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**NOTA**

**LEPIDOPTEROLOGICA**

A journal devoted to the study of Lepidoptera

Published by Societas Europaea Lepidopterologica (SEL)



**Vol. 24 No. 1/2 2001**

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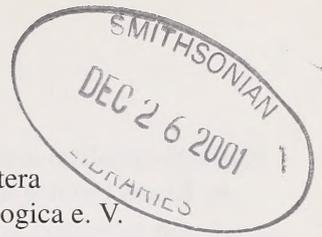
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# Nota lepidopterologica

A journal devoted to the study of Lepidoptera  
Published by the Societas Europaea Lepidopterologica e. V.



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Halle / Saale, 10.08.2001

ISSN 0342-7536

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## Editorial

In September 2001 SEL celebrates the 25<sup>th</sup> anniversary of its inaugural foundation, which took place at the Zoological Research Institute and Museum Alexander Koenig in Bonn (Germany). With the current issue we now also present the first pages of the 24<sup>th</sup> volume of SEL's scientific journal, *Nota lepidopterologica*, to our members and readers. This issue reflects the remarkable achievements of the past 25 years. *Nota* has become established as the only scientific periodical specifically devoted to the study of Lepidoptera that really has a Pan-European membership base and audience. Other societies and their journals have largely retained a narrower regional focus. A particular characteristic of *Nota*, moreover, reflects the special blend of SEL membership. From its very beginning SEL has aimed at bringing together expertise from amateur and professional lepidopterists alike, and the lively mixture of papers being published in *Nota* gives testimony that this basic philosophy is still valid and fruitful. Thanks to the services and efforts provided by the preceding editors, Otakar Kudrna (vol. 1/1977-3/1980), Emmanuel Bros de Puechredon (4/1981-13/1990, with suppl. 1/1989), Steven E. Whitebread (14/1991-18/1995-96, with suppl. 2/1991, 3+4/1992, 5/1994), and Alain Olivier (19/1996-23/2000), as well as by all others involved in the daily work required to produce a journal on schedule, *Nota* today is now well appreciated in the community of lepidopterists worldwide, but is also recognized at a much broader scale. This is exemplified by the regular coverage of *Nota* in global information services like the Zoological Record, BIOSIS, or else.

On the occasion of the 12<sup>th</sup> congress of lepidopterology held at Bialowieza (Poland) in 2000, SEL council and general assembly elected one of us (KF) as new Editor-in-Chief for *Nota*, while MN was nominated as Assistant Editor. A rearrangement of editorship was necessary since our predecessor, Alain Olivier, had indicated to resign from editorship with the completion of *Nota*'s vol. 23. We herewith heartily express our deep gratitude to A. Olivier for all his achievements during five years of service. By taking over our new responsibilities we also felt the time has come for a few changes and refinements in editorial policy of *Nota*. First of all, division of editorial tasks has turned out to be helpful to facilitate the regular production of *Nota* at the high standards our readership is expecting, while at the same time editorial work must be done in the editors' limited spare time. We have agreed, after intensive consultations with SEL council, that the Editor-in-Chief is mainly concerned with the handling of manuscripts from submission through review up to final acceptance for publication, while the Assistant Editor is largely responsible for all issues relevant to the printing and publication process.

For all authors of papers this means that manuscripts should primarily be submitted to the Editor-in-Chief who then sends out all papers for review by at least two independent experts. After receiving their statements the editor will decide whether a paper will be accepted for publication in *Nota* and whether a revision of the manuscript will be required. Once a paper is formally accepted for publication, the manuscript is passed to the Assistant Editor who arranges formatting and preparation for print, communi-

cates with the printers, passes correction proofs to authors, and finally gives the printing order. During all these stages the editors receive assistance from members of the Editorial Board (presently: Dr. Enrique García-Barros, Dr. Peter Huemer, Ole Karsholt, Dr. Yuri P. Nekrutenko, Dr. Erik van Nieukerken, Dr. Alexander Pelzer) who provide reviews of manuscripts, help with formatting of papers, or write book reviews or other supplementary material for publication in *Nota*. Moreover, manuscripts are frequently sent to reviewers outside the board to maintain high standards in the quality of accepted papers. We deeply thank all colleagues who have so far spent time and efforts for the service they have done to us and, thereby, to SEL membership at large.

Secondly, as you will immediately notice with the issue you just hold in your hands, we have polished the appearance of *Nota* in its printed form. While retaining the size of the journal, we have developed a new page layout which more effectively uses the printing space available. This new layout allows about 35% more information to be publicized on the same amount of paper as compared to the previous volumes – an important progress in times of steadily rising costs for printing and postage of *Nota*.

Thirdly, we have compiled a new edition of the instructions for authors. These are published at the end of this issue as well as on the SEL homepage (<http://www.zmuc.dk/EntoWeb/SEL/SEL.htm>) in full, and may also be obtained from the editors upon request. Important new aspects in these instructions are concerned with modified citations of references as well as with the opportunity, in our era of electronic communication and information processing, to submit papers in electronic form. Provided that authors strictly keep to these instructions (in particular with regard to file formats), electronic processing of manuscripts from submission onwards does not only speed up the process of handling a manuscript, but also spares a lot of mailing costs since materials can be sent cost-effectively via e-mail to reviewers as well as between the editors. The future may also see the world wide web being more explicitly used for publication purposes. We firmly believe that printed publications are essential in science, since of all currently used media only printed journals and books have the durability of centuries required to ensure that current knowledge will be held available for future generations. Nevertheless, given the financial constraints any non-profit society like SEL is permanently facing, electronic publication of supplementary material (such as raw data lists, additional figures, colour versions of illustrations that cannot be printed in colour for reasons of costs) on the SEL homepage may become an attractive opportunity. We are open to any requests and suggestions from our membership and readers.

Finally, concerning the contents of *Nota*, we would like to note that this always depends on the fruitful interplay between contributing authors and editors. In line with the by-laws of SEL and the commission of SEL council *Nota* will continue to be the journal for SEL members to promote all aspects of the serious study of Lepidoptera. As a European society we seek for contributions which are not only relevant at small regional scales. Moreover, each journal issue should preferably cover a range of topics and taxonomic groups, so as to provide material of interest to as large a fraction of members as possible. Therefore, lengthy type catalogues or lists of sampled specimens without further evaluation of their significance to the readership will usually no longer be published in *Nota*. On the other hand, *Short Communications* will be introduced as

a regular means of publicizing new findings of European-wide interest, be this important extensions of the documented range of species, remarkable new hostplant records, rearing reports, or other relevant material.

Editors may only be able to edit what they receive as submitted manuscripts. We hereby invite all our members and readers, amateurs and professionals alike, to submit their contributions for publication in *Nota*. Papers on 'Microlepidoptera', from eastern European countries or about topics thus far underrepresented in our journal (e.g. conservation and ecology) are most welcome, as are contributions to any other topic in the study of Lepidoptera. *Nota* also continues to publish papers in all three official SEL languages (French and German apart from English). Yet, readers complaining about an apparent lack of contributions on their preferred topic, or in their preferred language, are kindly asked whether they would be able to actively improve any imbalance *Nota* admittedly still shows by just compiling their observations in manuscript form. We are looking forward to a fruitful cooperation and correspondence, and we hope our efforts in further improving appearance, layout and quality of *Nota* may stimulate a larger fraction of our readership to contribute to our joint goal: the advancement of the study of Lepidoptera.

*Konrad Fiedler (Bayreuth) and Matthias Nuß (Dresden)*



## Revision of the *Brachodes pumila* (Ochsenheimer, 1808) species-group (Sesioidea: Brachodidae)

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**Summary.** Within the genus *Brachodes*, the *B. pumila* (Ochsenheimer, 1808) species-group is characterised by the antenna of the males (each segment with a single tooth-like processus) and the yellow-orange or white markings of the wings of the females. *Brachodes pumila* (Ochsenheimer, 1808) and *B. candefactus* (Lederer, 1858) are redescribed in detail; *B. diacona* (Lederer, 1858) **syn. n.** is synonymized with the latter species. Two new species, *Brachodes buxeus* **sp. n.** and *B. anatolicus* **sp. n.**, are described from Turkey. The species are compared with *Brachodes appendiculatus* (Esper, 1783), *B. compar* (Staudinger, 1879) **stat. rev.**, and *B. tristis* (Staudinger, 1879).

**Zusammenfassung.** Innerhalb der Gattung *Brachodes* wird die *Brachodes pumila* (Ochsenheimer, 1808) Artengruppe definiert und charakterisiert. Sie läßt sich durch die einfach gesägten Fühler der Männchen und die orange-gelbe oder weiße Flügelzeichnung der Weibchen abgrenzen. *Brachodes pumila* (Ochsenheimer, 1808) und *B. candefactus* (Lederer, 1858) werden detailliert beschrieben. *B. diacona* (Lederer, 1858) **syn. n.** wird mit letzterer synonymisiert. Außerdem werden zwei neue Arten, *Brachodes buxeus* **sp. n.** und *B. anatolicus* **sp. n.**, aus der Türkei beschrieben. Die Arten werden mit *Brachodes appendiculatus* (Esper, 1783), *B. compar* (Staudinger, 1879) **stat. rev.** und *B. tristis* (Staudinger, 1879) verglichen.

**Résumé.** A l'intérieur du genre *Brachodes*, le groupe-espèce de *B. pumila* (Ochsenheimer, 1808) est caractérisé par les antennes des mâles (chaque segment ayant un seule excroissance en forme de dent), ainsi que les taches jaune-orange ou blanches des ailes des femelles. *Brachodes pumila* (Ochsenheimer, 1808) et *B. candefactus* (Lederer, 1858) sont redécrits en détail. *B. diacona* (Lederer, 1858) **syn. n.** étant placé comme synonyme de la dernière. Deux nouvelles espèces, *Brachodes buxeus* **sp. n.** et *B. anatolicus* **sp. n.**, sont décrites de Turkey. Les espèces sont comparées à *Brachodes appendiculatus* (Esper, 1783), *B. compar* (Staudinger, 1879) **stat. rev.** et *B. tristis* (Staudinger, 1879).

**Key words.** *Brachodes pumila* species-group, revision, *candefactus*, *diacona* **syn. n.**, *anatolicus* **sp. n.**, *buxeus* **sp. n.**, *compar* **stat. rev.**

### Introduction

Until the publication of the classification of the superfamily Sesioidea by Heppner & Duckworth (1981) the Brachodidae remained unrecognized by most entomologists. This resulted in only insufficient knowledge even of the western Palaearctic fauna of the family. Investigation of the types of most of the Palaearctic species of *Brachodes* Guenée, 1845 has shown that there is a need to revise a number of taxa to stabilise the taxonomy of the genus. A first contribution to the knowledge of the genus *Brachodes*, a revision of the *B. fallax* (Staudinger, 1900) species-group, was published recently (Kallies 1998). The present work is the second contribution to ongoing studies on Palaearctic Brachodidae.

In 1859, Lederer described two species of *Atychia* Latreille, 1809 from Syria, *Atychia candefacta* from a single female and *Atychia diacona* from a single male, both taken near Damascus. Later, both taxa have been transferred to *Brachodes*, replacing the name

*Atychia* due to its preoccupation within Zygaenidae (Heppner 1981). Examination of material in the Lederer and Staudinger collections and a number of other collections has shown that the two taxa are conspecific: *Brachodes diacona* has to be considered a junior subjective synonym of *Brachodes candefactus*. In the course of study of *Brachodes* species, two other undescribed species from Turkey were found which are closely related to *B. candefactus*. They are described below as *Brachodes buxeus* **sp. n.** and *Brachodes anatolicus* **sp. n.** All three species were found to be similar to *Brachodes pumila* (Ochsenheimer, 1808) in basic morphological characters and are therefore placed in a species group.

Material mentioned in this work is deposited in the following collections: The Natural History Museum, London, England (BMNH); Museum für Naturkunde, Zentralinstitut der Humboldt-Universität, Berlin, Germany (MNHB); Naturhistorisches Museum Wien, Austria (NHMW); Zoologische Staatssammlung München, Germany (ZSM); Naturhistoriska Riksmuseet Stockholm, Sweden (NRMS); Museul di Istorie Naturala "Grigore Antipa", Bucharest, Romania (MGAB); Museum National d'Histoire Naturelle, Paris, France (MNHP); Collection of Axel Kallies, Berlin, Germany (CAK); Collection of Karel Špatenka, Prague, Czech Republic (CKS).

### The *Brachodes pumila* species-group

Description. – Small to medium-sized *Brachodes* moths (alar expanse 14–26 mm) with forewing densely covered with pale yellow to reddish brown scales; with or without yellowish streak along cubitus. Hindwing blackish brown, subbasally whitish to yellowish or at least pale. Antennal segments prismatic, scaled dorsally, each segment with a single tooth-like process (Figs. 14–18). Proboscis developed or absent. Labial palpus straight, rough-scaled, with or without long tufted scales basally. Female with orange or white forewing pattern. Female genitalia with ductus bursae in basal portion sclerotized asymmetrically and corpus bursae with two fields of small tooth-like, weakly sclerotized signa (cf. Fig. 21 and Zagulajev 1979: Fig. 3).

Diagnosis. – Members of the *Brachodes pumila* species-group are mainly characterised by the shape of the male antennal segments and by the bicolouration of the wings in the females. In certain characters they are similar to species of the *B. appendiculatus* (Esper, 1783) group. In males the latter can be distinguished easily by the antenna (each segment with two spoon-like processes, Figs. 11–13), in females by the completely black wings and the genitalia (without signa of the corpus bursae). The bicolouration of the females is also seen in *Brachodes funebris* (Feisthamel, 1833) and some related species as well as in some species of the *Brachodes fallax* (Staudinger, 1900) group (sensu Kallies 1998). However, all these species can be distinguished from the species treated here by the simple filiform structure of the antenna in male.

Structure. – According to the given description the following species are included in this group: *B. pumila* (Ochsenheimer, 1808), *B. candefactus* (Lederer, 1858), *Brachodes buxeus* **sp. n.**, *B. anatolicus* **sp. n.**, and *B. arenosa* (Zagulajev, 1979). However, the latter species is known to the author only from the description and was not examined.

Although a close relationship between the members of the *B. pumila* species-group is likely, the group characteristics given above are diagnostic only and do not necessarily indicate a monophyletic group.

***Brachodes pumila* (Ochsenheimer, 1808)**

(Figs. 1, 2, 14, 21)

*Atychia pumila* Ochsenheimer, 1808: 3. Type locality: Hungary. Type material not traced, probably in NHMW.

*Noctua chimaera* Hübner, [1808]: pl. 86, Fig. 405 (not *Sphinx chimaera* Hübner, [1796]). Type locality: unknown. Type material destroyed.

References. – Hübner [1822]: pl. 147, Figs. 678, 679 (*Noctua*); Spuler 1910: 301 (*Atychia*); Caradja 1920: 163 (*Atychia*); Buszko & Sliwinski 1978: 18–24, Figs. 2, 9, 10, 13, 14, 17, 18, 20 (*Atychia*); Leraut 1980: 87 (*Brachodes*); Razowski 1981: Figs. 14–17, 26 (*Atychia*); Heppner 1981: 13 (*Brachodes*); Povolny & Kralicek 1985: 94–102, Figs. 3–5, 7–11 (*Brachodes*).

Material examined. – Numerous specimens from Austria, Hungary, Dalmatia, Croatia, Macedonia and South Russia. From other parts of the distribution range only few specimens have been checked. Italy: 2♀, Valle d'Aosta, Ozein, 1300 m, 19. VII. 1993, leg. et coll. Bertaccini; ♂, Valle d'Aosta, Pondel, 800 m, 22. VII. 1993, leg. et coll. Bertaccini; Macedonia: ♀, Petrina planina, 1600 m, 24. VII. 1954, leg. Thurner (ZSM); Greece: 2♂, ♀, Chelmos Mts, 1600 m, 14. VII. 1995, leg. Lingenhöle (CAK); ♂, Ioannina, Vradeto, 2100 m, 29. VII. 1995, leg. Petersen (CAK); Turkey: ♂, Hadjin [Saimbeyli], [18]88 (MNHB); ♂, Kasikoparan, Korb 1901 (MNHB); ♂, Marasch [Prov. Maraş, Kahramanmaraş], [18]84 Man. (MNHB); ♂, Prov. Kars, 4–18 km SE Karakurt, Aras Valley, 1450–1850 m, 12.–14. VII. 1989, leg. v. Oorschot, de Prins, Coenen & Koolbergen (CWP); Syria: ♀♀, ♂♂, Shar Devesy (BMNH); Kazakhstan: ♀, Saisan [Zaisan] (MNHB); ♂, Kustanajskaja oblast 94, Amankaragaiski lezchos, 7. VII. 1973, leg. Aibasov (coll. Zolotuhin); ♀, Karag[anda]. oblast, Trostnik, 17. VIII. 1958, leg. Sanova (coll. Zolotuhin); China: 2♀, Kuldscha [Yining], Thian occ., coll. Caradja (NHMW, MGAB).

Description. – Male (Fig. 1). Alar expanse 18–22 mm (exceptionally 15–18 mm); forewing length 7–10 mm; body length 7–10 mm. Head: antenna black, scape white, processes of antennal segments apically somewhat bilobed (Fig. 14); labial palpus white, apical joint grey, rough-scaled, without tufted hair-like scales basally (Buszko & Sliwinski 1978: Fig. 2); frons shining leaden grey, ventrally and laterally white; vertex a mixture of white and black scales, with grey tile-like scales centrally; pericephalic scales white; proboscis long, well-developed. Thorax: black, with two short submedial lines in anterior part; tegulae with whitish yellow exterior margins; patagia white laterally, sometimes with a white posterior margin; a small white spot at base of forewing; ventrally mixed with grey and white scales; metathorax with white hair-like scales submedially. Forewing ground color blackish but densely covered with olive-yellow scales; with a white medial streak along fold extending to about one-half of wing; a small white spot close to costa at about two-thirds; all markings densely covered with olive-yellow scales; ventral side black with markings similar to upper side, an additional white patch near anal margin. Hindwing black; a white transverse band subbasally, not reaching anal and costal margins, sometimes divided by a black streak along vein CuA<sub>2</sub>; ventral side similar, but the white transverse band reaching the anal margin; additionally a white streak along costal margin extending into a small white spot near apex. Abdomen with black tergites, each with a narrow white posterior margin; sternites



Figs. 1–2. *Brachodes pumila* (Ochsenheimer, 1808), Greece, Chelmos. 1 – ♂ (CAK). 2 – ♀ (CAK).

white with scattered individual black scales; anal tuft yellowish apically. Male genitalia. – Uncus with two apical tips; valva relatively narrow; aedeagus thick, straight, of moderate length, with numerous weak cornuti.

