

Notes on the preimaginal stages and ecology of *Hadena drenowskii* (REBEL, 1930) in Southwest Bulgaria (Lepidoptera: Noctuidae)

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Abstract: In August 2017 eggs and young larvae of *Hadena drenowskii* (REBEL, 1930) have been observed on *Silene bupleuroides* L. (Caryophyllaceae) in SW-Bulgaria (Belassitsa Mountain, above Petrich town) in the field. Additionally, oviposition has been realized with females caught at light. The hitherto unknown preimaginal stages and the larval habitat are described and figured for the first time.

Bemerkungen zu den Präimaginalstadien und zur Ökologie von *Hadena drenowskii* (REBEL, 1930) in Bulgarien

Zusammenfassung: Im August 2017 wurden Eier und Jung-raupen von *Hadena drenowskii* (REBEL, 1930) im Freiland an *Silene bupleuroides* L. (Caryophyllaceae) in SW-Bulgarien (Belassitsa-Gebirge, Petrich) gefunden. Zusätzlich wurden am Licht angeflogene Weibchen zur Eiablage gebracht. Die bislang unbekannten Präimaginalstadien und das Larvalhabitat werden beschrieben und zum ersten Mal abgebildet.

Introduction

Hadena SCHRANK, 1802 is a species-rich genus with striking ecological adaptation to the Caryophyllaceae plant family. All so far known species feed as adults especially (or exclusively) on Caryophyllaceae flowers (mainly *Silene* L. or *Dianthus* L., according to the *Hadena* species) and are thus important pollinators of these plants. The eggs are deposited in most cases singly within the calyx of the flower (only rarely outside) and the young larva feeds within the ovary on the developing seeds, later often outside the ovary but still within the calyx and finally it becomes nocturnal and usually hides in the litter under the plants during daytime.

Despite this quite uniform life-cycle, there are various special adaptations, for example referring to habitat requirements or hostplant restrictions. *Hadena clara* (STAUDINGER, 1901) for example is correlated with only a few *Silene* species that grow on rocks, cliffs or in boulder fields at higher altitudes (usually above 1600 m). In the SW-Alps this species is restricted to *Silene cordifolia* ALL. and probably also *Silene vallesia* L. (WAGNER 2012). In the Balkans it develops on *Silene parnassica* BOISS. & SPRUNER (own observations in early July 2013 on Mount Tymfristos in Central Greece) while in S-Spain (Sierra Nevada) *Silene boryi* BOISS. seems to be the hostplant.

Other species can use a broad variety of hostplants in their habitat. For example *Hadena caesia* ([DENIS & SCHIFFERMÜLLER], 1775) uses nearly all *Silene* species and has even been recorded on *Saponaria* and *Gypsophila* (own observations).

But so far no species has been detected to oviposit on both *Dianthus* and *Silene*, despite larvae can switch occasionally in the field when both plant genera grow together (own observations with *Hadena compta* ([DENIS & SCHIFFERMÜLLER], 1775) in the Eastern Swabian Alb, S-Germany). *Dianthus* is the hostplant genus for *H. compta* and the species of the group of *Hadena luteocincta* (RAMBUR, 1834), while *Silene* (and occasionally *Saponaria* and *Gypsophila*) are the hostplants for the other European species (as far as known).

Hadena drenowskii (REBEL, 1930) is an East Mediterranean-Iranian (HACKER 1989, HACKER et al. 2002) species with four subspecies. Records are available from the Balkans, Asia Minor, S-Ukraine, the Levant (Mount Hermon, KRAVCHENKO et al. 2007), the Caucasus region, Iran and Turkmenistan. Nominotypical *Hadena drenowskii* (adult see Fig. 17) has been described from SW-Bulgaria (Alibotush mountain, nowadays Slavyanka mountain, Greek part known as Orvilos Oros; REBEL 1930) and its distribution is restricted to the Balkans (E-Serbia: BESHKOV 2015, Macedonia, Bulgaria, Greece, presumably also Albania).

The species is usually known from steppe-like slopes (usually pastures) in mountains between 1000 m and 2300 m, but is, e.g., in the S-Ukraine also found in lowland-steppes. Neither its hostplant nor the reproduction habitat nor its preimaginal stages have been known so far (e.g., BECK 2000).

In the course of the research on the European *Hadena* larvae the first author has tried to obtain the larvae in Greece (Mount Olympus, Mount Timfristos, Mount Falakro) and SW-Bulgaria (Southern Pirin, Belassitsa) in several years. These investigations involved collecting flowering *Silene* and *Dianthus* in several habitats, especially on rocks and dry nutrient-poor grasslands.

