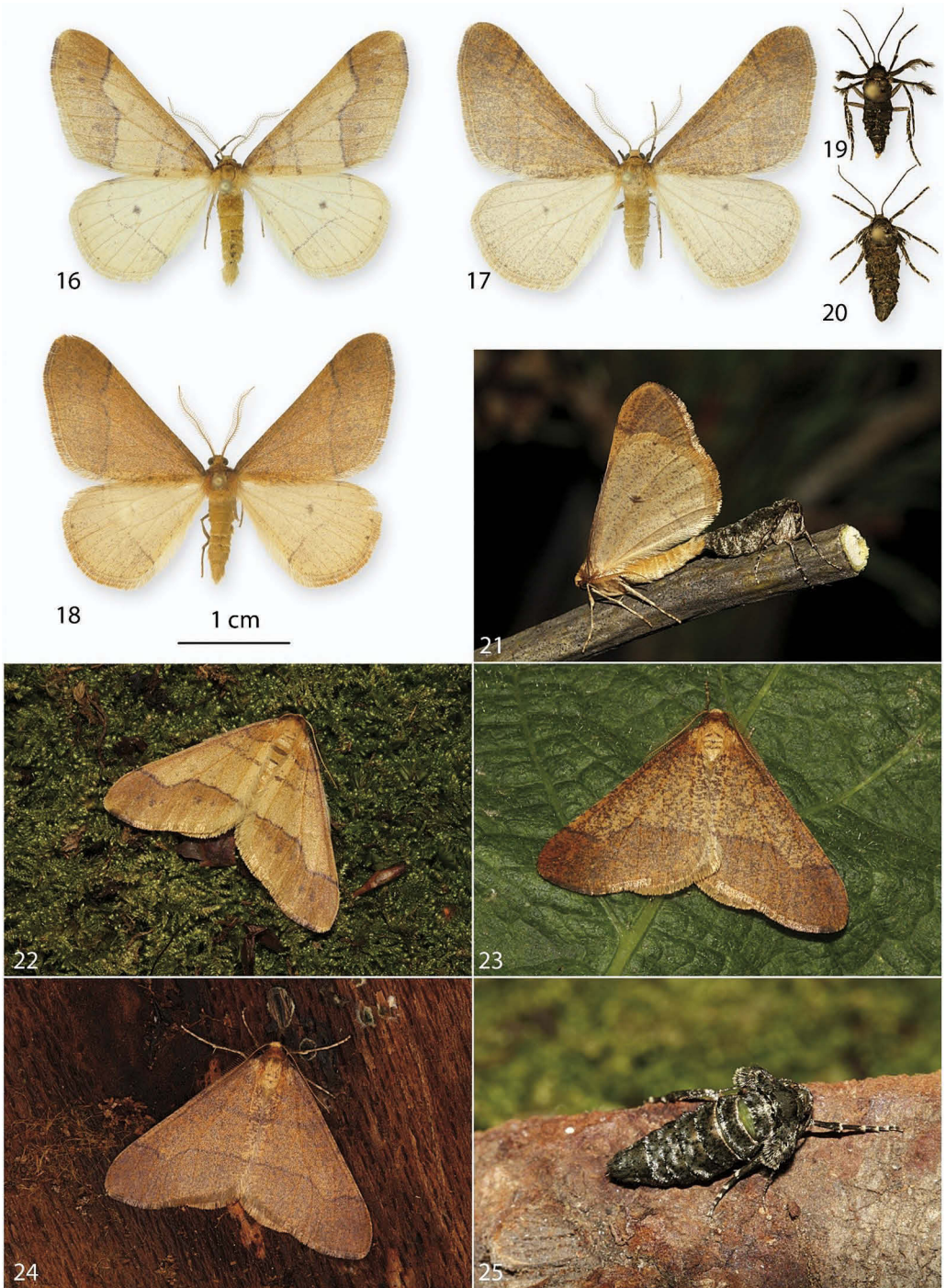
First instar (L1): Length about 1-2 mm. Head capsule light brown. Body with a broad yellow-brown dorsal band, a broad black-brown subdorsal band on each side, and a light brown lateral line on each side. Just after the start of feeding, the colour pattern fades and the whole body gets more or less monotonic grey-brown.

Second instar (L2): Length about 3-6 mm (fig. 6). Head light red-brown with fine, dark brown pattern. Body light yellow-brown with 4-7 fine, dark brown dorsal lines, a thin dark brown lateral line and a beige-yellow sub-lateral line.