Female (Fig. 2). – Alar expanse 16–21 mm; forewing length 7–9.5 mm, body length 10–13 mm. Head and thorax similar to male but antenna filiform, densely scaled dorsally; all dark parts black. Abdomen black; tergites 1 and 5 with some white scales at posterior margin; tergites 2 and 6 with well defined narrow white posterior margin; sternites similar but with scattered white scales; 7th segment prolonged, ovipositor about as long as complete abdomen. Forewing black, with a white transverse band at about 1/3 and two white spots at 2/3, ventrally similar to male. Hindwing as in male. Female genitalia (prep. AK140, Fig. 21) with basal portion of ductus bursae sclerotized asymmetrically; corpus bursae ovoid, with two fields of small tooth-like, weak sclerotized signa. Figures on the morphology of the adult, male and female genitalia were provided by Buszko & Sliwinski (1978), Razowski (1981), and Povolny & Kralicek (1985).

Diagnosis. – The male of this species is superficially similar to *B. appendiculatus* (Esper, 1783). However, it can be distinguished easily by the shape of the antennal segments (compare Figs. 11, 12, and 14), the presence of a whitish costal spot on the forewing (absent in *B. appendiculata*), and by the shape of the white hindwing pattern (broad and continuous in *B. appendiculata*). Males of *B. mesopotamica* (Amsel, 1949) can be separated most easily by the shape of the antenna (filiform, smooth, without distinct processes). The female of *B. pumila* is unique by the shape of the white pattern on the forewing and the presence of white markings on the hindwing. Females of the *B. appendiculatus* species-group are black throughout; females of *B. funebris* (Feisthamel, 1833), *B. beryti* (Stainton, 1867), *B. flavescens* (Turati, 1919) and some related species have a similar forewing pattern but lack the white markings of the hindwing.

Distribution. – *B. pumila* is an expansive ponto-mediterranean species occurring in a wide range from eastern Central Europe to Central Asia. Confirmed records are from Lower Austria, Slovakia, Hungary, Romania, Bulgaria, Italy, Dalmatia, Croatia, Mac-

edonia, Greece, South Russia, Turkey, Syria, Kazachstan, Kirgizstan, and North West China.

In the collection of the NRMS there are some females with printed labels "Andalusia". It is conceivable that some isolated populations of *B. pumila* may exist on the Iberian Peninsula, but until additional material becomes known these specimens are treated here as mislabelled. *B. pumila* is also mentioned for the fauna of France (Herrich-Schäffer 1854; Walker 1856; Heppner 1996). Although *B. pumila* does occur in the Valle d'Aosta (NW Italy) near the french border, no material or confirmed record has been found for France. Possibly previous authors have misidentified *B. funebris* (Feisthamel 1833), which has a similar female. Records of *B. pumila* from Germany (Heppner 1996) were repudiated recently (Kallies 1999).

Habitat and Bionomics. – The moths are active by day and have been found from June to mid August. Nothing is known about the early stages. Specimens have been collected in lowland steppe in central and eastern Europe, but also in xero-montane grasslands at altitudes of up to 2100 m in the southern part of the distribution range.

***Brachodes candefactus* (Lederer, 1858)**

(Figs. 3–6, 15, 16)

*Atychia candefacta* Lederer, 1858: 151. Type locality: Damascus [Syria]. Holotype ♀, in MNHB.

*Atychia diacona* Lederer, 1858: 151. **syn. n.** Type locality: Damascus [Syria]. Holotype ♂, presumably lost.

References. – Caradja 1920: 163 (*Atychia*); Heppner 1981: 13 (*Brachodes*)

Material examined. – Holotype ♀ (Fig. 5) "Orig." "Holotype / *Atychia candefacta* / Lederer, 1859 / Axel Kallies rev. 1998" (MNHB); ♂ "Syr[ia]." "Orig." (MNHB); ♂, "Syr[ia]." (MNHB); Lebanon: ♂, Bscharre [Bsharri], 1850 m, 1.–15. VI. 31, leg. Pfeiffer (ZSM); 3♂, Cedern b. Becharre, 1900 m, 24.–30. VI. 1931, leg. Zerny (NHMW); Syria: 4♂, Anti-Lebanon Mts., Bludan, 33°45'N, 36°0'E, 20. VI. 1997, leg. Spatenka (CKS); ♂, ♀, Jabel Chmiss W Sarghaya, 33°48'N, 36°08'E, 18. VI. 1997, leg. Spatenka (CKS); ♂, Libanon (ZSM); Turkey: 2♂, Central Taurus / *tristis* Stgr. [sic.!] (NHMW); 3♂, Hadjin [Prov. Adana, Saimbeyli, 38°07'N, 36°08'E], (MNHB, NHMW); ♂, Pont[us]. / *compar* [sic.!] (ZSM); ♂, same data (MNHP); ♂, ♀, Marasch, Cil. Taurus [Prov. Maraş, Kahramanmaraş], VI. 1907 (MGAB); ♂, ♀, Zeitun [Prov. Maraş, Süleymanlı] (NHMW); ♂, Taurus (MGAB); ♂, Eibes [Prov. Hatay, Amanos Daglari, Akbes W of Hassa, 36°53'N, 36°28'E] (ex coll. Staudinger) (MNHB); 2♂, 60 km E Develi, Gezbeli Geçidi 1850 m, 22. VII. 1996, leg. Lingenhöle (CAK) (Fig. 4); ♂, Prov. Van, Güzeldere Geçidi, S. side 2500–2600 m, 4.–10. VIII. 1988, leg. v. Oorschot, de Prins & Riemis (CWP) (Fig. 3); ♂, Prov. Muş, 10 km SW Eretepe, 1800–1900 m, 28. VII. 1988, leg. v. Oorschot, de Prins & Riemis (CWP); 2♂, Prov. Bitlis, Nemrut Dağı, 2100–2400 m, 30. VII.–1. VIII. 1988, leg. v. Oorschot, de Prins & Riemis (CWP, ZSM); 2♂, Prov. Bitlis, 20 km E Tatvan, 1750 m, 4. VII. 1990, leg. v. d. Brink, v. d. Poorten & de Prins (CWP, CAK); 12♂, 12 km W Sakaltutan Geçidi, 1900 m, 39°53'N, 39°01'E, 18. VII. 1996, leg. Spatenka (CKS, CAK); 2♂, Prov. Sivas, 25 km E Zara, 1600 m, 23. VII. 1995, leg. Kallies (prep. AK132, CAK); 2♂, Erzurum, Kopdağı Geçidi, 2370 m, 40°01'N, 40°31'E, 10. VII. 1996, leg. Špatenka (CKS); Iran: 2♂, Zanjan-Gilvan, 1. Pass ca 1km N Garavol Dag, 2400–2500 m, 3.–4. VII. 1999, leg. Hofmann & Meineke (CAK).

Description. – Male (Figs. 3, 4). Alar expanse 14–20 mm, usually 15–18 mm; forewing length 6–9 mm; body length 7–9 mm. Head with antenna black, scape yellow ventrally, segments prismatic, each with a short tooth-like process (Figs. 15, 16); frons shining black, with individual white or yellow scales; vertex black, mixed with yellow; patagia



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and tegulae black, densely mixed with yellow to ochre scales; labial palpus straight, black, yellow interiorly and exteriorly; proboscis absent. Thorax black, with single yellow scales, tegulae covered with a mixture of yellow and black scales, with individual hair-like scales apically; metathorax with long whitish hair-like scales submedially. Forewing ground color black, densely covered with light yellow to ochreous yellow scales; fringe whitish to fuscous; ventral side black; from base to about 1/2 a narrow yellow medial streak; along anal margin light yellowish; along costal margin towards apex some yellow scales. Hindwing brownish black; towards base a yellow medial spot reaching almost to anal margin; fringe white to brownish; with similar markings ventrally, yellow medial spot usually extended to anal margin. Abdomen black; tergites and anal tuft with narrow white to yellow posterior margins; sternites more or less densely covered with light yellow scales.

Male genitalia (prep. AK132). – Uncus without pointed tips; aedaeagus narrow, almost straight, with numerous weak cornuti.

Female (Fig. 5). – Alar expanse 14 mm; forewing length 6 mm, body length 10 mm. Head, thorax and abdomen black; antenna filiform. Forewing orange-yellow; with black scales near base; a black transverse fascia at about 2/3; exterior margin black; fringe black; ventral side with an ill-defined yellow patch at about 2/3; yellowish along cubitus. Hindwing black; with few yellow scales near base; ventrally with an ill-defined yellow patch at about 2/3 of costal margin.

Diagnosis. – The species is similar and closely related to *Brachodes buxeus* sp. n. described below (q. v.). In male, *B. candefactus* is sometimes similar to *B. mesopotamica* (Amsel, 1949), but the latter can be distinguished by the filiform, smooth shape of the antenna (without distinct processes).

Variability. – Specimens from Turkey, especially from the northern part, tend to a more ochre-brown coloration of the forewing and reduced yellowish to white markings of the hindwing. Specimens from Syria, Lebanon and East Anatolia have usually a light yellow forewing and well developed white markings of the hindwing. Additionally, the color of the fringe varies from white to fuscous.

Distribution. – Known from Syria, Lebanon, Turkey (Central and East Anatolia) and NW Iran (new record).

Habitat and Bionomics. – Adults were collected by day in grass steppe mainly in mountain areas at altitudes from 1600 to 2400 m. The flight period starts at the beginning of June and lasts till the end of July. The host plant is a *Secale* sp., Graminae (Špatenka, personal observation). Two specimens (Turkey, Prov. Sivas, Zara) were observed to be non-specifically attracted to artificial pheromones made for Sesiidae.

Remark. – In his original description Lederer (1858) mentioned the lack of the abdomen of the type specimen of *Atychia diacona* Lederer, 1858. However, the male specimen

**Figs. 3–10.** *Brachodes* species. **3** – *B. candefactus* (Lederer, 1858), ♂, Turkey, Güzeldere Geçidi (CAK). **4** – dito, ♂, Turkey, 60 km E Develi (CAK). **5** – dito, ♀, holotype (MNHB). **6** – dito, labels of holotype. **7** – *B. buxeus* sp. n., ♂, paratype, Turkey, 10 km N Akseki (CAK). **8** – dito, ♂, holotype, Turkey, Akbez (BMNH). **9** – dito, ♀, paratype, Turkey, Akbez (MNHB). **10** – *B. anatolicus* sp. n., ♂, holotype, Turkey, Zara (CAK).

from Lederer's collection, labelled as "Orig[inal]", bears a complete abdomen which obviously has not been attached later. Consequently this specimen cannot, unfortunately, be the holotype of *Atychia diacona* Lederer, 1858.

***Brachodes buxeus* sp. n.**

(Figs. 7–9, 17, 19)

Material examined. – Holotype ♂ (Fig. 8) "Asia minor. / Amanus Mts. / Eybiz [Turkey, Prov. Hatay, Amanos Dağları, Akbes W of Hassa, 36°53'N, 36°28'E], 1903–357." "*Atychia* ? / n. sp. Washbn." (BMNH); Paratypes: ♂, same data as holotype (BMNH); ♂ "Alma Dagh (Amanus Mts) / Asia Minor, -06" "Meyrick Coll. / B.M. 1938-290." "genitalia examined / by A. Kallies / prep. No. AK8" "B.M. Genitalia slide / No 29196" (BMNH); 2♂ "Eibes [Akbes]" "ex coll. Staudinger" (MNHB); ♂ "Eibes" "106." "Stgr. 14" (NHMW); ♀ (Fig. 9) "Eibes" "sp.?" "*Atychia candefacta* / *ab. fulminans* Rebel" (MNHB); ♂ "Hadjin [Turkey, Prov. Adana, Saimbeyli, 38°07'N, 36°08'E]" "*tristis* Stgr. [sic.!] / Hadjin" "107." "Stgr. 14" (NHMW); ♂ (Fig. 7) "Süd Türkei / 10 km nördl. Akseki / Irmasan Geçidi, 1100 m / 8. VII. 1996 / leg. Lingenhöle" "genitalia examined / by A. Kallies / prep. No. AK133" (CAK); ♂ "Türkei / Beysehir See (süd), 1150 m / 20 km W Beysehir / 9. VII. 1996 / leg. A. Lingenhöle" (CAK); ♂ "Türkei, Prov. Konya / Bakaran Umg., 1250 m NN / 23. VI. 1996 / leg. B. Schmitz" (CAK).

Description. – Male (Figs. 7, 8). Alar expanse 21.5–27 mm, typically 22–23 mm; forewing length 10.0–12.5 mm; body length 5.5–6.0 mm. In maculation of wings and body the male of the new species is very similar to the male of *B. candefactus* (cf. description given above). However, it can be distinguished by the wider alar expanse, by the presence of a developed proboscis, which is about as long as the fore coxa (absent in *B. candefactus*), by the longer tooth-like processes of the antennal segments (Fig. 17), and by the smaller beige-yellow marking on the hindwing underside (typically not reaching the anal margin).

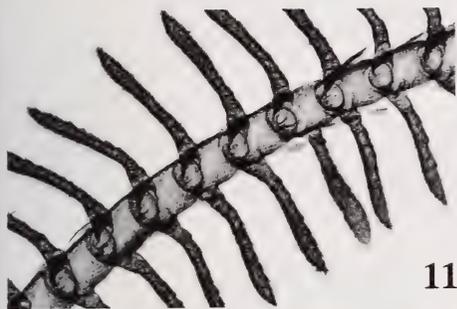
Male genitalia (prep. AK8, Fig. 19). – Uncus with well developed pointed apical tips (without in *B. candefactus*); aedaeagus narrow and long, curved basally (almost straight in the species compared); valva relatively narrow.

Female (Fig. 9). – Alar expanse 23 mm; forewing length 10.5 mm; body length 18.5 mm. By the orange and black markings of the forewing the female of *B. buxeus* sp. n. is similar to that of *B. candefactus* but can be separated easily by the size, the yellow, black bordered hindwing (black almost throughout in *B. candefactus*) and by the black transverse fascia and the exterior margin of the forewing (narrower in *B. candefactus*).

Diagnosis. – Both, *B. candefactus* and *B. buxeus* are similar to *Brachodes compar* (Staudinger, 1879) **stat. rev.**, and *Brachodes tristis* (Staudinger, 1879) superficially. However, these species belong to the *B. appendiculatus* species-group and can easily be separated by the bipectinate antennae (with two spoon-like processes on each antennal segment, Figs. 11–13) in the male, and by the completely black females.

Variability. – Males from the central Toros Mts (Akseki, Beysehir and Konya) show minor differences from specimens from the Amanus and eastern Toros Mts: the forewings

**Figs. 11–18.** Antenna of male *Brachodes* species. **11** – *B. appendiculatus* (Esper, 1783), middle portion, Russia, Seratov (prep. AK82-96, CAK). **12** – dito, apical portion, Italy, Aosta (prep. AK85-96, CAK). **13** – *B. cf. appendiculatus* (Esper, 1783), Turkey, Toros Mts (prep. AK91-96, CAK). **14** – *B. pumila* (Ochsenheimer, 1808), Greece, Ionannina (prep. AK90-96, CAK). **15** – *B. candefactus* (Lederer, 1858), Turkey, Zara (prep. AK127-96, CAK). **16** – dito, Lebanon, Becharre (prep. AK144-96, NHMW). **17** – *B. buxeus* sp. n., paratype, Turkey, Akbez (prep. AK130-96, MNHB). **18** – *B. anatolicus* sp. n., holotype, Turkey, Zara (prep. AK83-96, CAK).



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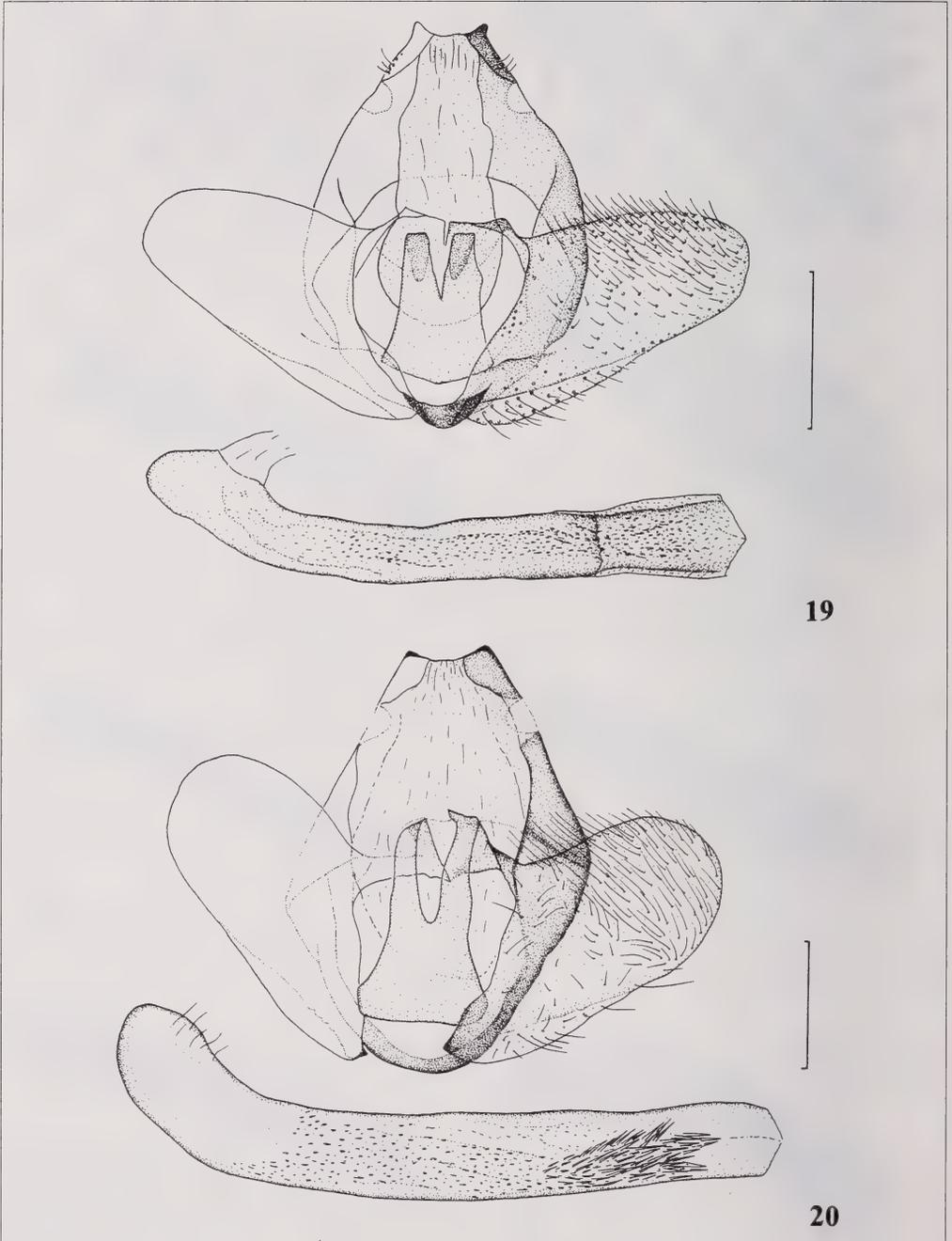


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are more brightly orange colored and the white pattern of the hindwings is better developed, on the ventral side extending to the anal margin. This range of variability is equally well seen in males of *B. candefactus*.