These samples resulted in species like *Hadena clara*, *H. vulcanica urumovi* (DRENOWSKI, 1931), *Hadena adriana* (SCHAWERDA, 1921) and *Hadena wehrlii* (DRAUDT, 1934), all very interesting and ecologically poorly known species (publication in preparation), but unfortunately not in *H. drenowskii*.

Thus a combined approach (light traps for ♀♀ and sampling of Caryophyllaceae) was selected, and a joint field trip to the Belassitsa Mountains in SW-Bulgaria together with the second author eventually brought the breakthrough.

Material and methods

The West-East Belassitsa (Greek: Kerkini) mountain ridge (highest peak: Radomir, 2029 m) is about 60 km long, but only a few (7–9) km wide, and the borders between Greece and Bulgaria in the East and between Macedonia and Greece in the West follow mainly the ridge. While the lower parts of this mountain ridge show large deciduous woodlands (above approx. 800 m especially beech, lower down dominated by oak and chestnut), the higher parts (above approx. 1700 m) are dominated by grassy vegetation and dwarf shrubs (especially *Juniperus* and *Vaccinium*). These parts trace back to ancient cutting of the woodlands for pastures and constitute the so-called pseudosubalpine zone. Nowadays this zone is no longer grazed. Thus very slow but steady reforestation is likely to occur in the bigger part of this zone.

A field trip to Belassitsa Mountain (between Kongur Hut and Kongur peak) was conducted in early August 2017 with light traps being used in the nights of 3./4. VIII. and 4./5. VIII. 2017). The light traps resulted in four ♀♀ of *Hadena drenowskii*.

The second author already knew the best sampling site on the northern slope of the mountain above Petrich between approx. 1700 and 1800 m due to earlier investigations. Thus the Caryophyllaceae of this confined area have been thoroughly studied and one species (*Silene bupleuroides*) proved to be the only *Silene* still flowering there. Except that species only some *Dianthus* and already dried *Silene vulgaris* occurred there. Therefore the flowers of *S. bupleuroides* were used for oviposition of the four captured ♀♀ and furthermore have been searched for eggs in the field. Because some 15 eggs could be found in the field, this plant has been finally also sampled (collecting of a plastic bag full of flowers and early seeds).

Only one out of the four ♀♀ oviposited (some 30 eggs, 20 of which in one single flower!). The eggs resulting from oviposition and the field eggs plus some 60 larvae out of the *Silene* sample have been reared separately with *Silene vulgaris* L. in Germany. Half of the larvae have been sent to an Austrian colleague.

Results and discussion

Rearing was simple up to the penultimate instar. Most larvae still reached the last instar, but they died prior to pupation. This was the same with the Austrian colleague. We do not know the reason, moreover as simultaneously reared larvae of *Hadena albimacula* (BORKHAUSEN, 1792) from the same *Silene* sample and with the same foodplant did not cause any problems. Most probably the different foodplant in combination with unfavourable microclimate was the crucial factor. The most important consequence from this is the fact that the pupa is still unknown. But as all *Hadena* pupae are quite uniform in their appearance (the only major difference is the thickness of the distal proboscis sheet) the *H. drenowskii* pupa is not expected to differ much from its congeners.

The larvae resulting from oviposition (14 reached the last instar) exactly looked the same as those found as eggs on *S. bupleuroides* (6 larvae in last instar) and those resulting from the sample (18 larvae in the last instar in the rearing of the first author). The only other species found in the sample was *H. albimacula*, but in a quite low density with only 20 larvae.

Ovum

The ova (Figs. 1–3) of this species are slightly larger than those of related species like *H. albimacula*. They are white and of similar oval shape as the eggs of the congeners. In the field the egg is laid about 8 mm deep within the flower and is stuck on the stamina or the inner side of the basal parts of the petals. This corresponds very well with the length of the ovipositor. After a few days the egg changed to a light brownish creamy colour and hatched after 7–8 days. Prior to hatching the black head capsule shines through (Fig. 3).

The eggs are usually laid singly. But in two cases we found two eggs in one flower, but the different colour showed that these originated from different oviposition time, respectively different ♀♀. As this occurred quite rarely the ♀♀ must usually be capable of recognizing an already occupied flower. Deviant from this one still quite fresh ♀ laid some 20 eggs into a single flower in captivity, probably because of the constricted room with only a few flowers.

Larva

In the first instar, the larva (Fig. 4) is yellow with black head, black prothoracal and anal shields.

In the second instar (Fig. 6) the whitish dorsal and subdorsal lines are well visible and the head and shields are more brownish.

