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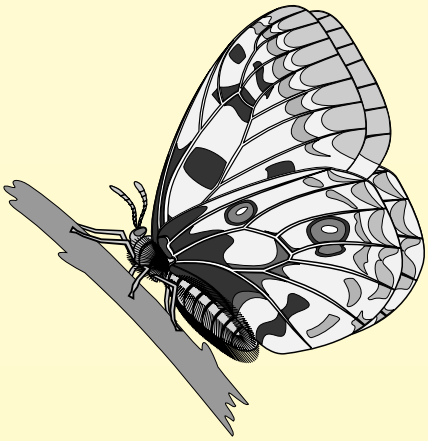

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Oviposition of the Niobe fritillary (*Argynnis niobe* (Linnaeus, 1758)) at sub-mountain conditions in the Czech Carpathians (Lepidoptera, Nymphalidae)

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Abstract: The Niobe fritillary (*Argynnis niobe*) is a critically endangered butterfly in the Czech Republic, and most of Europe. Despite this high conservation concern, its life history remains poorly known from European mainland. We report here oviposition patterns of a submountain population inhabiting the Javorníky and Vsetínské Vrchy Mts., Czech (= Western) Carpathians. The egg laying habitats were traditional non-intensive pastures with southern exposition, rather lower herbaceous cover (50–90 %), short sward (ca. 10 cm), and heterogeneous surfaces with much bare ground and rocks. Females chose bare ground micro-sites and laid eggs to dry leaves litter often closely to the locally used host plant *Viola odorata*.

Eiablageverhalten von *Argynnis niobe* (Linnaeus, 1758) unter submontanen Bedingungen in den tschechischen Karpathen (Lepidoptera, Nymphalidae)

Zusammenfassung: *Argynnis niobe* (Linnaeus, 1758) ist eine kritisch gefährdete Art in der Tschechischen Republik und in weiten Teilen Europas. Trotz dieser hohen Gefährdungslage ist die Biologie der Art in Europa weitgehend ungeklärt. Wir berichten hier über das Eiablageverhalten einer submontanen Population aus den Javorníky- und Vsetínské-Vrchy-Bergen der tschechischen (= westlichen) Karpathen. Die Eiablagebiotope sind traditionell bewirtschaftete, extensive Streuobstwiesen in südlicher Exposition, mit eher niedriger Krautschicht (Bedeckungsgrad ca. 50–90 %), kurzrasig (ca. 10 cm), und verschiedengestaltigem Untergrund mit viel unwachsener Erde und Steinen. Die Weibchen suchen pflanzenfreie Mikrohabitate und legen die Eier an trockene Pflanzenteile, oft nahe zu der örtlich genutzten Raupenfutterpflanze *Viola odorata* (die zum Eiablagezeitpunkt weitgehend vertrocknet ist).

Introduction

The Niobe fritillary (*Argynnis niobe* (Linnaeus, 1758)) is a Palaearctic butterfly, still distributed across entire Europe (Kudrna 2002). Despite its wide distribution range, the populations in most European countries are rapidly declining (Pretscher 1998, Van Swaay & Warren 1999, Beneš et al. 2002, Bos et al. 2006). In present, the butterfly is seriously threatened in Germany (Settele et al. 1999), e.g. in Saxony (Reinhardt et al. 2007), and is critically endangered in the Czech Republic (Beneš et al. 2002, Farkač et al. 2005). It was historically widely distributed in the country, but has dramatically declined due to habitat loss, fragmentation and isolation, caused by the intensification of agriculture and changes in land holding patterns. It almost completely disappeared from its former strongholds, the mountain ranges in western part of the state. The strongest and apparently viable (meta-)population is recently restricted to remote valleys of Czech (= Western) Carpathians in Moravia. A few other weak populations remain scattered in two other regions only, the foothills of Šumava Mts. (southern Bohemia) and Orlické Mts. (a part of Eastern Sudetans, northeastern Bohemia).

Although oviposition patterns and larval requirements determine the quality and suitability butterfly of habitats (Fartmann & Hermann 2006, Van Swaay et al. 2006), only few descriptions of oviposition and larval habitat exist for *A. niobe*. Its larvae feed on violets (*Viola* spp.) in the spring, while adult flight lasts from the last quarter of June into early August. Hafner (2005) observed laying eggs individually to dry litter on pastures, larvae were found consuming *Viola canina* leaves. Salz & Fartmann (in press) studied the oviposition behavior and larval requirements within a strong *A. niobe* metapopulation inhabiting North Sea sand dunes. They detected a preference of egg-laying females for sparse vegetation (with mosses and lichens prevailing over grasses), short turf, and abundant supply of the local host plant, *Viola canina*. They argued that due to rarity of appropriate microhabitat conditions, even at the sand dunes, *A. niobe* populations require exceptionally large habitat areas; a conjecture earlier reached by Bink (1992). The detailed results of Salz & Fartmann (in press) (303 egg and 89 larval habitats records), however, originated from sandy habitats, where the conditions can differ from sub-mountain pastures. Requirements of *A. niobe* populations inhabiting the latter habitat type remain poorly known, although sub-mountain grasslands represent a principal habitat of the species in many parts of Europe (e.g. SBN 1987, Ebert & Rennwald 1991, Settele et al. 1999, Beneš et al. 2002).