**Figs. 19–20.** Genitalia of *Brachodes* species. **19** – *B. buxus* sp. n., ♂, paratype, Turkey, Akbez (prep. AK8/BMNH 29196). **20** – *B. anatolicus* sp. n., ♂, holotype, Turkey, Zara (prep. AK52, CAK).

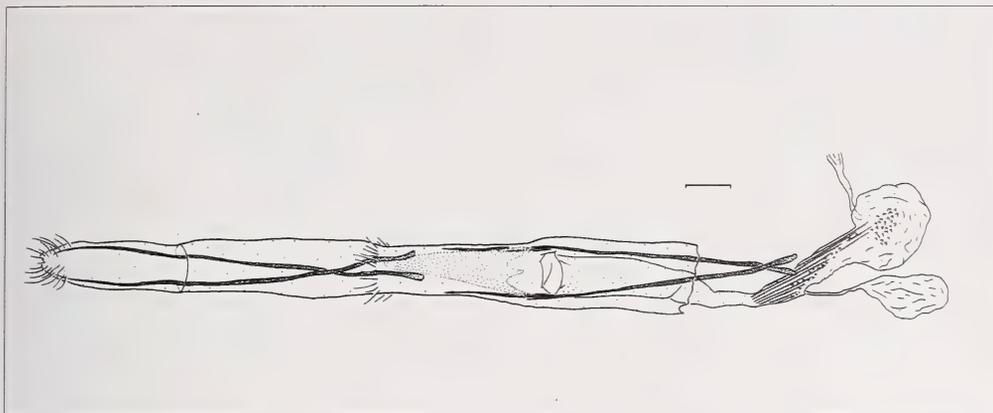


Fig. 21. – *Brachodes pumila* (Ochsenheimer, 1808), ♀, without data (prep. AK140, MNHP).

Habitat and Bionomics. – Unknown for the type locality. Three males from the central Toros Mts. were collected at altitudes between 1100 and 1250 m at the end of June and beginning of July.

Distribution. – Known only from the Amanus Mts (Akbes), the eastern and central Toros Mts in south-eastern and southern Turkey.

***Brachodes anatolicus* sp. n.**

(Figs. 10, 18, 20)

Material examined. – Holotype ♂ (Fig. 10) “Turkey, Prov. Sivas / 25 km E Zara, 1600 m / 23. VII. 1995 / leg. A. Kallies” “genitalia examined / by A. Kallies / prep. No. AK52” (CAK, will be deposited in MNHB later); Paratype: ♂, same data as holotype.

Description. – Male (Fig. 10). Alar expanse 18–19.5 mm; forewing length 8.5–9 mm, body length 8.5 mm. Head with black antenna, scape white, segments (Fig. 18) with long simple processes; labial palpus straight, rough, black and white scaled, apical segment smooth and black, basal and middle segments with long tufted scales ventrally; proboscis present but very short; frons shining black, with some white scales at upper margin; vertex and pericephalic hairs black, mixed with white scales. Thorax with black ground color, with narrow yellow-white scales; patagia black; tegulae black, covered with yellow-white hair-like scales. Forewing yellowish grey, in middle somewhat lighter, but without clearly defined white streak along fold and without costal spot; fringe yellowish grey; ventral side blackish grey, in middle part light grey; fringe white. Hindwing blackish grey; white subbasal band well developed, not reaching anal margin; fringe white; ventral side with similar markings. Abdominal tergites and sternites blackish grey, each with a narrow white posterior margin.

Male genitalia (prep. AK52, Fig. 20). – Uncus with short blunt apical tips; aedeagus long and strong, with a bunch of relatively strong cornuti; valva short.

Diagnosis. – This new species is somewhat similar to *B. pumila* and *B. candefactus*. In male, it can be distinguished by the shape of the processes of the antennal segments (apically bilobed in *B. pumila*, shorter in *B. candefactus*), by the short proboscis (long in

*B. pumila*, absent in *B. candefactus*), by the markings of the forewing (with a well defined narrow streak along fold and costal spot in *B. pumila*, without defined maculation in *B. candefactus*), and by the markings of the hindwing (the white band on the ventral side reaches the anal margin in *B. pumila* and *B. candefactus*). *B. anatolicus* is superficially also similar to species of the *Brachodes appendiculatus* group, such as *B. dispar* (Herrich-Schäffer, 1854), *B. keredjella* (Amsel, 1953), and *B. formosa* (Amsel, 1953), but it can be separated easily by the group characteristics given above.

**Habitat and Bionomics.** – The type specimens were observed to be weakly and unspecifically attracted to artificial pheromones made for Sesiidae in the late morning hours. They were collected in a hilly limestone area (karst) which is interrupted by ground depressions of brownish loess-like soil. This area is used for agriculture only in part. A highly diverse vegetation and a rich lepidoptera fauna has been observed in this area, including the Sesioidea: *Brachodes candefactus*, *Tinthia brosisiformis* (Hübner, [1813]), *Tinthia hoplisiformis* (Mann, 1863), *Bembecia cf. puella* Lastuvka, 1989, *B. stitiziformis* (Herrich-Schäffer, 1851), *Chamaesphecia proximata* (Staudinger, 1891), *Ch. colpiformis* (Staudinger, 1856), and *Bembecia scopigera* (Scopoli, 1763).

#### Acknowledgements

My cordial thanks are due to M. Lödl (NHMW), W. Mey (MNHB), J. Minet (MNHP), G. S. Robinson, and K. Tuck (both BMNH) for the loan of material under their care, as well as to M. Nuß (Staatliches Museum für Tierkunde, Dresden, Germany) for arranging the loan from the MNHP respectively. I am also indebted to K. Špatenka (Prag, Czech Republic) for the loan of material and important bionomic information. Additionally I want to thank G. Baldizzone (Asti, Italy), G. Derra (Reckendorf, Germany), G. Fiumi (Forli, Italy), M. Petersen (Pfungstadt, Germany), W. de Prins (Antwerpen, Belgium), and A. Scholz (†) (Vöhringen-Illerberg, Germany) for the possibility to study the material in their collections, and M. Bakowski (Poznan, Poland), A. Hofmann (Freiburg, Germany), P. Kautt (Tübingen, Germany), P. M. Krystal (†) (Büstadt, Germany), Z. Lastuvka (Brno, Czech Republic), A. Lingenhölle (Biberach, Germany), W. Speidel (Bonn, Germany) as well as V. Zolotuhin (Uljanovsk, Russia) for supplying material for this study. Special thanks are due to K. Tuck (BMNH) for linguistic help.

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## New and scarce European *Eupithecia* species (Geometridae)

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**Summary.** Information on eight scarce species of *Eupithecia* Curtis, 1825 from Europe is presented. Three species, namely *Eupithecia deverrata* Chrétien, 1910 from southern France, *E. reisserata* Pinker, 1976 from Greece and *E. spadiceata* Zerny, 1933 from southern Ukraine, are new to Europe. The little known species *Eupithecia lentiscata* Mabille, 1869 is recorded for southern Greece for the first time. *Eupithecia mandarinca* sp. n. from southern Crimea is described.

**Zusammenfassung.** Der vorliegende Artikel enthält Angaben zu acht interessanten und seltenen europäischen Arten der Gattung *Eupithecia* Curtis, 1825. Drei Arten (*Eupithecia deverrata* Chrétien, 1910 aus Süd-Frankreich, *E. reisserata* Pinker, 1976 aus Griechenland und *E. spadiceata* Zerny, 1933 aus der Süd-Ukraine) sind neu für die europäische Fauna. Eine wenig bekannte Art, *Eupithecia lentiscata* Mabille, 1869, wurde zum ersten Mal in Süd-Griechenland gefunden. *Eupithecia mandarinca* sp. n. wird von der südlichen Krim beschrieben.

**Résumé.** La présente contribution inclue de l'information concernant huit espèces européennes rares appartenant au genre *Eupithecia* Curtis, 1825. Trois espèces, à savoir *Eupithecia deverrata* Chrétien, 1910 du sud de la France, *E. reisserata* Pinker, 1976 de Grèce et *E. spadiceata* Zerny, 1933 du sud de l'Ukraine, sont nouvelles pour l'Europe. L'espèce peu connue *Eupithecia lentiscata* Mabille, 1869 est mentionnée du sud de la Grèce pour la première fois. *Eupithecia mandarinca* sp. n., de Crimée méridionale, est décrite.

Key words. Geometridae, *Eupithecia*, Europe.

### Introduction

*Eupithecia* is one of the most species-rich genera of the Geometridae. According to the latest and comprehensive publication (Müller 1996), this genus is represented by 123 species in Europe. During an examination of the material deposited in collections of the Zoologische Staatssammlung München (ZSM), Zoological Museum of the University of Copenhagen (ZMUC) and Zoological Institute, Russian Academy of Sciences, St. Petersburg (ZISP), eight interesting, local and scarce *Eupithecia* species were found. Three of them were hitherto unknown to the fauna of Europe, one species from the Crimea (Ukraine) is described here as new. A redescription of two species is given.

### *Eupithecia laquaearia* Herrich-Schäffer, 1848

Material examined. – 3♂, ♀, Greece, Timfi, Papigon, 800 m, 28.vi.1990, Schepler leg.; ♀, Delfi, 18–19.v.1997, Selling leg. (ZMUC).

Note. – The first record for Greece.

***Eupithecia groenblomi* Urbahn, 1969**

Material examined. – 7♂, ♀, Russia, Novgorodskaja oblast', village Kostroni near Batetskiy, ex larva, 16.vii.1999, 4., 14., 16.iv, 1., 20., 25., 26., 27., 31.vii, 11.viii.2000, Mironov leg. (larvae on the flowers and seeds of *Solidago virgaurea* from mid-August to late September); ♀, Leningradskaya oblast', Mikhailovskaya, at light, 25.vii.1999, Ivanov leg. (ZISP).

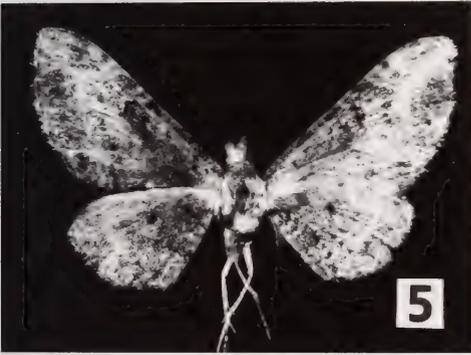
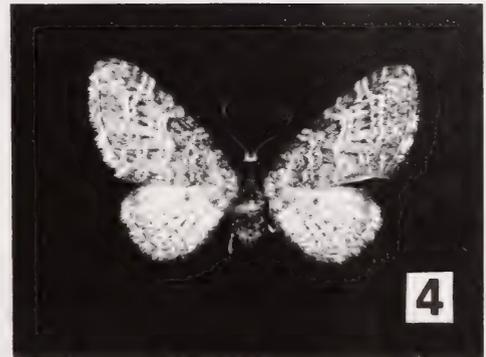
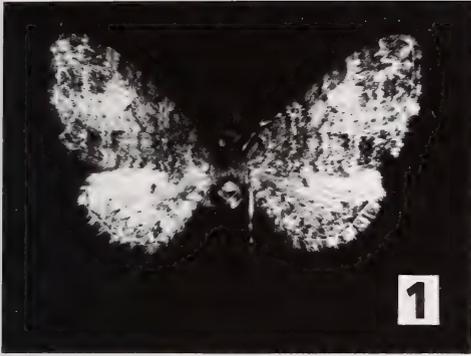
Note. – A very local and rare boreal species. It has been described from Finland (Pälkane) on the basis of adults reared from larvae. The first Russian records were made in St. Petersburg province: ♀, Kastenkaja near Tosno, 23.–29.vii.1995 (Söderman et al. 1998). The first record for Novgorodskaya oblast' (Novgorod province), where the species possibly approaches the southern limit of its range.

***Eupithecia lentiscata* Mabille, 1869****(Fig. 1)**

Material examined. – ♂, Greece, Lakonia, 5 km S. of Monemvasia, 3.II.1983, Christensen leg. (ZMUC).

Diagnosis. – Labial palpi light brown with whitish apices; extending beyond front of eyes approximately 0.9 times diameter of eyes (in male). Front and vertex covered with whitish grey scales. Antennal setae dense, length approximately 0.5 times width of flagellum (in male). Notum pale brownish grey with brown transverse band in front. Wingspan 17.5 mm, length of forewing 9.5 mm. Forewing rather short and broad; costa arched near base and apex; termen slightly curved; apex bluntly rounded; ground colour brownish grey, costal margin slightly darker; cubital vein covered with black scales; crosslines (basal, postbasal, antemedian and median) sinuate, not sharply angled near costa, distinctly marked with dark narrow costal spots; median line crosses discal spot; postmedian line inconspicuous, bent with right angle near costa, well marked with two pairs of short black touches (on the  $M_1$  and  $M_2$  veins and as well as on the  $Cu_2$  vein and under it); terminal area with distinct pale minutely waved subterminal line; pale tornal spot absent; discal spot obliquely elongate, very narrow, blackish. Hindwing paler, whitish grey with delicate brownish tint; crosslines indistinct, marked with minute dark dots on the  $Cu$  vein; terminal area darker, with waved inner border and with a series of small dark wedge-shaped dots; pale subterminal line fine, indented; discal spot large, rounded. Terminal lines on fore- and hindwings narrow, black-brown, interrupted by veins. Fringe light brownish grey with brown at vein endings.

Male genitalia (Figs. 7–10). – Uncus short, thin, biapical. Papillae rather elongated and narrow, length approximately 0.9 times uncus length. Valva without ventral process, widest medially and tapered to apex; apex of valva rather pointed; sacculus weakly sclerotized. Vinculum short and broad, with shallow medial hollow. Aedeagus large and thick, length equal to valva length; approximately 3.5 times longer than medial width. Vesica membranous; with large striated round pouch; armed with three stout, heavily sclerotized horn-like sclerites (one smaller almost straight, one slightly curved along the length and sharply curved at base, the 3rd sclerite approximately two times longer than others, with broadened irregular base) and with one short twisted sclerite at ductus ejaculatorius base. 8th sternite narrow; base broadened with shallow basal hollow; two basal processes pointed laterally; apical processes very short and weakly sclerotized. Female unknown.



**Figs. 1–6.** *Eupithecia* spp.: **1** – *E. lentiscata* Mabille, 1869 ♂ (Greece, Lakonia); **2** – *E. deverrata* Chrétien, 1910 ♂ (France, Corbières); **3** – *E. mandarinca* sp. n., holotype ♀ (Ukraine, Crimea); **4** – *E. reisserata* Pinker, 1976 ♀ (Greece, Arkadia); **5** – *E. spadiceata* Zerny, 1933 ♀ (Ukraine, Crimea); **6** – *E. spadiceata* Zerny, 1933 ♀ (Russian Federation, Daghestan). Photographs by V. N. Tanasiychuk and B. A. Anokhin.

Distribution. – Corsica, S. Greece.

Similar species. – Closely related to *E. abbreviata* and *E. dodoneata*, the only two species with which it could be confused. *E. abbreviata* has the forewing more pointed and elongated in proportion, the ground colour more brown with distinctly paler medial area between discal spot and postmedian line, the small pale tornal dot is present; the hindwing more brown with termen more deeply concave and with more conspicuous crosslines than those in *E. lentiscata*. In the male genitalia of *E. abbreviata*: the valve with large ventral process, the sacculus heavily sclerotized, the vesica armed with two horn-like sclerites (one very long and other short, basally broadened) and with a single elongated curved sclerite. *E. lentiscata* can be distinguished from *E. dodoneata* by more obtuse forewing, the less angulated basal, postbasal and antemedian lines near the costa, the smaller and narrower discal spots on the forewings, and by the less deeply concave termen of the hindwing. The very short 8th sternite, the only small heavily sclerotized horn-like sclerite, one pointed weakly sclerotized sclerite and elongated twisted sclerite at ductus ejaculatorius base on the vesica render it easy to distinguish the male genitalia of *E. dodoneata* from those of *E. lentiscata*.

Note. – The first record for Greece.