In the third instar the larva is lighter or darker creamy to brownish (Figs. 7–10) and the white dorsal line is usually widened in the rear part of the segment and usually accompanied by darker elements. The head is light brown with dark setal spots.

The penultimate (Fig. 11) and the last (Figs. 12–16) instars are very similar. The larva shows a more or less creamy basic colour with extended brownish (sometimes even yellowish to reddish brown), greyish or/and blackish elements. The white dorsal line is usually recognizable, but quite weak especially in the central zones of the segments, better in the intersegmental areas. This line is still accompanied by darker elements which are well developed and most often blackish in the intersegmental zone (they build up a more or less distinct X-shape). The intersegmental skin itself is very light and contrasty. The *Hadena*-typical chevrons are quite camouflaged and usually hardly visible. Due to the X-shape and the darker joining parts of the X the dark dorsal elements form indistinct rhombs.



Plate 1, Figs. 1–15: *Haden drenowskii*, preimaginal instars. — **Figs. 1–3:** Ova. **Fig. 1:** Field egg in *S. bupleuroides*, flower opened. **Fig. 2:** Eggs laid in captivity. **Fig. 3:** The same eggs prior to hatching. — **Figs. 4–16:** Larval instars. **Fig. 4:** Larva in first instar. **Fig. 5:** Borehole into the seed ovary and droppings of a larva in the first instar. **Fig. 6:** Larva in second instar. **Fig. 7:** Larva in third instar, dark form. **Fig. 8:** Larva in third instar, light form. **Fig. 9:** Larva in third instar, light form. **Fig. 10:** Larva in third instar, normal form. **Fig. 11:** Larva in penultimate instar. **Figs. 12–15:** Larva in last instar.

The pinacula are white with small black bristle point. The stigmata are light white to creamy with narrow black edges. The head (Fig. 16) is light brown with darker reticulate elements. Characteristic and present in all larvae is the greater extent of light colour at the rear end of the larva. This is caused by a large extension of the light colour of the intersegmental skin. This is a good discrimination character for similar larvae of other species. The most similar species are *H. caesia* (mostly with reddish brown head, different details), *H. vulcanica* and the *H. luteocincta* group. Judging from the larva we think that *H. drenowskii* is closest to *H. vulcanica* (group?). The latter is significantly smaller but otherwise very similar. HACKER et al. (2002) hint that the ♂ genitalia of both species are similar, too.

Hostplant and larval habitat

The only so far known hostplant in the wild is *Silene bupleuroides*. This is a more or less densely caespitose, perennial species with thickened rootstock, lanceolate to linear leaves, stems up to 40–80 cm height and large, creamy to pink flowers with 20–30 mm long calyx (e.g., STRID & TAN 1997).

The first author already sampled all available Caryophyllaceae in late July and in late August 2015 on Belassitsa Mountain between Kongur Hut and the rocks near Kongur Mount, especially *Dianthus minutiflorus* BORN. (a close relative of *D. integer* Vis.), *Dianthus* sp. (red flowers), *Silene saxifraga* L., *S. bupleuroides* and *S. vulgaris*.