Third instar (L3): Length about 7-14 mm (fig. 7). Head red-brown, with several tiny, dark brown lines. Body light yellow-brown, with 4-7 dark brown longitudinal dorsal lines, fine dark brown lateral line and a broad beige-yellow sub-lateral line.



Figures 6–11. Larva *Agriopsis budashkini*: 6. second instar larva (L2), 7. third instar larva (L3), 8. fourth instar larva (L4), 9–11. fifth instar larva (L5); **Figures 12–13.** Larva (L5): 12. *Agriopsis bajaria*, 13. *Agriopsis marginaria*; **Figures 14–15.** Pupa, *Agriopsis budashkini*: 14. pupa ♀, 15. pupa ♂. All specimens are from the second generation (F1) of the larvae collected from: Creta, eastern part of Levka Ori Mts., between Kallikratis and Asfendos, altitude: 800 m.



Figures 16–25. *Agriopis budashkini*: 16-18 & 22-24. ♂♂, variation of wing colour and pattern, 19-20 & 25. ♀♀ specimens, 21. Copulation. All specimens are from the second generation (F1) of the larvae collected from: Creta, eastern part of Levka Ori Mts., between Kallikratis and Asfendos, altitude: 800 m.

Fourth (L4, fig. 8) and fifth (L5, figs 9–11) instars: Length 15-25 mm and 25-34 mm, respectively. Head light brown with tiny, dark brown lines. Colour of body varies from yellow to medium brown (see figs 9–11), with 6-7 thin, dark brown to black lines, sometimes with tiny spots beside the dorsal lines; lateral lines usually yellow-beige.

L4 and L5 instars of *Agriopis budashkini* may be confused with those of dark-patterned of *A. aurantiaria*, however the latter species is not yet recorded in Crete. The larvae of other *Agriopis* species occurring in Crete, i.e. *Agriopis bajaran* and *A. marginaria*, are shown in figs 12 & 13.

Pupa (figs 14 & 15).

Under rearing conditions pre-pupation lasts approximately 10-13 days, and pupation takes place in sandy humus soil. The fully grown larva stops feeding and buries into the soil to a depth of approximately 4-7 cm. After pupation the pupa is yellow-green, gradually turning red-brown with a dark brown shadow and a dark green wing shaft. The male pupa is slightly longer and narrower (length 11-14 mm; width 3-3.5 mm) than the female (length 10-13 mm; width 4-4.5 mm). In captivity the imago emerges after 6 to 7 months.

Imago

Female specimens of *Agriopis budashkini* are brachypterous (figs 19–21 & 25) and the males show high variation in colour and pattern (see figs 16–18 & 22–24). Mating in captivity occurs in the early evening (see fig. 21).

Further breeding experiments:

While collecting the larvae of *Agriopis budashkini*, the larvae of the following geometrid species were collected on *Acer sempervirens*:

1. *Agropis bajaran* (DENIS & SCHIFFERMÜLLER, 1775)
2. *Agriopis marginaria* (FABRICIUS, 1776)
3. *Cyclophora ariadne* (REISSER, 1939).

Note: REISSER (1939) recorded "*Cosymbia ariadne*" on *Platanus orientalis* (Platanaceae).

The first author of this paper (M.L.) tried to feed the larvae of this species with *P. orientalis*, but the larvae rejected this plant. Additionally, he searched intensively for the larvae of *C. ariadne* on *P. orientalis*, but without success. Instead, several larvae were found on *Acer sempervirens* (natural food-plant) and later were reared on *Acer monspessulanum* and *Acer saccharinum*.

4. *Crocallis helenaria* RUCKDESCHEL, 2006
5. *Ennomos quercaria duercki* REISSER, 1958
6. *Epirrita terminassianae* WARDIKJAN, 1974
7. *Erannis defoliaria* CLERCK, 1759
8. *Peribatodes umbraria* (HÜBNER, 1809)

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Zusammenfassung

Raupen des bisher wenig bekannten Frostspanners *Agriopis budashkini* KOSTJUK, 2009 wurden auf der Insel Kreta gesammelt und erfolgreich gezüchtet. Im vorliegenden Artikel wird die Biologie dieser Art vorgestellt und von Fütterungsversuchen mit verschiedenen Pflanzenarten berichtet.

Freilandfunde der Raupen erfolgten an *Acer sempervirens*, erfolgreiche Zuchtverläufe waren auch an *Acer pseudoplatanus*, *Quercus robur* und *Quercus petraea* zu verzeichnen. Die Variabilität in Farbe und Zeichnung wird sowohl für die Raupen als auch für die Imagines abgebildet bzw. beschrieben. Einige weitere, im Raupenstadium an *Acer sempervirens* gesammelte Geometridenarten werden aufgelistet.

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