### ***Eupithecia euxinata* Bohatsch, 1893**

Material examined. – ♂, Russia, Krasnodarskiy krai (territory), Abrau-Dyurso near Novorossiysk, 8.x.1997, Stschurov leg. Also recorded from Cyprus: ♂, K. K. T. C., Dipkarpaz, 28.xii.1993, Ahola leg.; ♀, K.K.T.C., Kantarara, 700 m, 29.xii.1993–1.i.1994, Ahola leg. (ZISP).

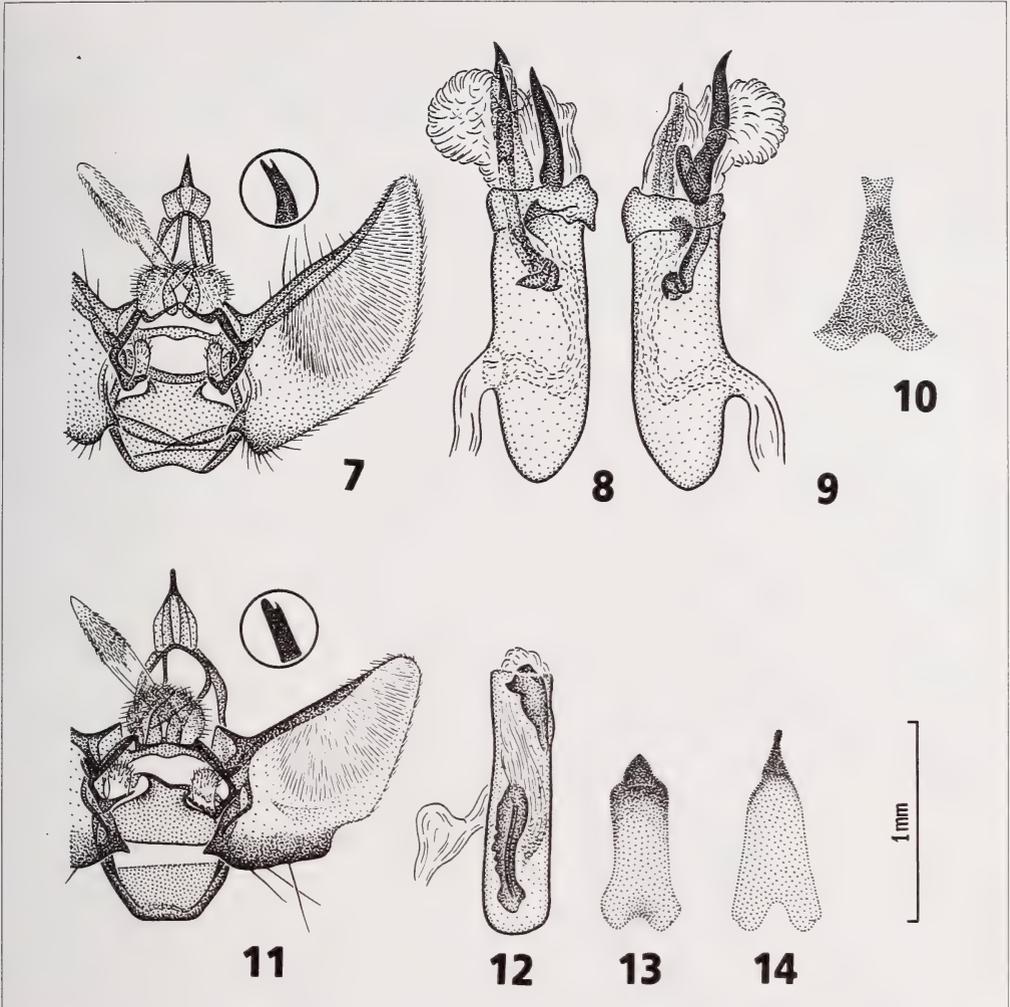
Note. – The first record for Russia and Cyprus.

### ***Eupithecia deverrata* Chrétien, 1910**

(Fig. 2)

Material examined. – ♂, France, Corbières, Albas, 400 m, 13.v.1975, Lukasch leg. (ZSM).

Diagnosis. – Labial palpi yellowish grey; extending beyond front of eyes approximately 0.8–0.9 times diameter of eyes (in male). Front, vertex and notum pale yellowish grey. Antennal setae length approximately 0.5 times width of flagellum (in male). Wingspan 17.5 mm. Forewing rather narrow and elongate, costa slightly arched, apex pointed, termen obliquely straight; ground colour pale yellowish grey; crosslines brownish, slightly broadened and darker near costa; basal line dentated, bent with right angle near costa; antemedian line almost straight, obtuse angled near costa; the first median line slightly sinuous, crosses discal spot and sharply angled toward costa; postmedian line fine, faintly sinuate and waved, perpendicularly curved to costa; terminal area relatively narrow; pale subterminal line distinct, indented, with brownish shade on the innerside; terminal line narrow, dark brown, interrupted by veins; discal spot large, obliquely elongate, rather ovate-oblong, intensely black. Hindwing with shallowly concave termen near apex; of the same colour, mottled and irrorate with dark brown scales; crosslines indistinct, except basal and postmedian lines; terminal area very narrow; pale subterminal line conspicuous, indented, running near termen; discal spot distinct, relatively large, elongate, paler than those on the forewing. Fringe whitish



**Figs. 7–14.** Male genitalia of *Eupithecia*. **7–10** – *E. lentiscata* Mabille, 1869 (Greece, ZMUC): **7** – ventral view (in the circle: apex of uncus at right side), **8, 9** – aedeagus with vesica everted from the two positions, **10** – 8th sternite; **11–13** – *E. deverrata* Chrétien, 1910 (France): **11** – ventral view (in the circle: apex of uncus at right side), **12** – aedeagus, **13** – 8th sternite; **14** – *E. distinctaria* Herrich-Schäffer, 1848 (France), 8th sternite.

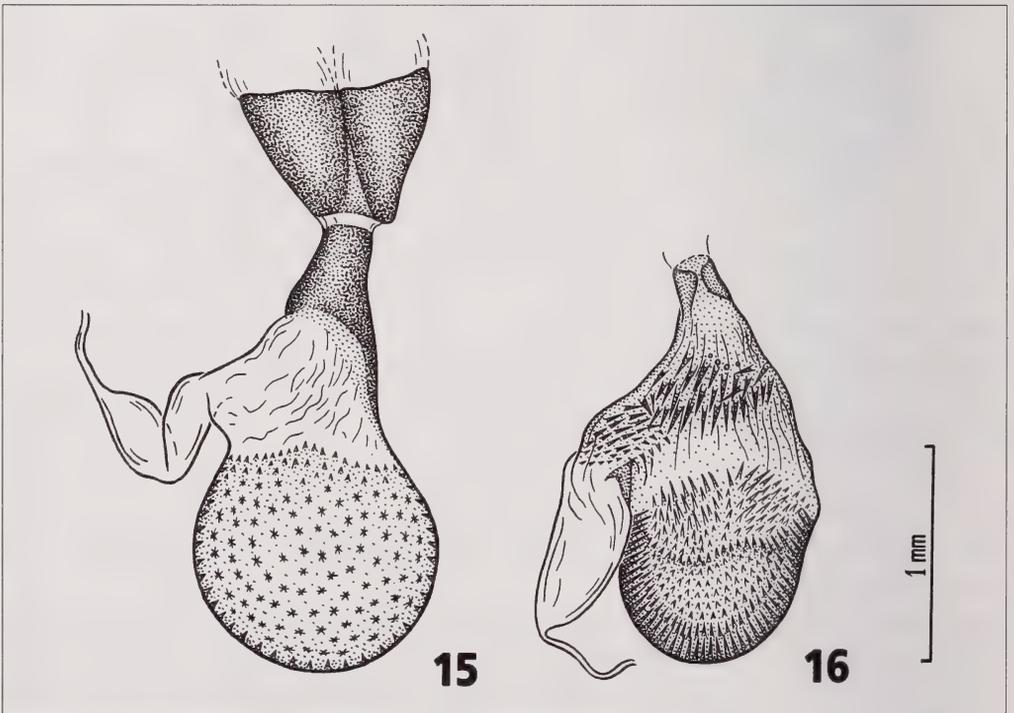
yellow, slightly spotted brownish at vein endings. Abdomen ventrally smoky-white, dorsally pale yellowish grey.

Male genitalia (Figs. 11–13). – Uncus bifid, medium length, with elongated basal part. Papillae short and broad, length approximately 0.5 times uncus length. Valva with short, broad and blunt ventral process near base, preceded by shallow medial cleft; with straight dorsal margin, tapered to apex; sacculus heavily sclerotized. Vinculum short, medium width. Aedeagus relatively long, slim, length approximately equal to valva length, approximately 4.0 times longer than medial width. Vesica armed with one broad, flat

apical sclerite and with one elongated, broad, twisted sclerite at ductus ejaculatorius base. 8th sternite peg-like, slightly broadened at base; basal cleft shallow; with one short and broad sclerotized apical rod; sternite length approximately 0.6 times valva length. Distribution. – Occurs from Morocco (ssp. *lecerfi* Prout, 1928) to Lebanon (ssp. *prouti* Zerny, 1933).

Similar species. – According to the structure of male genitalia, *E. deverrata* is closely related to *E. distinctaria* Herrich-Schäffer, 1848. There is no difference in structure of the male genitalia between these species. However, the 8th sternite of male *E. deverrata* is heavily sclerotized, with the basal cleft shallower, the apical project shorter, broader and more blunt than those in *E. distinctaria* (Fig. 14). The adults of *E. deverrata* rather similar to *E. liguriata*, but can be distinguished by the less arched costa near apex, the more pointed apex and the less rounded termen of forewing, the yellowish suffusion. The costal spots on the forewing smaller, the antemedian line obtuse, angled near costa, the postmedian line less curved, the pale subterminal line more distinct and more indented, with inner shade; on the hindwing the postmedian line less angled than those in *E. liguriata*.

Note. – The first record for Europe. The specimen mentioned under *Material* entry above had been misidentified as *Eupithecia liguriata*.



**Figs. 15–16.** Female genitalia of *Eupithecia*. **15** – *E. mandarinca* sp. n., holotype, bursa copulatrix; **16** – *E. spadiceata* Zerny, 1933 (Ukraine, Crimea), bursa copulatrix.

***Eupithecia mandarinca* sp. n.****(Fig. 3)**

Material examined. – Holotype ♀, Ukraine, Crimea, Karadagh, 26.vi.1924, at light (Djakonov leg.). Prep. gen.: No. 304, ♀ (Djakonov) (ZISP).

Diagnosis. – Labial palpi whitish grey; extending beyond front of eyes approximately 0.66 times diameter of eyes. Front, vertex and notum whitish grey. Wingspan 16.0 mm. Forewing with slightly arched costa, pointed apex and obliquely faintly rounded termen; ground colour whitish grey; crosslines light brownish grey; basal, ante- and postmedian lines forming a broad dark costal spots; basal and antemedian lines evenly curved; postbasal line inconspicuous; postmedian line slightly sinuous, three times obtusely angled toward costa; terminal area broad, darker, brownish grey; whitish subterminal line wide, broken; terminal line very weak defined, fine, brownish grey, interrupted by veins; discal spot large, elongate, rather ovate-oblong, brownish grey. Hindwing with weakly concave termen; slightly paler, whitish grey; basal and medial areas mottled and irrorate with brownish grey scales; terminal area broad, darker, brownish grey as on the forewing; pale subterminal line rather indistinct, indented, fine and broken; discal spot large, narrow and elongate, dark brownish grey. Fringe smoky-white, marked with brownish grey at vein endings.

The holotype lacks antennae, abdomen removed (see *Note* below).

Female genitalia (Fig. 15). – Bursa copulatrix pear-shaped; completely covered by small spines in broadest basal part; with narrower, spineless heavily sclerotized ductus bursae, which without longitudinal striations. Ductus seminalis membranous, broadly attached to medial part of corpus bursae. Ostium bursae large, broad, funnel-like, heavily sclerotized, with two long and broad ventral lobes.

Distribution. – Ukraine (Southern Crimea).

Flight. – The single known specimen was caught at light late June.

Similar species. – *E. limbata* Staudinger, 1879, the only species with which it may be confused. The new species distinguished externally from nominate subspecies of *E. limbata* in the paler ground colour, the more curved antemedian line; the postmedian line curved around discal spot at shorter distance; short and black touches on the veins of forewing absent. Unlike *E. limbata* it has indistinct crosslines on the hindwing, the terminal areas brownish-grey, without rust tint, the terminal lines inconspicuous, paler, but not black, and lighter, larger and more elongated discal spots are situated on the whole wings. The female of *E. mandarinca* sp. n. has a more elongated bursa copulatrix than that in *E. limbata*.

Note. – The genitalia slide of the type-specimen is apparently lost, however two good sketches of its genitalia were found in the archives of A. M. Djakonov.

***Eupithecia reisserata* Pinker, 1976****(Fig. 4)**

Material examined. – ♂, 8♀, Greece, Arkadia, 19 km S. of Argos, 17.iv.1981; Arkadia, Astros, 19.iv.1981; Thrakia, S. of Ismaros, 150 m, 30.iv–1.v.1988; Sithonia, 6 km NW. of Koufos, 5.v.1988, Schepler leg. (ZMUC).

Note. – The first record for Europe. The moths from Greece are larger, darker and more brown than those of the nominotypical subspecies from Anatolia and Naxçivan

(Azerbaijan). They are rather similar to ssp. *levarii* Hausmann, 1991 described from Jordan. The sclerites on the vesica in the male genitalia of this species are very variable, as reported for the first time by Hausmann (1991).

***Eupithecia spadiceata* Zerny, 1933**

(Figs. 5–6)

Material examined. – ♀, Ukraine, Crimea, Krasnolesye, 7.vii.1986, Zaguljaev leg. (ZISP).

Note. – The first record for Europe. I found a single Crimean specimen of this species in poor condition on a cotton layer. The genitalia of this specimen are illustrated (Fig. 16).

**Acknowledgements**

I am grateful to O. Karsholt (Zoological Museum, University of Copenhagen) and Dr A. Hausmann (Zoologische Staatssammlung München) who provided access to the material. My thanks are due to Mr C. Herbulot (Paris) for exhaustive information about the type specimen of *Eupithecia lentiscata*, and to my Russian colleagues Dr S. V. Baryshnikova, Dr V. A. Lukhtanov, Dr S. Yu. Sinev and Dr V. N. Tanasiychuk for valuable help and assistance. The project was sponsored by the Russian Fundamental Research Foundation (Code 98-04-49818).

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## *Araeopteron ecphaea*, a small noctuid moth in the West Palaeartic (Noctuidae: Acontiinae)

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**Summary.** The small Acontiine moth *Araeopteron ecphaea* (Hampson, 1914) is recorded new to the West Palaeartic from Greece, Turkey, Spain (including Mallorca), and is further reported from additional countries in the Afrotropical region. The species is redescribed and the genitalia of both sexes are figured for the first time. The worldwide distribution of the known species of the genus *Araeopteron* Hampson, 1893 is given.

**Zusammenfassung.** Die kleine Acontiinae *Araeopteron ecphaea* (Hampson, 1914) wurde in Griechenland, der Türkei und Spanien (einschließlich Mallorca) erstmalig für die West-Paläarktis nachgewiesen. Hinzu kommen Nachweise aus verschiedenen Ländern in der Afrotropischen Faunenregion. Die Morphologie der Art wird beschrieben, die Genitalia beider Geschlechter erstmals illustriert. Die Verbreitung der bislang bekannten Arten der Gattung *Araeopteron* Hampson, 1893 wird aufgelistet.

**Résumé.** Le petit taxon d'Acontiinae *Araeopteron ecphaea* (Hampson, 1914) est nouvellement rapportée pour la région paléarctique occidentale de Grèce, de Turquie et de d'Espagne (comprenant Majorque), et est également mentionnée de pays supplémentaires de la région Afrotropicale. L'espèce est redécrite et l'armure génitale des deux sexes est illustrée pour la première fois. La répartition mondiale des espèces connues du genre *Araeopteron* Hampson, 1893 est donnée.

Key words. Noctuidae, Acontiinae, *Araeopteron ecphaea*, West Palaeartics

### Introduction

Among the Microlepidoptera preserved for Ole Karsholt, Zoological Museum Copenhagen (ZMUC), was one specimen of a very small Noctuid taken by the first author from Greece in July 1990. The determination caused difficulty, both because the conspicuous wing-shape was unfamiliar among European Noctuidae, and the specimen was a female. Judging from the size, the wing pattern, and the shape of the wings the specimen could belong to *Araeopteron* Hampson but the distribution of species in this genus made it unlikely. The closest known *Araeopteron* species, geographically, are from Sri Lanka and Nigeria. A loan of two of the five species occurring in Japan made it clear from the genitalia that the Greek specimen indeed belonged to *Araeopteron*, and it was presented at the Noctuidae workshop during the SEL Congress in Lednice in 1994. The first author decided not to publish the record until both sexes were known, and tried with success to obtain further specimens in 1997 (one male was recorded).

The second European specimen to be recognised, a male, was taken by the second author on Mallorca in May 1997. It was shown to various experts in The Natural History Museum (NHM) in London, among whom Jeremy Holloway, suggested to David Agassiz the Acontiinae subfamily. The Mallorcan specimen appeared to match the holotype of *Araeopteron ecphaea*. A dissection of the holotype by Martin Honey confirmed that the Greek specimen was conspecific with *A. ecphaea* Hampson.