S. bupleuroides has only been sampled in July 2015. The first author already had sampled this species on Mount

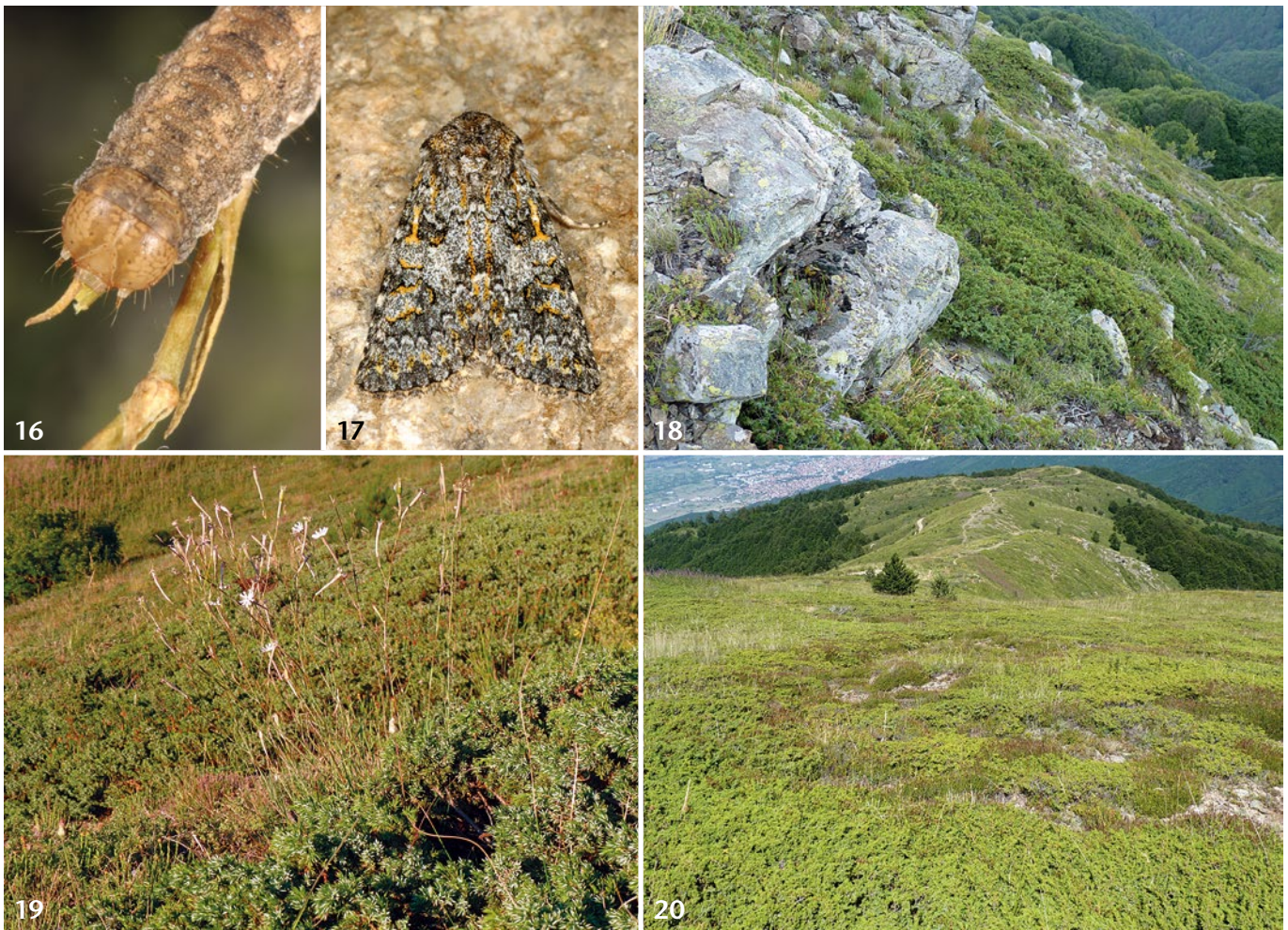


Plate 2, Fig. 16: Larva in last instar. — **Fig. 17:** Female which laid eggs in captivity. — **Fig. 18–20:** Larval habitat in the Belassitsa Mountain between 1700 and 1800 m. **Fig. 18:** *S. bupleuroides* prefers spots with rocks or open soil. **Fig. 19:** *S. bupleuroides* can persist for some time within creeping juniper, but obviously cannot reproduce there. **Fig. 20:** Overview of the larval habitat above the *Fagus* woodland. Petrich town in the background. — All photos by the first author. *Hadena drenowskii*, larvae after oviposition in captivity, ♀ on IV. VIII. 2017, Belassitsa Mountain, SW-Bulgaria.

Olympus (Greece) in July 2010 and this sample resulted only in very many *H. albimacula* and because this happened also with the sample from Belassitsa in July 2015, it was thought that it was the wrong plant species. But in fact it was probably either too early (July), or the masses of *H. albimacula* masked *H. drenowskii*.

Another important psychological factor was that the first author compared some known sites of *H. drenowskii* (e.g. Mount Olympus, Timfristos, Mount Falakro, all Greece and Southern Pirin, Belassitsa in SW-Bulgaria) and came to the conclusion that all possessed steep rocks. Thus the first author concentrated on those rocks and unfortunately missed *H. drenowskii*. In Belassitsa, *Hadena confusa* (HUFNAGEL, 1766) (*S. vulgaris*), *H. albimacula* (all *Silene*), *H. magnolii* (BOISDUVAL, 1829), *H. caesia* (both *S. saxifraga* on rocks), *Hadena tephroleuca* (BOISDUVAL, 1833) (adults recorded by the second author) and *H. compta* (all *Dianthus* species) could be found.

Thanks to the light trap results of the second author the area for sampling could be distinctly constricted so that *S. bupleuroides* was the only sensible alternative.