Here, we report observations of *A. niobe* oviposition behaviour in warm sub-mountain pastures of Western Carpathians, eastern Czech Republic. They originated from remote valleys of the Vsetínské Vrchy and Javorníky Mts. (maximum altitudes 1024 and 1071 m, respectively), catchment of the Vsetínská Bečva River (around Halenkov village, 49°19' N, 18°9' E). The climate is mildly warm, with the mean annual precipitation 782 mm, and the mean annual temperature 7.0°C (Pavelka & Trezner 2001). The landscape consists of diverse mosaic

of woodlands, orchards, meadows and pastures. Owing to scattered land holding pattern, many of the meadows and pastures are still used in traditional ways, ensuring a high diversity of land use approaches. The richest butterfly habitats are traditionally used non-intensive sheep pastures with characteristic vegetation, classified as *Cynosurion* (*Anthoxantho odorati-Agrostietum tenuis* Silinger 1933) association, with smaller patches of *Violion caninae* and *Bromion erecti* (*sensu* Chytrý 2007). The locally occurring violets include *Viola hirta* (most common), *V. odorata* and *V. canina*, *V. riviniana* (at drier sites) and *V. reichenbachiana* (in taller-sward woodland mantles) (Spitzer & Tkačíková 2005).

Results

During surveys in the Vsetínské Vrchy and Javorníky Mts. valleys, we observed 6 ovipositing females at 6 sites. The information on vegetation cover was taken visually from a circle (1 m diameter) around the centres of egg placement points.

(1) Halenkov-Dinotice

49°21'6" N, 18°6'47" E; alt. 525 m; 20. vii. 2008; 13:30 h; 23°C, half-overcast, a moderately windy day.

Habitat: a verge of unpaved road bordering an abandoned pasture (ca. 15 years); vegetation cover ca. 70%, sward height 10 cm; steep SW slope.

Oviposition: 3 instances, all directly to patches of bare ground (2 eggs to a patch 30 × 10 cm, 1 to a patch 10 × 5 cm), bordered by *Festuca* tufts, dried leaves and litter.

(2) Halenkov-Lušová

49°21'7" N, 18°9'20" E; alt. 535 m; 16. vii. 2008; 15:30 h; 28°C, sunny, weak wind.

Habitat: a pasture grazed periodically for the entire season, with sheep present 1–2 days each week; sward rather homogenous, with a high cover of *Thymus pulegioides*; total herb cover 90% height 10 cm; bare ground rare; steep SW slope.

Oviposition: 2 eggs deposited during 7 minutes; the substrate was bare ground beneath drying leaves close to *Viola* sp. plants.

(3) Halenkov-Lušová

49°21'35" N, 18°9'19" E; alt. 545 m; 17. vii. 2008; 13:30 h; 29°C, sunny, weak wind.

Habitat: a non-intensive sheep pasture grazed for entire season; herbaceous cover 70%, the sward extremely short (7 cm); flowering plants almost missing, except for dominant *Thymus pulegioides;* surface of locality heterogeneous; common microsites with bare ground and small rocks; steep S slope.

Oviposition: 1 egg to a bare ground gap.

(4) Huslenky-Losový

49°18'57" N, 18°5'40" E; alt. 505 m; 15. vii. 2008; 14:00 h; 32°C, half-overcast, no wind, advancing storm.

Habitat: non-intensive sheep pasture grazed only in spring, vegetation cover 50%, height 15 cm, a high proportion of flowering forbs (*Centaurea* spp., *Leontodon* spp., orchids); surface is rocky, with much bare ground (Fig. 1); SW slope.

Oviposition: 5 separate events during ca. 15 minutes into a sparse sward with much bare ground beneath leaves of *Viola odorata* (det. J. Danihelka 2008); eggs placed two times to small crevices between grass tufts (ca. 1 dm^2), three times to sparse grass tufts (average height 15 cm) (Fig. 2).

(5) Karolinka-Kobylská

49°21'20" N, 18°13'13" E; alt. 575 m; 28. vii. 2008; 15:30 h; 27°C, clear, moderately windy.

Habitat: a border between abandoned, shrub-encroached pasture (ca. 5 years) and regularly cut hay meadow; vegetation cover 60%, height 20 cm; steep SE slope.

Oviposition: 1 egg deposited to a bare ground gap (5 × 8 cm); closely to a *Viola* plant.

(6) Nový Hrozenkov-Březitá

49°18'47" N, 18°11'7" E; alt. 510 m; 29. vii. 2008; 14:30 h; 28°C, sunny, no wind.

Habitat: non-intensive sheep pasture with vegetation dominated by *Festuca* spp. and *Poa* spp.; SW slope.