***Araeopteron ecphaea* (Hampson, 1914)**

Material examined. – In all 19 specimens of *Araeopteron ecphaea* are known: Holotype ♂ (Fig. 1), Nigeria, Baro, Genitalia slide No. BM Noct. 16421, coll. NHM (Fig. 5); ♀ Greece, 10 km S of Iguminitsa, 2 m, 25–26.vii.1990, Genit. prep. 4844 O.Karsholt, leg. & coll. M.Fibiger; ♂, Greece, 11 km S of Iguminitsa, Plataria-Faskomilia, 30 m, 14.v.1997, genit. prep. 3150 M. Fibiger, leg. H. Habeler, coll. H. Hacker; ♂, Greece, 12 km S of Iguminitsa, Plataria, 5 m, 29.vii.1997, leg. & coll. M. Fibiger; 2♂, 1♀, Greece, W, Lefkada Is., Nidri, 16-19.viii.1995, leg. J. P. Baungaard, coll. ZMUC; 3♂, Greece, Crete, 15 km S Chania, 100 m, 30.vi.2000, leg. M. Fibiger, D. Nilsson, A. Madsen, P. Svendsen; 3♂ Spain, Mallorca, S'Albufera, coll. NHM: (i) 22.viii.1995, leg. N. Riddiford, BM Noct. slide No. 16427 (Fig s 3–4), (ii) 26.viii.1995, leg. N. Riddiford, (iii) 3.v.1997, leg. D. J. L. Agassiz (Fig. 2); ♂, Spain, prov. Cadiz, 2 km S of Almoreima, 50 m, 24.ix.1987, leg. P. Skou, genit. prep. 3609 M. Fibiger, coll. ZMUC; ♂, Spain, Barcelona, Lloret de Mar, 30.vi.-7.vii.1998, leg. & coll. Z. Tokár; ♂, Turkey, Taurus, 10 km N Adana, 50 m, 6.ix.1983, genit. prep. 3157 M. Fibiger, leg. & coll. G. Derra; ♂, Yemen, Prov. Ibb, Wadi Malhama, Village Malhama, 20 km NNE Ibb, 1650 m, 6.v.1998, genit. prep. 3163 M. Fibiger, leg. A. Bischof, J. Bittermann, M. Fibiger, H. Hacker, H. Peks, H.-P. Schreier; ♂, Congo, Elisabethville, 24.x.1937, genit. prep. 3160 M. Fibiger, leg. Ch. Seydel, Royal Museum of Central Africa, Tervuren; ♂, Malawi, Mulanje Mts, Likabula, 800 m, 19.x.1996, *Brachystegia* forest, LF, genit. prep. 3166 M. Fibiger, leg. W. Mey & M. Nuss, Museum für Naturkunde, Berlin; ♂, Namibia, E Caprivi, Katima Mulilo, 17°29 S / 24°17 E, lux, 3–8.iii.1992, genit. prep. 3165 M. Fibiger, leg. W. Mey, coll. Museum für Naturkunde, Berlin.

Diagnosis. – Wingspan 11–12 mm. Head pale straw, palpi curved upwards, terminal segment 2/3 length of second segment; ochreous, suffused dark fuscous on outer sides. Antennae of both sexes filiform, pale straw. Thorax and forewing pale straw, costa of forewing with irregular sequence of narrow blackish spots; crosslines light brownish, weakly marked, terminal area suffused blackish from tornus to below apex forming an indistinct spot one third of distance from apex; subterminal line whitish; terminal spots present; fringes with suffusion of fuscous scales; a conspicuous black discal spot. Hindwing heavily suffused blackish and fuscous. Abdomen blackish, pale scaled on edge of each segment and anal tuft. Legs pale ochreous, foreleg suffused blackish above, 2 tibial spurs on hind leg.

Male genitalia. – Armature (Fig. 3) simple, uncus curved, valves with a strong thorn-like clasper arising from the inner surface and reaching to the costa. Aedeagus (Fig. 4) cylindrical, a small sclerotised plate in the vesica.

Female genitalia (Fig. 5). – Ductus bursae twisted with a broad diverticulum, corpus bursae ovoid, signum comprising a "shuttlecock" shaped structure, with a variable number of spines internally. Ventrally, between the 8th and 9th abdominal segments, and between the anterior ends of the ovipositor lobes is a peculiar membranous, rounded, conical structure (a flat-topped hill) with long narrow setae. This structure varies in size and shape between the species but may be autapomorphic for the genus.

Bionomics. – Little is known concerning the biology of *Araeopteron* species. Like other Acontiinae species *A. ecphaea* seems to be multiple brooded, in Europe at least occurring from May to September. The habitats are situated in moist areas. The Greek specimens were taken close to the seashore in dried-out maquis and grass vegetation, but not from river beds or around lakes. The Mallorcan specimens were recorded from the middle of a large (2 x 1km) wetland biotope, consisting mainly of *Phragmites* reedbeds, they were taken at the Park headquarters. All specimens were taken at light, 15W superactinic tube and 125W mercury vapour lamps, respectively. The early stages are unknown.



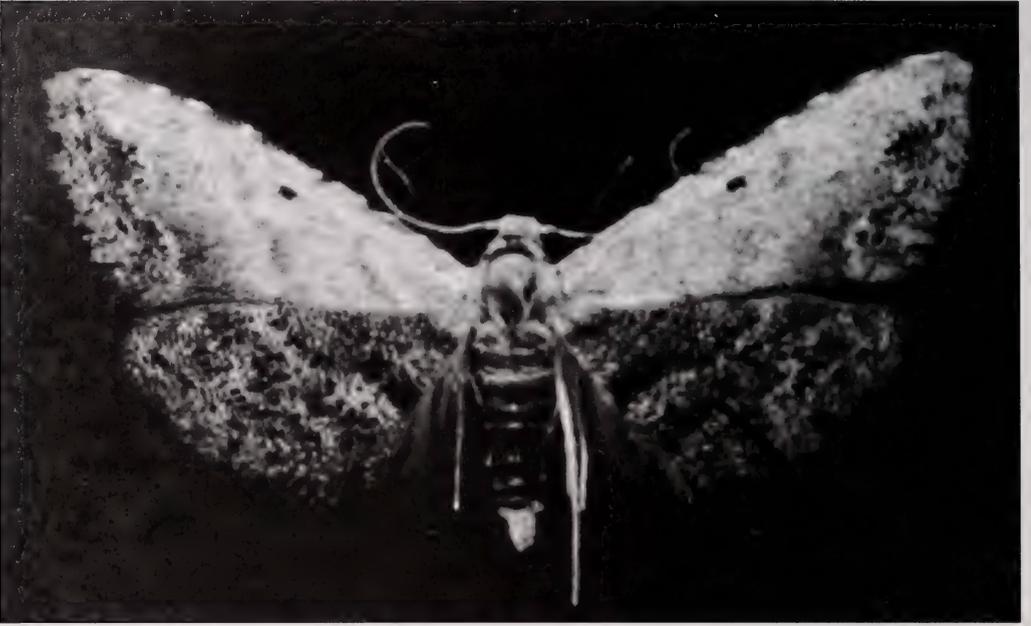
Fig. 1. Holotype female *Araeopteron ecphaea* (Hampson), Nigeria, Baro.

Remarks. – The genus *Araeopteron* was erected by Hampson in 1893 as a monotypic genus for the species *A. pictale*. Since then 28 more species have been described in the genus, *ecphaea* was originally described in *Araeoptera* a Hampson, 1914, a synonym of *Araeopteron*. The apomorphic characters states which define the genus are in the wing venation (Fig. 6) and the structure in the female genitalia described above. Other synapomorphies for *Araeopteron* are the pointed apex of the narrow forewing and in the genitalia the structure of the male armature and the signum in the bursa of the female. These are distinct from other European representatives of Acontiinae. The monophyly of the Acontiinae is based on the following characters: an enlarged, heavily sclerotised alula overlying the tympanum and a reduced counter-tympanal hood. The male genitalia are often asymmetrical. In larvae the spinneret is often reduced, SV2 is absent on A1 and prolegs are absent on A3-4. Acontiinae larvae are frequently obligate feeders on Malvales and Asteraceae, but are of no economic importance (Kitching & Rawlins, 1999).

*A. ecphaea* has a characteristic resting posture for a noctuid moth, which might prove to be a synapomorphic character for the genus: the forewings are slightly spread so that the termen of the hindwing is visible.

In the European list of Noctuidae (Fibiger & Hacker 1991; Nowacki & Fibiger 1996) *Araeopteron* should be listed between *Eublemma* and *Rhypagia*.

Distribution. – The 29 described species of *Araeopteron* are distributed in the tropical and sub-tropical regions world-wide. In the Palaearctic *Araeopteron* is known from five species from the East Palaearctic and at least two undescribed species. To these is now added *A. ecphaea* from Europe (Greece, mainland Spain and Mallorca), from Turkey, the Arabian Peninsula and from the Ethiopian region (Nigeria, Congo, Malawi, Namibia). An undescribed species occurs in Sierra Leone. In the Oriental region occur 12 described species, mostly from Sri Lanka, and also including Borneo, Mauritius and



**Fig. 2.** Male, Mallorca, S'Albufera, 5.v.1997.



**Fig. 3.** Male genital armature of *A. ecphaea*.



Fig. 4. Aedeagus removed from armature of Fig. 3.



Fig. 5. Female genitalia of holotype of *A. ecphaea*.

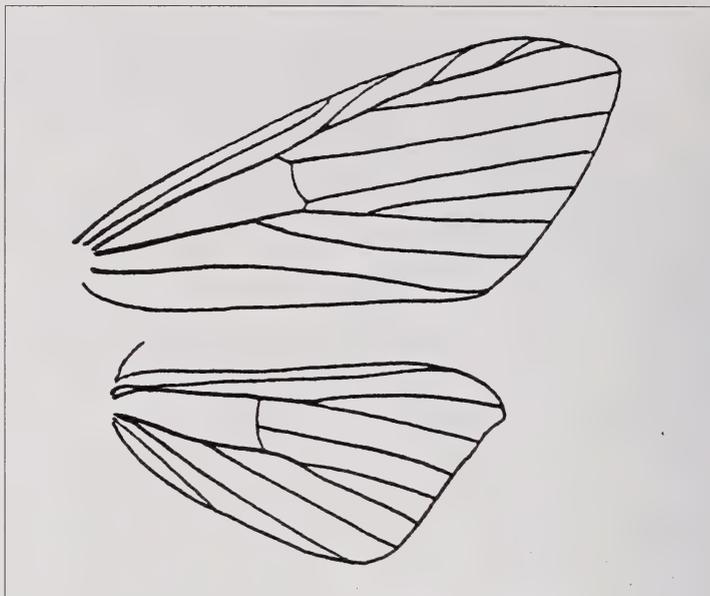


Fig. 6. Wing venation of an *Araeopteron* species (from Inoue, 1958)

the Seychelles. Undescribed species occur in Thailand and Hong Kong. In the Australian region seven species have been described from eastern Australia (Queensland). In the Neotropical region (The Caribbean) 4 species occur.

Further study may reveal that *Araeopteron* has a less fragmented distribution in the world, and that *A. ecphaea* in Europe is more widely distributed in near-coastal habitats of the Mediterranean area.

#### Acknowledgements

We are sincerely grateful to Ole Karsholt, ZMUC for recognising the small Noctuid from Greece and for genitalia preparation; to Jeremy Holloway (NHM) for helpful advice, to Martin Honey (NHM) for genitalia preparation and photographs of the holotype and other specimens, and advice about literature, and to T. Mano and H. Yoshimoto, Japan, W. Mey, Berlin, U. Dall'Asta, Tervuren, G. Derra, Bamberg, and H. Hacker, Staffelstein for loan of *Araeopteron* material. The study yielding the Mallorcan specimens formed part of Earthwatch Europe's Project S'Albufera, a long-term programme of research into biodiversity and environmental change at the Parc Natural de S'Albufera, Mallorca. We would like to thank the Balearic Ministry of the Environment's Conservation department for granting permission to operate, Earthwatch Europe for its support and the park staff for their friendship and help.

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## Book Review

**Hausmann, A. 2001. Introduction. Archiearinae, Orthostixinae, Desmobathrinae, Alsophilinae, Geometrinae.** – *In*: A. Hausmann (ed.), *The geometrid moths of Europe 1*, 282 pp. Apollo Books, Stenstrup. – ISBN 87-88757-35-8. Price DKK 490,00.

This book is the first volume of a new series aimed to provide a monographic treatment of European geometrid moths. It is the first book since 80 years which deals with this diverse group in the whole Western Palaearctic region. A comprehensive work on geometrid morphology, especially on the diagnostically important genitalia, has been lacking. Data on biology and habitats are also widely scattered in the literature and hence difficult to access.

The first part of the new volume gives general information about ecology, morphology and systematics of the family. It covers many aspects, some of them of a more general character like conservation or the meaning of collections. A chapter on the morphology of Geometridae contains a compilation of important information and will be particularly useful for readers who do not have access to the scattered literature on this subject.

In the second part of the book a systematic account is given of the subfamilies Archiearinae, Orthostixinae, Desmobathrinae, Alsophilinae and Geometrinae. For each of the 41 species the following information is presented: valid and unavailable names, diagnosis, genitalia of both sexes, distribution, phenology, biology (including larval host plants), parasitoids (when data available), habitat, similar species and remarks. The text is short and informative with focus on taxonomical and morphological problems. Additional black and white photographs showing diagnostic characters are scattered in the text. Although a identification key is lacking, one of the great merits of the book is that it offers the possibility to identify Geometridae of Europe safely.

Adults of the species are illustrated in natural size on eight colour plates with up to 18 individuals per species to show the variation within one taxon. Eighteen black and white plates contain drawings of all genitalia of both sexes. The quality of the colour plates is not excellent but good; a higher resolution would be desirable for further volumes of the series. Early stages are not illustrated. At least a representative choice of larvae and references to illustrations in the literature would have been helpful.

For each species a distribution map is added in which those localities are marked from which specimens have been examined. This gives a clear picture of the European distribution of the species. Additionally, a hypothetical resident distribution area is underlayed in grey. All dots should be within the hypothetical area, but this not always the case. It is sometimes difficult to comprehend the information that lead to the hypothetical area.

Information on host plants are much more transparent because the original source of each record is cited and it is noticed whether the larvae were found on a plant or were reared in captivity. Botanical nomenclature follows a book on the central European flora which may not be accurate for many of the mediterranean species. It would often be helpful for the reader if the plant families would always be mentioned, particularly if less common plants are listed. The introduction to the systematic account should list all references and sources used because it remains unknown to the reader if the lists of host plants and parasitoids are fully comprehensive. For the parasitoids this may not be the case because only very few sources mainly from the 1940ies have been used

Hopefully, this new standard book on Geometridae will find a wide distribution among Lepidopterists within and outside Europe, increases the knowledge further and makes new friends to this beautiful group of moths. We can look forward to five more volumes, the next (Larentiinae I) will be published late 2001.

*Gunnar Brehm*

## On the presence of *Phytometra sanctiflorentis* and *Heterophysa dumetorum* in Italy (Noctuidae)

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**Summary.** The presence of *Heterophysa dumetorum* (Geyer, 1834) in Italy is confirmed, whereas *Phytometra sanctiflorentis* (Boisduval, 1834) is to be definitively excluded from the list of the Italian fauna.

**Zusammenfassung.** Das Vorkommen von *Heterophysa dumetorum* (Geyer, 1834) in Italien wird bestätigt. *Phytometra sanctiflorentis* (Boisduval, 1834) wurde aufgrund einer Fehlbestimmung für Italien gemeldet und ist damit nicht für die Fauna Italiens bekannt.

**Résumé.** La présence en Italie de *Heterophysa dumetorum* (Geyer, 1834) est confirmée, alors que *Phytometra sanctiflorentis* (Boisduval, 1834) est à exclure définitivement de la faune italienne.

The examination of the original material, preserved in the collections Attilio Fiori (Museo Civico di Storia Naturale of Milan) and Roger Verity (Museo Zoologico de “La Specola” of Florence), has allowed to confirm the presence of *Heterophysa dumetorum* in Italy and to exclude *Phytometra sanctiflorentis* definitively from the list of the Italian fauna.

### *Phytometra sanctiflorentis* (Boisduval, 1834)

Verity (1905) recorded the presence of *Prothymnia sanctiflorentis*, “new species for Italy”, on the coast of Tuscany at Forte dei Marmi. This only record is taken up by Mariani (1941–43), who reports it for Tuscany. Raineri & Zilli (1995) and Nowacki & Fibiger (1996) raised doubts about its presence in Italy. In the Verity collection there are three specimens determined as belonging to this species, one of which was caught at Forte dei Marmi in September 1903. They completely lack the red colour, which is generally present in *Phytometra viridaria* (Clerck 1759), but they lack the other characteristics typical of *P. sanctiflorentis*: brown median shade of fore wing more perpendicular, less slanted, reniform stigma lighter than the ground colour and marked by two overlapping blackish spots, etc. Therefore they are specimens of *P. viridaria* which can be attributed to f. *fusca* Tutt, 1892, as recorded by Berio (1991).

According to Calle (1982) *P. sanctiflorentis* is endemic to the Iberian peninsula where it is recorded from Spain and Portugal (Nowacki & Fibiger 1996). It is to be definitively excluded from the Italian fauna.

### *Heterophysa dumetorum* (Geyer, [1834])

Costantini (1922) signalled the presence of *Luperina dumetorum* Hb.-Geyer in central Italy, on the basis of a specimen collected by Attilio Fiori at Arapietra (on the northern

slope of Gran Sasso, in Abruzzo) on 27 July 1898 (Turati det.). The record, however, was ignored by the following faunal catalogues and neither Mariani (1941–43), nor Raineri & Zilli (1995), nor Nowacki & Fibiger (1996) reported the species as present in Italy. The above mentioned specimen is stored in the Fiori collection: besides the label with the place and date of collection (the same reported by Costantini), it bears another label written by Boursin, who confirmed the previous determination by Turati. The determination was further confirmed by examination of the male genital armature, which is depicted in Calle (1982).

The species is also known from Spain and France (Nowacki & Fibiger, 1996). Outside Europe, *H. dumetorum* is represented by the subspecies *mutica* (Christoph, 1885), which is distributed in Anatolia, Caucasus, Transcaucasia, Armenia, Turkestan, and Mazandaran.

### Acknowledgements

I would like to thank for their collaboration the curators of Museo Zoologico de "La Specola" of Florence and of Museo Civico di Storia Naturale of Milan and Dr. Alberto Zilli, of Museo Civico di Zoologia of Rome.