Silene bupleuroides occurs in several subspecies (Greece and some adjacent parts of the S-Balkans: mostly ssp.

staticifolia, further North and East, e.g. Crimea, ssp. *bupleuroides*, TUTIN et al. 1993) from the lowlands (e.g. E-Europe, Crimea) to the higher mountains (2100 m in Europe, 2500 m in Turkey). It is a species of steppe grasslands with a portion of open soil. It sometimes also occurs in rocky embankments or rocky pastures, but is not a true rock species because it needs deeper soil. In the Belassitsa Mountains it is a quite local species, but it is sociable at its local spots. In Greece and SW-Bulgaria the plant (ssp. *staticifolia*) is usually restricted to heights between 1000 and 2100 m. But North of Greece there are subspecies also in lower altitudes.

The sampled habitat constitutes a weak, sunny ridge with partly open, stony soil (Figs. 18–20). In comparison with adjacent areas without *S. bupleuroides* the ridge is less overgrown with grasses and juniper and shows more bare ground. Though *S. bupleuroides* can be quite long-lived and persists in densely grown places, its reproduction is dependent on spots with open ground.

Thus it is probable that the abandonment of grazing on the Belassitsa Mountains will decrease the plant and the moth in the long term. The most important problem is the creeping juniper. But in the long term also the woodland is expected to expand upward.

The total range of *S. bupleuroides* includes the Balkans with S-Serbia, Bulgaria, Macedonia, Albania and Greece, SE Central Europe, Romania, Turkey, the Crimea, South Russia, the Caucasus region with Armenia and eastward to Iran and Central Asia.

Thus the distribution of *H. drenowskii* and *S. bupleuroides* coincide to a high extent. The area of the plant is a bit larger and covers some areas where the moth is not found (e.g. in E-Europe).

Even the local distribution seems to be congruent. The first author recorded *S. bupleuroides* (but did usually not sample it due to the mentioned reasons) on Mount Falakro, Olympus, Timfristos and in Southern Pirin. Together with the negative result of intense sampling of other *Silene* species especially in rocky habitats, it is very probable that *S. bupleuroides* is the most important, in many sites possibly also the only hostplant for *H. drenowskii*.

Whether other related *Silene* species (e.g. *Silene sclerophylla* CHOWDH. or *S. caramanica* BOISS. & HELDR., see YILDIZ & ÇIRPICI 2013 for Turkey) are also used (e.g. in some parts of the range) remains to be studied in the field. Already now it is quite certain that *H. drenowskii* has a much narrower choice of oviposition plants than many related species like *H. caesia*. It is comparable with *H. adriana* which seems to be restricted to *Silene paradoxa* L. at least in northern Greece or *H. wehrlii* which is restricted to *Dianthus cruentus* GRISEB. in the same area (WAGNER, in preparation).

Life cycle

Hadena drenowskii is perfectly adapted to its hostplant *S. bupleuroides*. This species usually (exception: ssp. *bupleuroides* already starting in June) flowers quite late in July and August exactly within the flight time of the moth and provides flowers for at least four weeks, even in quite dry and hot conditions.

The flowers and capsules are very large and thus offer enough food for the large species. According to the site (altitude and latitude, exposition) oviposition takes place between mid-July and mid-August.

Thus the larvae are fully-grown in September or even early October. Taking into account the altitude, the late flight time and the hibernation as pupa, it is clear that the species can occur only in more Southern regions and there in so-called xeromontane habitats (sunny, well-drained and comparatively warm) which allow full development to pupa until the weather conditions deteriorate. In some regions (e.g. Crimea) both the plant and the moth can also occur in lower altitudes.

The eggs are deposited singly supposedly when or after feeding on the fresh flowers with the very long proboscis and the young larva buries into the seed ovary where

the first instars live. The hole through which the larvae buried in is visible as dark spot and usually also has some droppings beneath (Fig. 5). The older larvae (at least penultimate and last instar, probably already many antepenultimate instar larvae) hide at the ground during daytime and supposedly climb the plants to feed on the capsules during the night.

In late August 2015 the first author crossed the *H. drenowskii* habitat (which he was not aware of at this time) when ascending to the main ridge with the target *S. saxifraga* on the rocks. At this occasion he recorded many eroded capsules of *S. bupleuroides* and shortly tried to find larvae below the plants in the litter, expecting *H. albimacula*. He recorded two half-grown larvae which – because of their colouration – unfortunately had been considered *H. caesia*. As in fact not a single *H. caesia* had been found in *S. bupleuroides* in 2017 (but very many in *S. saxifraga*) the first author believes that these two larvae had been *H. drenowskii*, the first but unrecognized records.

Pupation should occur in the soil in a relatively loose cocoon as it is the case with all known congeners.

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