Oviposition: 6 instances; the substrate were edges of small bare ground gaps; beneath leaves and among stems of *Festuca ovina* and dry remnants of *Viola* sp.

Behavior: laying eggs interrupted by very short overflights (not more than 1 m).

Discussion and conclusion

Based on observation of 6 ovipositing ♀♀ and overall character of detected *A. niobe* localities, we can conclude that *A. niobe* larval development occurs on traditionally used sub-mountain pastures, typically on steep and sun-exposed slopes. The larvae apparently utilize patches with the warmest microclimates within this otherwise rather cool mountain region (see the altitude range of the sites). They frequently bask (Salz & Fartmann in press), which is facilitated by their darkly brown coloration (cf. Koch 1954). Pupae are also darkly coloured (Schwarz 1949), which may speed up their development. Larval sites contain sparse (50–90%) herbaceous cover and short (ca. 10 cm) sward. Eggs are placed either directly to loose grass tufts, or to small bare ground gaps, created either by livestock trampling (hoofprints, sheep trails), or by small landslides and ground rifts, which are characteristic features of steep slopes on the rather mobile flysh bedrock. They are always placed to dry litter, often closely to the larval host plant.

Fig. 1: An overall view of the *A. niobe* locality in Vsetínské Vrchy Mts. (Huslenky-Losový, as in Fig. 2). The front part is flower-rich hay meadow, middle part is the sheep pasture where oviposition was observed, and the back part is hay meadow again. Note that the hay meadows are mown asynchronously. **Fig. 2:** Detailed photograph of *A. niobe* oviposition substrate (Huslenky-Losový).

The overall pattern does not differ from that described from other parts of Europe by Hafner (2005) and Salz & Fartmann (in press). The authors also observed that eggs were frequently placed beneath plants growing at edges of bare ground gaps. They assumed that while the bare ground ensures a warm microclimate, the plant litter protects the overwintering eggs and prevents dessication in warmer periods of the year. The fact that the eggs were not always placed closely to a violet plant suggests that the young larvae actively search for their host plants, similarly to a related species, *Argynnis paphia* (Linnaeus, 1758) (e.g. Ebert & Rennwald 1991). Another related species, *A. adippe* (Denis & Schiffermüller, 1775), utilizes warm open-vegetation patches in British woodlands and brackens (Warren 1995), whereas still another, *A. aglaja* (Linnaeus, 1758), does not appear to prefer host plants in particular microtopography conditions (Zimmermann et al. in press). These four *Argynnis* species co-occur within our study region, but seem to differ in preference for grassland successional stages (*A. niobe:* shortly grazed pastures; *A. aglaja:* taller mown meadows; *A. adippe:* abandoned pastures and scrub; *A. paphia:* woodland edges; cf. Spitzer et al. 2009).

We only once identified the host violet to species; in other instances, the plants were already too deteriorated. This one case was violet-flowered *V. odorata*. The populations studied by Salz & Fartmann (in press) and Hafner (2005) also feed on a violet-flowering species, *V. canina*, whereas the lightly-flowered *V. tricolor* seemed to be avoided (Salz & Fartmann in press).

Typical for the Carpathian sub-mountain landscape is a high heterogeneity of habitat conditions, both among individual grassland allotments (depending on slope, inclination, livestock density, etc.), and within single pastures. The pastures may or may not contain landslides exposing the bedrock, and my or may not be surrounded by stony walls and heaps, created by gradual removal of stones from the grasslands during centuries of traditional land use. As nectar can be in shortage at the sheep pastures, adult butterflies apparently depend on existence of rich nectar sources (e.g., *Cirsium* spp., *Centaurea jacea* or *Origanum vulgare*), at sites poorly accessible for livestock (e.g., steep slopes).

A. niobe often accompanies other specialized insects of non-intensive sub-mountain rangeland. The region discussed here represents the Czech Republic stronghold for the critically endangered butterfly *Phengaris* (= *Maculinea*) *arion* (Linnaeus, 1758), which exhibits similar habitat preferences (Spitzer et al. 2009). Other nationally endangered species include the butterflies *Melitaea cinxia* (Linnaeus, 1758) and *Spialia sertorius* (Hoffmansegg, 1804) (the latter depending on open ground patches); the moths *Zygaena brizae* (Esper, 1800), *Jordanita notata* (Zeller, 1847) and *Lemonia taraxaci* (Denis &

Schiffermüller, 1775); or the grasshopper *Psophus stridulus* (Linnaeus, 1758) (Spitzer 2007, Spitzer et al. 2009).

Long-term conservation of *A. niobe,* and all the accompanying species, depends on the continuation of the traditional small-scale management practices, including both grazing of small flocks of sheep, combined with hay making elsewhere nearby. Sheep grazing is necessary, as it is the only management method supplying the larval habitats in a long term. It cannot be replaced by hay-making, because mowing turns the short and patchily open turf to long-bladed and close one, completely unsuitable for *A. niobe* and the accompanying endangered insects.

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