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## Habitat utilization and behaviour of adult *Parnassius mnemosyne* (Lepidoptera: Papilionidae) in the Litovelské Pomoraví, Czech Republic

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**Summary.** Within-habitat distribution and diurnal behaviour of adults of the Clouded Apollo (*Parnassius mnemosyne*) were studied in the Litovelské Pomoraví, Moravia, Czech Republic. Data were collected by censuses along a regular transect route, which crossed three clearings in a mature deciduous forest. A loglinear model was constructed in order to explain variability in collected behavioural data. Hour of observation, Transect section, Behaviour, Sex and the interactions among factors Transect section-Behaviour and Sex-Behaviour significantly influenced the number of butterflies seen. More males compared to females were seen, both sexes markedly prevailed at the clearings, they hardly ever entered the high forest. Mating, oviposition and late afternoon basking-resting were all also restricted to the clearings. These findings further highlight the importance of sunny forest gaps for conservation of the species in Central Europe. There was no distinct diurnal pattern in behaviour, except for the fact that males patrolled for most of day-time, but predominantly basked in early mornings and late afternoons. Females behaved much more cryptically, they spent their time by nectaring (more so than males) and laying eggs. The lack of distinct diurnal patterns in behaviour is tentatively explained by high-altitude origin of the species.

**Zusammenfassung.** Das Vorkommen adulter Tiere des Schwarzen Apollon (*Parnassius mnemosyne*) innerhalb ihres Lebensraumes sowie deren tageszeitliche Verhaltensmuster wurde im mährischen Gebiet Litovelské Pomoraví in der Tschechische Republik untersucht. Die Datenerfassung erfolgte entlang eines Transekts, welcher drei Lichtungen in einem alten Laubwald kreuzte. Ein logarithmisch-lineares Modell wurde entwickelt, um die Variation der gesammelten Verhaltensdaten zu veranschaulichen. Die Stunde der Beobachtung, Transektbereich, Verhalten, Geschlecht sowie die Interaktionen zwischen Transektbereich-Verhalten und Geschlecht-Verhalten beeinflussten die Anzahl der gesichteten Falter signifikant. Es wurden mehr Männchen als Weibchen beobachtet; beide Geschlechter waren vorwiegend auf den Lichtungen und flogen kaum in den Hochwald. Kopulation, Eiablage und die spät-nachmittägliche Sonnenbad-Ruhe waren ebenfalls auf die Lichtungen beschränkt. Diese Ergebnisse machen die Bedeutung sonniger Waldlichtungen für die Erhaltung der Art in Mitteleuropa deutlich. Es gab keine unterschiedlichen Verhaltensmuster am Tage, mit Ausnahme der Tatsache, daß die Männchen die meiste Zeit des Tages mit dem Patrouillieren verbrachten und sich vorwiegend am frühen Morgen sowie am späten Nachmittag sonnten. Die Weibchen verhalten sich deutlich kryptischer, verbringen mehr Zeit beim Nektarsaugen und natürlich mit der Eiablage. Das Fehlen eines ausgeprägten Verhaltensmusters im Tagesverlauf wird mit einem stammesgeschichtlichen Ursprung der Art in hohen Berglagen erklärt.

**Resumé.** La répartition dans l'habitat et le comportement diurne des adultes du Semi-apollo (*Parnassius mnemosyne* (Linnaeus, 1758)) ont été étudiés dans le Litovelské Pomoraví, République tchèque. Les données ont été collectées lors de parcours réguliers sur une voie qui croise trois éclaircies dans une forêt déciduée mature. Un modèle loglinéaire a été établi pour expliquer la variabilité des données sur le comportement. L'heure d'observation, la section du transect le comportement, le sexe et les interactions de facteurs telles que transect-comportement et sexe-comportement, influen-

cent significativement le nombre de papillons observés. Il y avait plus de mâles observés que de femelles, les deux sexes se rencontrant principalement dans les clairières et pénétrant difficilement dans les sous-bois forestiers denses. Les phases d'accouplement, de ponte et de repos de fin d'après-midi étaient limitées exclusivement aux clairières. Ces résultats confortent l'importance primordiale d'espaces ensoleillés en forêt pour la conservation de l'espèce en Europe centrale. Il n'y a pas de partition journalière distincte du comportement, hormis le fait que les mâles patrouillent presque toute la journée et se reposent principalement tôt le matin ou en fin d'après-midi. Les femelles ont un comportement encore plus cryptique, passent l'essentiel de leur temps à s'alimenter (plus que les mâles) et à pondre. L'absence de partition journalière comportementale pourrait s'expliquer par l'origine de haute altitude de cette espèce.

**Key words.** *Parnassius mnemosyne*, butterfly conservation, diurnal behaviour, mate locating, copulation, sphragis, forest Lepidoptera.

## Introduction

The endangered Clouded Apollo, *Parnassius mnemosyne* (Linnaeus, 1758) is a forest-dwelling butterfly in western part of its range (i.e. north-western and central Europe). Its larvae feed on *Corydalis* plants in early spring. At its localities, it forms relatively sedentary populations with limited adult dispersal (Väisänen & Somerma 1985; Napolitano *et al.* 1988; Aagaard & Hanssen 1992; Kudrna & Seufert 1991; Konvička & Kuras 1999; Megléc *et al.* 1999). Genetic separation was documented for populations separated by about 10 km of non-hospitable habitats (Descimon & Napolitano 1993; Napolitano & Descimon 1994; Megléc *et al.* 1997b; Megléc *et al.* 1998). It was also suggested that the species persists at its localities via metapopulation dynamics (Konvička & Kuras 1999; Megléc *et al.* 1999). From the studies cited, conclusions regarding causes of vulnerability and implications for conservation of *P. mnemosyne* in North-western and Central Europe emerged. In the area of interest, the butterfly inhabits structured habitats that consist of deciduous forests interspersed with clearings, glades and forest meadows. The cited authors agree that (1) smaller clearings are preferable to large-sized clear-cuts and (2) with regard to conservation management, it is recommended to generate new clearings concurrently with the succession on old habitat patches. Despite indisputable importance of such information for conservation management, only a few of the studies cited above (e.g. Kudrna & Seufert 1991) provide evidence for the dependency of *P. mnemosyne* on sunny patches and gaps. Particularly, there are contradictory information, even from geographically close areas, regarding location of oviposition sites of females (i.e. larval habitats) and microhabitat distribution of adults. Megléc *et al.* (1999), who studied *P. mnemosyne* in NE Hungary, stated, that „females lay their eggs in the forests near clearings“, while Kudrna & Seufert (1991) and Konvička & Kuras (1999) (working, respectively, in the Rhön Mts., Bavaria and in the Litovelské Pomoraví, Czech Republic) observed that majority of egg-laying occurred at forest clearings. However, no study to date aimed specifically on deducing patterns of *P. mnemosyne* adult habitat utilisation. Here, we investigate within-habitat distribution of *P. mnemosyne* adults, as well as changes of adult distribution and behaviour during day time. We basically asked, which sections of their habitats do adult butterflies frequent and what do they do there.

## Material and methods

This study was performed in the Litovelské Pomoraví Protected Landscape Area, Moravia, Czech Republic (49°40'N and 16°55'E). The area is a Moravian stronghold of *P. mnemosyne* (Kuras *et al.* in press). There are several distinct colonies of the butterfly, which are interconnected by imaginal dispersal. Prior to this study in 1996, the total adult population size was estimated, using mark-release-recapture methods, to exceed 1000 individuals (Konvička & Kuras 1999) and did not change abruptly ever since (unpublished). The colonies are largely confined to commercial clearings within mesophilous deciduous forests, which grow on mild hills of the Třesínský Práh Ridge (left bank of the Morava River). The fieldwork was carried out at southern slopes the Mlýnský Vrch Hill (370 m); the study site is inhabited by the largest of the local colonies.

In May 1999, we delimited a regular transect route across the colony site. The route, which was 800 m long, was divided into 5 sections, which were clearly differentiated by vegetation. The sections were as follows: A – Clearing 7 years old, reforested by oak and ash saplings, dense shrub layer consisting mainly of *Rubus* spp. and *Sambucus* spp. B – Sparse and light deciduous forest (oak, hornbeam and basswood) about 100 years old. C – Clearing 3 years old, previously oak and spruce forest, now reforested with oak. D – Mature (80 years) forest consisting of oak, beech and hornbeam, relatively dense and shady. E – Glade, about 10 meters wide which separated a clearing about 12 years old from dense oak-hornbeam forest. The adjoining clearing was reforested by oak and ash (with dense *Rubus* and *Sambucus* shrub layer), the forest was as in subsite D.

We walked the transect on May 17, 19, 20, 23, 24 and 25, 1999, attempting – if weather permitted – to cover entire days, i.e. from 9 AM till 18 PM (Central European summer time). We restricted our observations to one week only, since *P. mnemosyne* is a protandrous species (cf. Ebert & Rennwald 1991), and temporal changes in sex ratio might seriously affect a behavioural pattern observed. For each encountered butterfly, we recorded respective transect section, sex and behaviour. For recording of behaviour, we recognised the following categories: “Flight-Patrolling” (if males, the mate-locating activity as defined in Scott (1974); if females, any rather straight searching flight); “Nectaring”; “Basking/Resting”; “Copulation”; “Oviposition” (any of the specific sequence of behaviours described in Konvička and Kuras 1999); and “Chasing”.

To study the relationships among discrete variables we used log-linear models (LLM) for multidimensional contingency tables (Zar 1996). LLM may be used to analyse surveys, which have complex (multi-way) interrelationships among the variables. We used the program NCSS 6.0.22 (© Jerry Hintze 1997) with default options. The first step in LLM is to find an appropriate model of the data. Hierarchical models are a particular class of models in which no interaction term is specified unless all subset combinations of that term are also in the model. We employed the step-down selection procedure, which begins with the full, saturated model and searches for a model with fewer terms that still fits well. The program uses a backward elimination selection technique. This procedure works as follows. First, a significance level (here:  $\alpha = 0.05$ ) is chosen for the goodness of fit test to signal if a model does not fit the data more severely than just by

random effects. Next, each of the highest-order hierarchical terms is removed, being replaced with appropriate terms so that the resulting expanded model differs only by the term of interest. The  $G^2$  values of the original model and the subset model are then subtracted so that the term may be tested individually. The model with the largest significance probability is chosen for the next step. The procedure terminates when no sub-model can be found with a probability greater than alpha (Hintze 1995). In the model constructed, the number of butterflies seen was the frequency variable, while Behaviour, Hour, Sex and Transect section were factor variables. Since lengths of transect sections were unequal, we standardised all our observations on unified transects lengths before analysis. To avoid empty cells in the data matrix, we did not consider day of observation when constructing the model (not all combinations of date-hour were present in the data). Since zero counts are not permitted in computation of LLM, we added small delta values ( $\Delta' = 0.1$ ) to each cell count. Although the use of LLM requires few basic assumptions, there is the problem of pseudoreplication in our data set. We repeated walks on identical transect multiple times a day and this over six days of observation and thus, in practice, observations are not fully independent from each other which limits the interpretation of the model.

## Results

During the 1999 season, we walked 111 transects and obtained 2110 individual observations of *P. mnemosyne* (Table 1). However, the later number does not refer to individual butterflies but to observations, and many of the individuals were most probably seen several times. Males were observed more frequently than females, there were 7.2 times more records of males than females (deviation from 1:1 sex ratio,  $\chi^2_{1df}=702$ ,  $p \ll 0.001$ ). Also, observations of males markedly prevailed when evaluated on per-transect basis (Wilcoxon's Matched pairs test,  $n=111$ ,  $Z=9.10$ ,  $p \ll 0.001$ ). There was no significant shift in ratio of observed sexes in consecutive days (logit regression of numbers of observations of males vs females against consecutive days,  $\chi^2_{1df}=0.08$ ,  $p=0.78$ ). This suggests that changes in sex ratio with duration of flight season should not influence the patterns described below.

The individual transect sections differed significantly in numbers of butterflies recorded (Friedman's nonparametric ANOVA, males:  $Q^2_{4df}=295.76$ ,  $p \ll 0.001$ ; females:  $Q^2_{4df}=142.72$ ,  $p \ll 0.001$ ) (Fig. 1). Both sexes were mainly encountered on clearings, especially on the clearings C and E, less so on the clearing A. Very few animals were observed to fly under the closed-canopy forest (sections B and D). In fact, the prevalence of butterflies on clearings was even stronger, since the section D was longer than the sections A, B and C (Fig. 2).

Butterflies were on the wing since about 9 AM, the first (basking) individuals were seen at 8:30 AM. Earlier in the morning, the vegetation was covered by dew and most of the clearings were shaded. At about 5 PM, there was a sharp drop in flying-patrolling activity and a corresponding increase in the proportion of basking-resting individuals (Fig. 3). The last butterflies, resting in lower layers of grassy vegetation, were seen shortly after 6 PM. Besides the late-afternoon drop in number of butterflies, there was a

**Tab. 1.** Descriptive statistics of observations of *Parnassius mnemosyne* individuals along the fixed transect route.

	Total no. of observations	Mean per transect	SE	Range
Both sexes	2110	19.0	0.72	5–54
Males	1852	16.7	0.66	4–50
Females	258	2.3	0.21	0–16

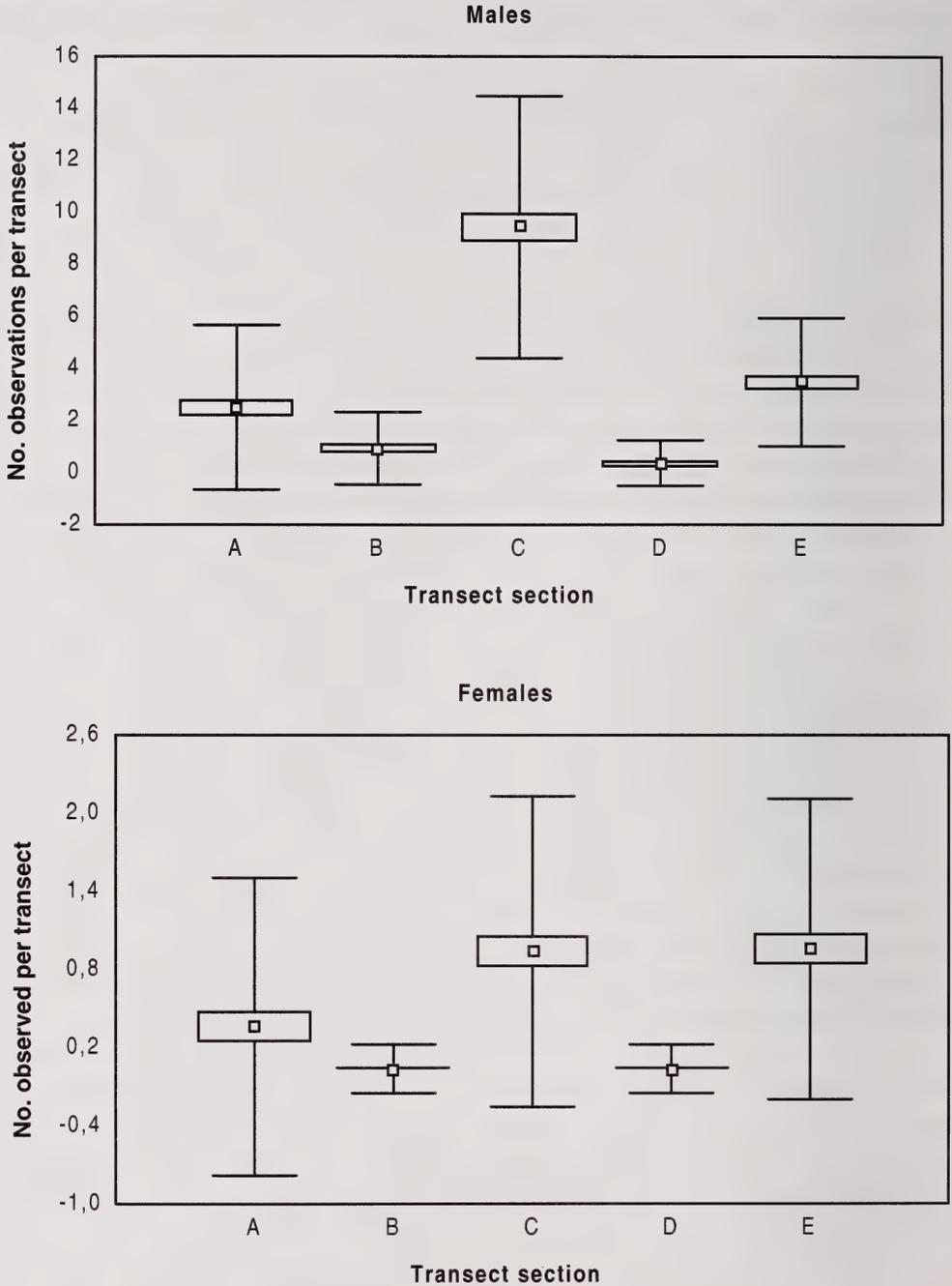
decrease in numbers of observed individuals along noon time contrasting with two “peaks”, which occurred earlier and later (see the numbers above bars in Fig. 3).

For most of days, the males actively patrolled over the clearings. During this mate-locating activity, they frequently chased each other (152 cases of chasing seen). 15 chases with females and 2 chases with other butterfly species (*Pieris napi*) were recorded. Besides of this, males occasionally investigated other light-coloured objects, such as whitish undersides of blackberry leaves (16 cases), or notebooks of observers (7 cases). Attempts to mate with non-receptive (sphragis-bearing) females were frequent (17 cases observed). The male typically approached a basking or resting female, who either ignored his attempt or responded by closing her wings. After a short time (about 10 seconds) the male typically gave up and flew away. No distinct escape reactions of females were seen.

We observed copulation from the beginning in 3 pairs. In addition to this, we observed 4 beginnings of copulations (and 7 mating pairs) in 1996. The three 1999 copulations started at 12:30, 12:30 and 14:40. Males approached virgin females shortly after their emergence: in 1996, two of the recorded 11 copulations started before females' wings dried. The males “raped” the females in a very short time, ranging from 5 to 15 seconds. While in copula, the pairs slowly crawled over the vegetation, the actively moving sex was always the female. The pairs remained in copula for several hours: the three matings that we observed to the end (one of them in 1996) lasted 110, 170 and 200 minutes. The extended copulation in Parnassiinae is necessary for sphragis formation (Petersen 1928; Scott 1973; Matsumoto 1987); in 2 pairs observed in 1999, the sphragis was well-formed 90–100 minutes after beginning of the copulation. After termination of the mating acts, both sexes basked for a while near the places where they mated.

Besides the females encountered during copulation, we observed only 3 virgin females. Two of them (freshly emerged) were seen in morning hours, the third was basking at 4:45 PM. It was of interest that several males flew nearby the „afternoon“ virgin without paying attention to her.

With regard to utilisation of nectar plants, we recorded 216 nectaring visits on 6 species of flowering plants. Females were seen nectaring more often than males: 19.8% of all observations of females occurred on nectar plants, while in males it was 9.2% ( $\chi^2_{1df}=21.42, p<0.001$ ). Numbers of nectaring records of per individual plant species, split according to sexes (males/females), were as follows: *Melandryum rubrum* (92/24), *Rubus* spp. (29/14), *Stellaria holostea* (24/2), *Myosotis nemorosa* (12/6), *Fragaria vesca* (7/1) and *Veronica chamaedrys* (3/2). The sexes did not differ in frequencies of



**Fig. 1.** Plot showing mean, standard deviation and standard error of numbers of *P. mnemosyne* males females seen on individual transect sections. The sections A, C, E were clearings, the sections B and D crossed high forest.

visits on individual plants (maximum likelihood  $\chi^2_{1df}=8.99$ ,  $p=0.11$ ). The nectar plant records in 1999 were necessarily limited to the species which flowered along the transect. In 1996 (cf. Konvička & Kuras 1999), we recorded utilisation of several other nectar plants, namely *Ajuga reptans*, *Alliaria officinalis*, *Ranunculus repens*, *Lychnis flos-cuculi*, *Knautia arvensis*, *Symphytum officinale* and *Taraxacum* spp.

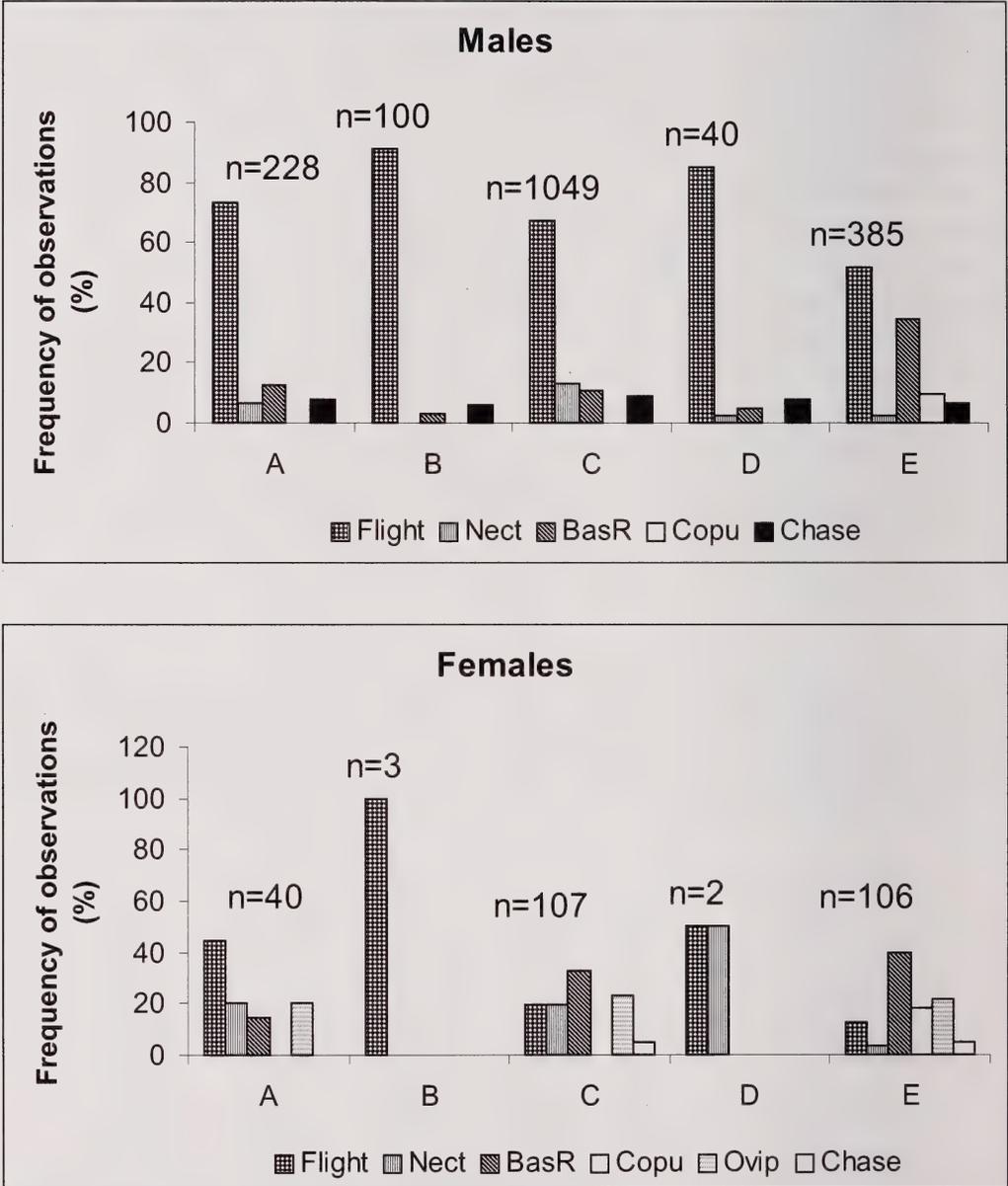
Table 2 summarises all terms (factors and interactions among factors) that were considered in the construction of the loglinear model. The step-down hierarchical model selection procedure selected the 34th model in order of decreasing complexity. Test for goodness of fit revealed good fit with the data (likelihood ratio  $G^2_{496df}=470.86$ ,  $p=0.76$ ; Pearson's  $\chi^2_{496df}=543.96$ ,  $p=0.07$ ). The factors that were included into the model thus sufficiently explained a substantial portion of variability in recorded data. The included factors were Hour, Transect section, Behaviour, and Sex; plus the two combinations of factors "Transect section – Behaviour", and "Behaviour – Sex".

The significant result for the two-factor term "Behaviour – Sex" is rather obvious, given, e.g., the nearly constant patrolling of males, or the fact that a high proportion of observed females were laying eggs (Fig. 2, 3). The significant influence of the interaction Behaviour – Transect section was most likely due to the uniform behaviour of the butterflies that were seen in closed forest (sections B and D), where virtually all the butterflies encountered were just flying as opposed to relatively diverse behaviours observed on clearings (Fig. 2). On the other hand, it was surprising that the interaction Behaviour-Hour was excluded from the final model, although the interaction was nomi-

**Tab. 2.** Summary of single-term tests of all terms (e.g. factors and combinations of factors) which were considered in construction of loglinear model explaining variability in observational records of *Parnassius mnemosyne* along a fixed transect route. The terms not included in the final model are given in *italics*. Partial  $G^2$  statistic tests whether the term is significant after considering all other terms of the same order. The marginal-association  $G^2$  tests whether the term is significant ignoring all other terms of the same order.

Term	d.f.	Partial $G^2$	P	Marginal $G^2$	P
Hour [A]	8	591.82	0.0000	591.82	0.0000
Transect section [B]	4	1752.71	0.0000	1752.71	0.0000
Behaviour [C]	5	2348.81	0.0000	2348.81	0.0000
Sex [D]	1	1327.15	0.0000	1327.15	0.0000
[BC]	20	271.52	0.0000	320.65	0.0000
[CD]	5	381.89	0.0000	425.09	0.0000
[AB]	32	72.33	0.0001	94.41	0.0000
[AC]	40	270.67	0.0000	301.55	0.0000
[AD]	8	12.73	0.1213	28.89	0.0003
[BD]	4	14.04	0.0072	48.45	0.0000
[ABC]	160	143.04	0.8280	158.82	0.5115
[ABD]	32	33.35	0.4013	58.10	0.0032
[ACD]	40	47.33	0.1984	49.99	0.1338
[BCD]	20	13.08	0.8739	11.54	0.9310

nally highly significant when tested separately (see Table 2) and some time-related differences are apparent by visual examination of the data (Fig. 3). However, the interaction Behaviour-Hour was included in the model that directly preceded the final selected model in the step-down selecting procedure, i.e. in the model 33, as well as in all hierarchically higher models. It was thus exclusion of this single factor that rendered the final



**Fig. 2.** Types of behaviour of adult *P. mnemosyne* observed at individual transect sections. Legend: Flight – flying and/or patrolling, Nect – Nectaring, BasR – Basking or resting, Copu – Copulation, Ovip – Egg laying, Chase – Chasing. The numbers above bars are total numbers of individuals (100%) seen at individual sections.

model formally significant. We conclude, that there are some diurnal differences in behaviour (e.g. much basking-resting in late afternoon or prevalence of nectaring in afternoon hours, see Fig. 3), but they are not very profound and were masked by other patterns in our data in model construction.

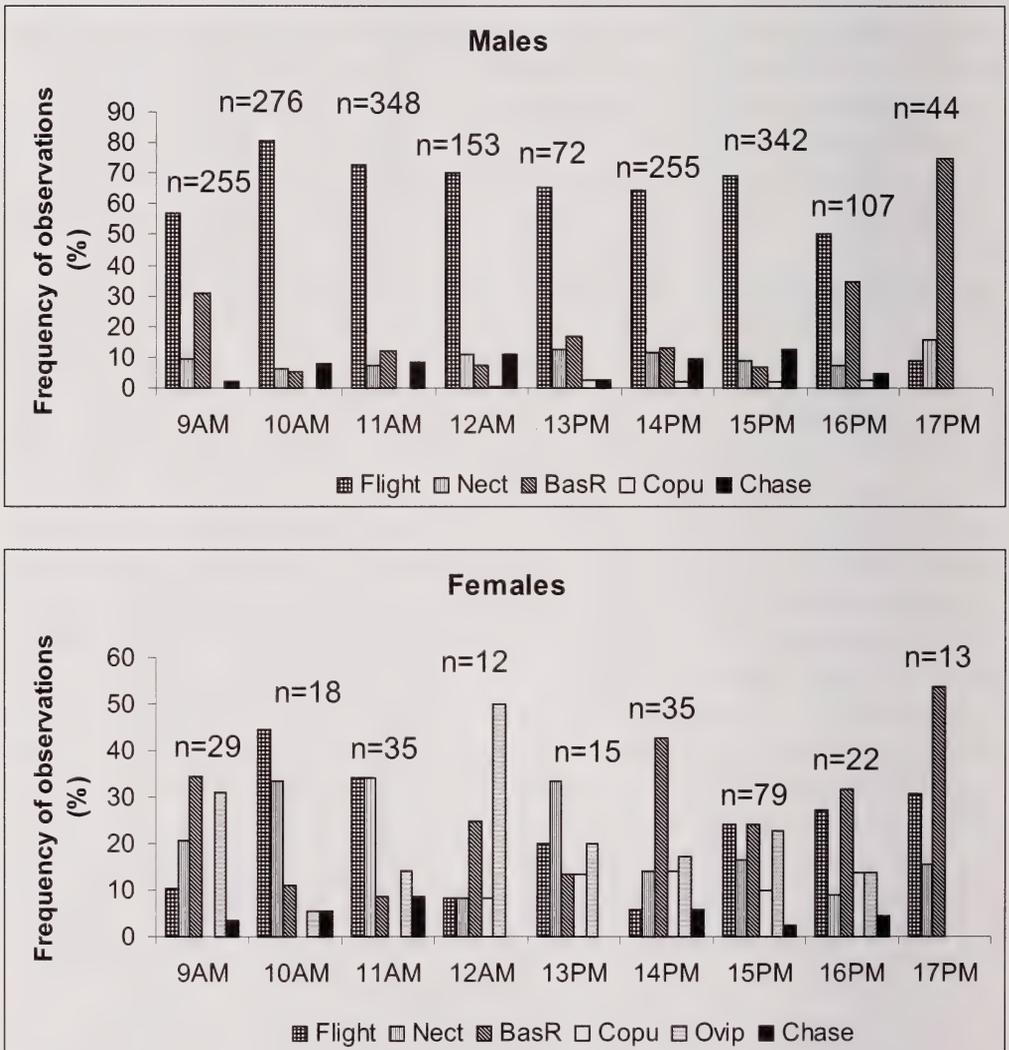
## Discussion

*P. mnemosyne* adults of both sexes spend most of their time at open forest clearings. This further supports the notion of strict gap dependency of European forest dwelling populations of this endangered species and confirms earlier conclusions of many authors (Väisänen & Somerma 1985; Kudrna & Seufert 1991; Konvička & Kuras 1999; Meglécz *et al.* 1999). In this respect, *P. mnemosyne* resembles other European forest-dwelling butterflies, many of which are locally endangered by modern changes of forest management (Warren & Key 1991; Robertson *et al.* 1995). Similarly, high forest was identified as a dispersal barrier for a Canadian population of *Parnassius smitheus* (Keyghobadi *et al.* 1999; Ronald *et al.* 2000). At our study locality, the forest clearings did not only serve as mate-locating and ovipositing sites; virtually all crucial events of *P. mnemosyne* adult life, i.e. mating, nectaring and overnight resting, were restricted to them. Although closed forest does not act as impenetrable barrier for *P. mnemosyne* adults (in 1996, as many as 60% of individuals of both sexes moved between “subsites” of the study colony; see Konvička & Kuras 1999), the butterflies seemed to avoid high forest. When crossing it, they did so by either straight flight or flying over treetops. Moreover, the fact that the butterflies stayed on the clearings throughout whole days nearly excludes a possibility of regular within-habitat movements, such as the movements between mate-locating and feeding sites, which have been described for some butterfly species (e.g. Dempster 1997). This information is of practical interest for conservation monitoring (such as transect censuses), because it guarantees that results obtained from any time of day between 10 AM and 4 PM are reliable for at least relative estimation of male population size.

The male-biased sex ratio in observations of individual sexes is in accord with other work done on Parnasiinae butterflies. However, any finding regarding sex ratio, if based solely on observational data, is necessarily biased due to different activity of sexes and resulting higher apparency of males. However, surplus of males in populations of *P. mnemosyne*, and related species, was reported from mark-release-recapture studies as well. Konvička & Kuras (1999) obtained capture sex ratios ranging from 2.0 to 10.6. Meglécz *et al.* (1997a, 1999) reported a “deficit of females” in *P. mnemosyne* populations in Hungary, while Scott (1973) and Matsumoto (1985) reported male-biased capture sex ratios in *Parnassius phoebus* F. and *Parnassius glacialis* Butler, respectively. Nothing definite can be said about realised sex ratio in *P. mnemosyne*, until sufficient data from lab rearing, and perhaps from specifically designed experiments (for instance, mark-release-recapture study done by independent workers separately with males and females) are available.

The behaviour observed in this study is in agreement with the patterns previously published for various species of Parnassinae (e.g. Scott 1973; Kudrna & Seufert 1991;

Matsumoto 1984, 1985). The higher relative frequency of nectaring in females is noteworthy, although it probably does not reflect higher energy requirements of that sex, but rather cryptic nature of the main females' activity, i.e. egg-laying. The lack of distinct courtship, frequent male harassment of non-receptive females and prolonged mating are common characteristics of sphragis forming species (cf. Scott 1974; McCorkle & Hammond 1985; Matsumoto 1987; Orr & Rutowski 1991; Matsumoto & Suzuki 1995; Orr 1995). The decrease of male patrolling towards late afternoon seems to concur with reduction of males' readiness to mate, as the only records of males that did not



**Fig. 3.** Types of behaviour of adult *P. mnemosyne* as observed during day time (both sexes and all transect sections combined). Legend: Flight – flying and/or patrolling, Nect – Nectaring, BasR – Basking or resting, Copu – Copulation, Ovip – Egg laying, Chase – Chasing. The numbers above bars are total numbers of individuals (100%) seen in respective hours.

show interest in virgin females came from late afternoon. The same situation was described for *Parnassius phoebus* by Scott (1973) and for *Luehdorfia japonica* by Matsumoto (1987). The late-afternoon disinterest in mating might correspond with the long duration of copulation, since a pair which would initiate copulation in too late an hour could not terminate it before sunset. Staying in copula after sunset would be selected against if there were increased mortality tied to overnight copulation.

The loglinear model did not point to any marked differences in behaviours in different hours of day, although there clearly were some differences, such as prevalence of basking/resting in morning and late afternoon hours. Thus, hour-to-hour behaviour of *P. mnemosyne* butterflies, the early morning and late afternoon hours aside (see Fig. 3), did not show any sharp diurnal changes. This is especially striking when compared to marked diurnal differences in behaviour reported for many nymphalids (e.g. Baker 1972; Bitzer & Shaw 1979; Wickman 1984; Fric & Konvička 2000) or skippers (Dennis & Williams 1987). We suggest that the situation found in *P. mnemosyne* might be explainable by descent of the species. Most of extant *Parnassius* species are found in mountainous regions, the entire genus has its greatest radiation in high-altitude habitats of mountains of Central Asia (Ackery 1975). Mountain origin of the group is supported by its phylogeny (Ackery *et al.* 1999; Holloway & Nielsen 1999). Even today, some populations of *P. mnemosyne* retain the ancestral generic habit to occur at high altitudes. Lack of distinct within-day behavioural patterns coupled with simple patrolling mate-locating behaviour was reported for several alpine and arctic butterflies including *Parnassius phoebus* (Scott 1973), *Erebia* ringlets (Brussard & Ehrlich 1970; Ikejiri *et al.* 1980) and alpine *Colias* species (Watt 1968). Behaviour of such species is strongly constrained by ever-changing, often adverse weather. They must respond immediately, irrespective of time of day, to abrupt changes of conditions in their alpine and/or arctic homelands, since a delayed response to any weather change might have fatal consequences. Lowland populations of *P. mnemosyne* probably retained the trait that allows mountainous populations of the species, as well as of its relatives, to inhabit high altitudes. Closer study of other lowland butterflies of tentative alpine origin (such as some European lowland *Erebia*) could reveal whether there, indeed, is a pattern in behavioural adaptations of mountain butterflies, which persists in their lowland congeners.

### Acknowledgements

We are grateful to two anonymous referees whose comments much improved quality of this paper.

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## Book Review

**Hodges, R. W. 1999. Gelechioidea, Gelechiidae (part), Gelechiinae (Part-*Chionodes*). - In: Dominick, R.B. et al., *The Moths of America North of Mexico, fascicle 7.6*. - The Wedge Entomological Research Foundation, Washington. - 21.3 x 28.1 cm, 339 pp., 49 black & white and 5 colour plates, paperback. - ISBN 0-933003-10-2.**

The 23<sup>rd</sup> publication in the prestigious series *The Moths of America North of Mexico* is the second part of Fascicle 7 that treats the Gelechiidae. This volume is entirely devoted to the gelechiid genus *Chionodes* Hübner and is the result of more than 30 years study of the North American fauna by the author. The diversity of this genus in northern America is enormous. A total of 187 species are recognized of which no fewer than 115 are new to science! For comparison, Karsholt and Razowski in their European catalogue mention only 28 taxa for Europe.

The book starts with a general introduction to the genus *Chionodes* in America north of Mexico. Collecting methods, diagnosis and classification are briefly discussed. The section on classification ends with a description of the six species groups in which the genus is subdivided. Line drawings of the typical male and female genitalia of each group and a key to group level complete this section.

The main body of the book consists of dichotomous keys to species level for each group followed by the species descriptions. The keys deserve special attention since they contain information not always present in the species description themselves. Despite an extensive text the keys are easy to use and essential for correct identification.

Each species is thoroughly described. Scientific name and list of synonyms are given with reference to the original publication. Type material of new species and their depositories are listed in full. For previously described taxa summaries are given (complete data of all material used for this study is available via internet). Short statements on ecology and distribution and a reference to similar species complete the description.

The book ends with a series of plates. On 49 black and white plates photographs of nearly all male and female genitalia of the species described are given. The photographs are of variable quality and despite the 49(!) plates in general too small to be used for direct identification. At this point one cannot but admire the keys to the species provided earlier in the book. Genitalia are most easily identified by switching between keys and illustrations. All species are figured on 5 colour plates. Though most species are well recognized, at up to two times the natural size, the moths are rather small and the plates appear too crowded. Having added one or two more plates would have allowed for fewer specimens per plate, a greater magnification, thus making details better visible, and it also would have avoided that species at the edge of the plates often have part of their wing cut off. It is also to be regretted that most pale specimens, through lack of contrast, nearly merge with the background. Studies on (North) American Lepidoptera rarely get much response from European lepidopterologists yet books like these surely deserve their attention. Not only is the book well written, its content is also of importance for those studying European Gelechiidae. At least four of the species treated here: *G. continuella*, *G. lugubrella*, *G. praeclarella* and *G. viduella* also occur in Europe. It cannot be excluded that as research progresses, the list may become longer still. One must also realize that the great diversity of the genus in Northern America may shed light on the situation elsewhere.

Summing up this book not only is absolutely indispensable to anyone with an interest in north American Gelechiidae, but is also highly recommended for anyone with an interest in (European) Gelechiidae.

*Twan Rutten*

## Intraspecific structuring of *Polyommatus coridon* (Lycaenidae)

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**Summary.** The intraspecific differentiation of species is often a controversial matter. We analysed the population genetics of *Polyommatus coridon* (Poda, 1761), by means of allozyme electrophoresis over large regions of Europe, to obtain insight into patterns of intraspecific differentiation. We found significant population structuring ( $F_{ST}=0.060 \pm 0.007$  SD). A UPGMA analysis showed a division into two major genetic lineages that had a mean genetic distance (according to Nei 1978) of 0.041 ( $\pm 0.010$  SD). The analysed samples from Hungary, Slovakia, the Czech Republic and Brandenburg (north-eastern Germany) represented a monophyletic group, and those from Italy, France and Germany (excluding Brandenburg) another monophyletic group. The genetic differentiation within these two genetic lineages was rather weak. In general, genetic diversity within populations was high for all analysed parameters (number of alleles; observed and expected heterozygosity; percentage of polymorphic loci).

**Zusammenfassung.** Die intraspezifische Differenzierung von Arten wird häufig kontrovers diskutiert. Wir analysierten die Populationsgenetik von *Polyommatus coridon* (Poda, 1761) über weite Bereiche Europas mittels Allozymelektrophorese, um die intraspezifische Strukturierung dieser Art besser zu verstehen. Wir fanden eine signifikante Differenzierung der Populationen ( $F_{ST}=0.060 \pm 0.007$  SD). Eine UPGMA-Analyse ergab die Aufspaltung in zwei große genetische Linien, die eine durchschnittliche genetische Distanz (nach Nei 1978) von 0,041 ( $\pm 0,010$  SD) aufwiesen. Die analysierten Proben aus Ungarn, der Slowakei, Tschechien und Brandenburg (nordöstliches Deutschland) repräsentieren eine monophyletische Gruppe. Diejenigen aus Italien, Frankreich und Deutschland (ohne Brandenburg) stellen ein weiteres Monophylum dar. Die genetische Differenzierung innerhalb dieser beiden genetischen Linien war gering. Generell war die genetische Diversität innerhalb der Populationen für alle analysierten Parameter hoch: Anzahl an Allelen, beobachtete und erwartete Heterozygotität sowie der Prozentsatz polymorpher Loci.

**Résumé.** La différenciation intraspécifique des espèces est souvent une question controversée. Nous avons analysé la génétique des populations de *Polyommatus coridon* (Poda, 1761) au moyen de l'électrophorèse allozymique sur une large partie de l'Europe, afin d'obtenir une compréhension des modes de différenciation intraspécifique. Nous avons trouvé une structuration de populations significative ( $F_{ST}=0.060 \pm 0.007$  SD). Une analyse par agglomération hiérarchique (UPGMA) a démontré une division en deux lignées génétiques majeures ayant une distance génétique moyenne (d'après Nei 1978) de 0.041 ( $\pm 0.010$  SD). Les échantillons analysés d'Hongrie, de Slovaquie, de République Tchèque et du Brandebourg (Allemagne du nord-est) représentent un ensemble monophylétique, et ceux d'Italie, de France et d'Allemagne (à l'exclusion du Brandebourg) une autre ensemble monophylétique. La différenciation génétique à l'intérieur de ces deux lignées génétiques était assez faible. En général, la diversité génétique à l'intérieur des populations était élevée pour tous les paramètres analysés (nombre d'allèles; hétérozygotité prévue et observée, pourcentage de locus polymorphiques).

**Key words.** intraspecific differentiation, allozyme electrophoresis, *Polyommatus coridon*, *borussia*, *Lysandra*, *Meleageria*.

## Introduction

During the 19th and the first half of the 20th century, taxonomy was one of the most prominent fields in biology. Numerous genera, subspecies, forms and aberrations of butterflies were described at this time (e.g. Seitz 1909, 1932). Recent trends have been towards reducing the number of taxa, and trying to obtain a more phylogenetically rigorous system (e.g. Nässig 1995). At a subspecific level, many formerly proposed taxa are no longer considered to be valid (e.g. Leraut 1997).

For *Polyommatus coridon* (Poda, 1761), the taxonomic situation is comparable to many other butterflies. In the past, many subspecies were described on the basis of minor morphological differences, with different subspecies often having peculiar distribution patterns (e.g. Seitz 1909, 1932). In a morphology-based revision of the *Lysandra*-group, Schurian (1989) reduced the number of subspecies to six: the nominate form in western and south-eastern Europe, *P. coridon borussia* (Dadd, 1908) in eastern Europe, *P. coridon asturiensis* (de Sagarra, 1924) restricted to northern Spain, *P. coridon caelestissimus* (Verity, 1921) endemic in central Spain, *P. coridon apennina* (Zeller, 1847) from central Italy and *P. coridon nufrellensis* (Schurian, 1977) endemic to Corsica. Not mentioned by Schurian (1989) were additional populations in Sardinia, which have been described as subspecies *P. coridon gennargenti* (Leigheb, 1987).

The aims of this work were to obtain data on the genetic structure of *P. coridon* and to re-analyse the intraspecific differentiation. Therefore, we sampled butterflies in an area that extended from the central Pyrenees to north-eastern Hungary and from central Italy to the Baltic Sea (see Fig. 1) and performed allozyme electrophoresis.

## Ecology and distribution pattern of *P. coridon*

*Polyommatus coridon* is a characteristic species of barren grasslands on base-rich soils (Weidemann 1986; Ebert & Rennwald 1991; Settele *et al.* 1999). Its myrmecophilous larvae mainly feed on *Hippocrepis comosa* (de Bast 1987; Ebert & Rennwald 1991). Larvae of eastern populations feed on *Coronilla varia* (Schurian 1989; Settele *et al.* 1999).

The distribution range extends from the north of the Iberian Peninsula (Fernández-Rubio 1991) and the south-east of England (Emmet & Heath 1990) over major parts of temperate Europe (Tolman & Lewington 1998). *Polyommatus coridon* is nearly absent in the Netherlands (Wynhoff *et al.* 1992) and northern Germany (Bink 1992). In Poland, it can be found as far north as the Baltic Sea (Buszko 1997). In the Balkans, it reaches northern and central Greece (Pamperis 1997). No populations are known from Scandinavia (Henriksen & Kreutzer 1982). In the east, *P. coridon* can be found as far as the steppes north of the Lake Caspi (Lukhtanov & Lukhtanov 1994). Only one individual has been recorded from Turkey (Hesselbarth *et al.* 1995). Some authors classify Spanish populations as distinct species (e. g. Manley & Allcard 1970; Mensi *et al.* 1988).

## Materials and Methods

*Collection and allozyme electrophoresis.* We collected butterflies at 36 localities (Fig. 1) and immediately stored them in liquid nitrogen until analysis. Half of the abdomen of each individual was homogenised in Pgm-buffer (Harris & Hopkinson 1976) by ultrasound and centrifuged at 17,000 g for 5 min. For the analysis, we applied cellulose acetate electrophoresis (Hebert & Beaton 1993). A total of 17 enzyme systems representing 20 loci were analysed. Four buffer systems were used. The electrophoresis conditions for the different enzymes are given in table 1.

The discrimination between some alleles of Ldh was not always possible. Therefore, the results for this enzyme were excluded for all calculations of genetic distances and all further calculations based on these values.

## Data analysis

All loci showed banding patterns consistent with known quaternary structures and with autosomal inheritance (Richardson *et al.* 1986). The slowest migrating allele was labelled "1", the second "2" and so on.

Allele frequencies, F-statistics (Weir & Cockerham 1984), Nei's standard genetic distances (Nei 1978) and RxC  $\chi^2$ -tests (Sokal & Rohlf 1995) were calculated with the

**Tab. 1:** Conditions of electrophoresis for the different enzymes tested. – TB: Tris-borate pH 8.9 (adjusted from TB pH 7.0 (Shaw & Prasad 1970)), TC: Tris-citrate pH 8.2 (Richardson *et al.* 1986), TG: Tris-glycine pH 8.5 (Hebert & Beaton 1993), TM: Tris-maleic acid pH 7.0 (adjusted from TM pH 7.8 (Richardson *et al.* 1986)). All buffers were run at 200 V. – \* moves towards cathode; \*\* cold buffer necessary

enzyme	EC-Nr.	number of loci	buffer	Homogenate applications	running time (min)
6-Pgdh	1.1.1.44	1	TC	2	40
G-6-Pdh	1.1.1.49	1	TC	2	40
G-3-Pdh	1.2.1.12	1	TC	2	30
Gpd	1.1.1.8	1	TM	3	45
Hbdh*	1.1.1.30	1	TG	3	30
Idh	1.1.1.42	2	TC	2	40
Ldh	1.1.1.27	1	TB	5	40
Mdh	1.1.1.37	2	TC	2	40
Me	1.1.1.40	1	TB	2	30
Fum	4.2.1.2	1	TC	3	45
Aat	2.6.1.1	2	TG	3	45
Acon	4.2.1.3	1	TM	4	50
Pep D (Phe-Pro)	3.4.11/13	1	TM	4	30
Apk	2.7.3.3	1	TG	1	30
Ak	2.7.1.40	1	TC	3	45
Pgi	5.3.1.9	1	TG	1	40
Pgm**	5.4.2.2	1	TG	1	40



**Fig. 1.** Sampling localities of *Polyommatus coridon*. The species' distribution (Tolman & Lewington 1998, modified) is marked by a lighter gray area. Population numbers refer to those in Fig. 2. White circles with black population number: populations of the western genetic lineage; black circle with white number: populations of the eastern lineage.

program G-Stat (Siegismund 1993). Hardy-Weinberg equilibrium (Louis & Dempster 1987), genetic linkage disequilibrium (Weir 1991) and the exact tests (Raymond & Rousset 1995a) were performed with the package GENEPOP (Raymond & Rousset 1995b). Neighbor-joining (Saitou & Nei 1987) and UPGMA diagrams based on Nei's (1978) genetic distances were calculated with the package PHYLIP (Felsenstein 1993). Differences between means were tested with two-tailed t-tests, using STATISTICA (Stat Soft inc. 1993). Sequential Bonferroni corrections were performed as described in Rice (1989).

## Results

Polymorphisms were observed for all analysed loci. The minimum number of alleles per locus over all 36 populations was three for Acon; the maximum was 16 for Pgi. The mean number of alleles per locus over all populations was 7.7 ( $\pm 3.2$  SD). Allele frequencies are available on request from the authors.

Genetic variability within each population was high: the average number of alleles detected per locus per population was 2.68 ( $\pm 0.33$  SD), ranging from 1.9 to 3.5. The mean percentage of polymorphic loci was 74.2% ( $\pm 9.2$  SD) (minimum 55%; maximum 95%). Restricted to loci with the most common allele not exceeding 95%, the mean

**Tab. 2.** Average number of alleles per locus (alleles), expected (He) and observed (Ho) percentage of heterozygosity, percentage of polymorphic loci (P tot) and on 95%-level (P95) for all analysed samples of *P. coridon*; ind: number of individuals examined. The averages are given with standard deviations. – Names of sample sites are abbreviated. Population numbers refer to Fig. 2.

	1	2	3	4	5	6	7	8	9	10
	Perl	Dock	Wein	Niede	Münst	Griesh	Dapfe	Impfi	Craula	Hessel
alleles	2.40	2.50	2.50	2.75	2.60	2.70	2.80	2.75	2.75	2.65
He	19.2	19.4	19.0	19.4	21.1	18.7	21.6	18.7	21.1	19.3
Ho	18.5	19.7	17.1	19.8	21.5	19.5	21.5	17.6	20.3	17.7
P tot	75.0	75.0	60.0	80.0	70.0	85.0	90.0	80.0	75.0	65.0
P95	60.0	50.0	45.0	55.0	45.0	45.0	50.0	50.0	50.0	50.0
ind.	39	40	44	45	37	49	39	45	43	50

	11	12	13	14	15	16	17	18	19	20
	Neust	Tiefen	Staad	Zimm	Tölz	Pätz	Libbe	Gartz	Chauv	Nogen
alleles	2.65	2.60	2.60	2.45	2.70	2.00	2.35	1.90	2.65	3.25
He	18.7	20.3	18.2	19.3	20.1	19.5	19.8	17.0	21.3	20.1
Ho	17.8	19.0	18.1	19.0	19.8	19.9	18.4	16.1	20.2	19.3
P tot	75.0	75.0	75.0	75.0	60.0	55.0	80.0	55.0	75.0	85.0
P95	50.0	45.0	45.0	50.0	45.0	55.0	65.0	50.0	55.0	60.0
ind.	40	41	50	40	50	48	40	33	42	50

	21	22	23	24	25	26	27	28	29	30
	Velars	Barce	Palud	Langu	Carol	Baldo	Sasso	Černín	Milov	Lažan
alleles	3.30	3.50	3.05	3.25	2.60	2.35	2.95	2.40	2.55	2.55
He	20.1	23.8	20.1	23.1	21.1	19.0	22.7	19.3	20.2	19.7
Ho	19.5	23.1	18.0	23.6	22.1	18.2	22.7	17.4	19.5	19.0
P tot	80.0	95.0	85.0	80.0	75.0	60.0	75.0	70.0	70.0	80.0
P95	45.0	60.0	55.0	60.0	60.0	45.0	50.0	55.0	65.0	50.0
ind.	53	40	40	40	36	56	39	45	50	40

	31	32	33	34	35	36			
	Klent	Hradiš	Spišsk	Rezi	Csákv	Arany	average	min.	max.
alleles	2.75	2.80	2.40	2.90	2.90	2.80	2.68 ± 0.33	1.9	3.5
He	21.9	18.4	19.1	20.7	18.5	20.3	20.0 ± 1.5	17.0	23.8
Ho	18.9	19.6	18.5	20.6	18.8	19.7	19.4 ± 1.7	16.1	23.6
P tot	75.0	80.0	65.0	75.0	75.0	65.0	74.2 ± 9.2	55.0	95.0
P95	65.0	60.0	50.0	60.0	55.0	60.0	53.2 ± 6.5	45.0	65.0
ind.	47	45	50	40	40	40	43.5 ± 5.3	33	56

percentage of polymorphic loci was 53.2% ( $\pm 6.5$  SD) (minimum 45%; maximum 65%). The high percentage of polymorphic loci coincided with high observed heterozygosities (average 19.4% ( $\pm 1.7$  SD)), ranging from 16.1% to 23.6%). Based on Hardy-Weinberg equilibrium, the expected values were even higher (mean 20.0%; minimum 17.0%; maximum 23.8%). All data are given in detail in table 2.

Linkage disequilibrium between loci was not detected after sequential Bonferroni correction.

Over all populations and loci, no significant deviation from Hardy-Weinberg equilibrium was detected ( $p > 0.99$ ). No single sample deviated from Hardy-Weinberg equilibrium at the 5% level except for Bad Tölz ( $p = 0.041$ ), which was not significant after Bonferroni correction. No single locus deviated except 6-Pgdh ( $p = 0.026$ ) and Hbdh ( $p = 0.008$ ), which were not significant after Bonferroni correction. Therefore, further analyses were performed using the standard statistics of population genetics.

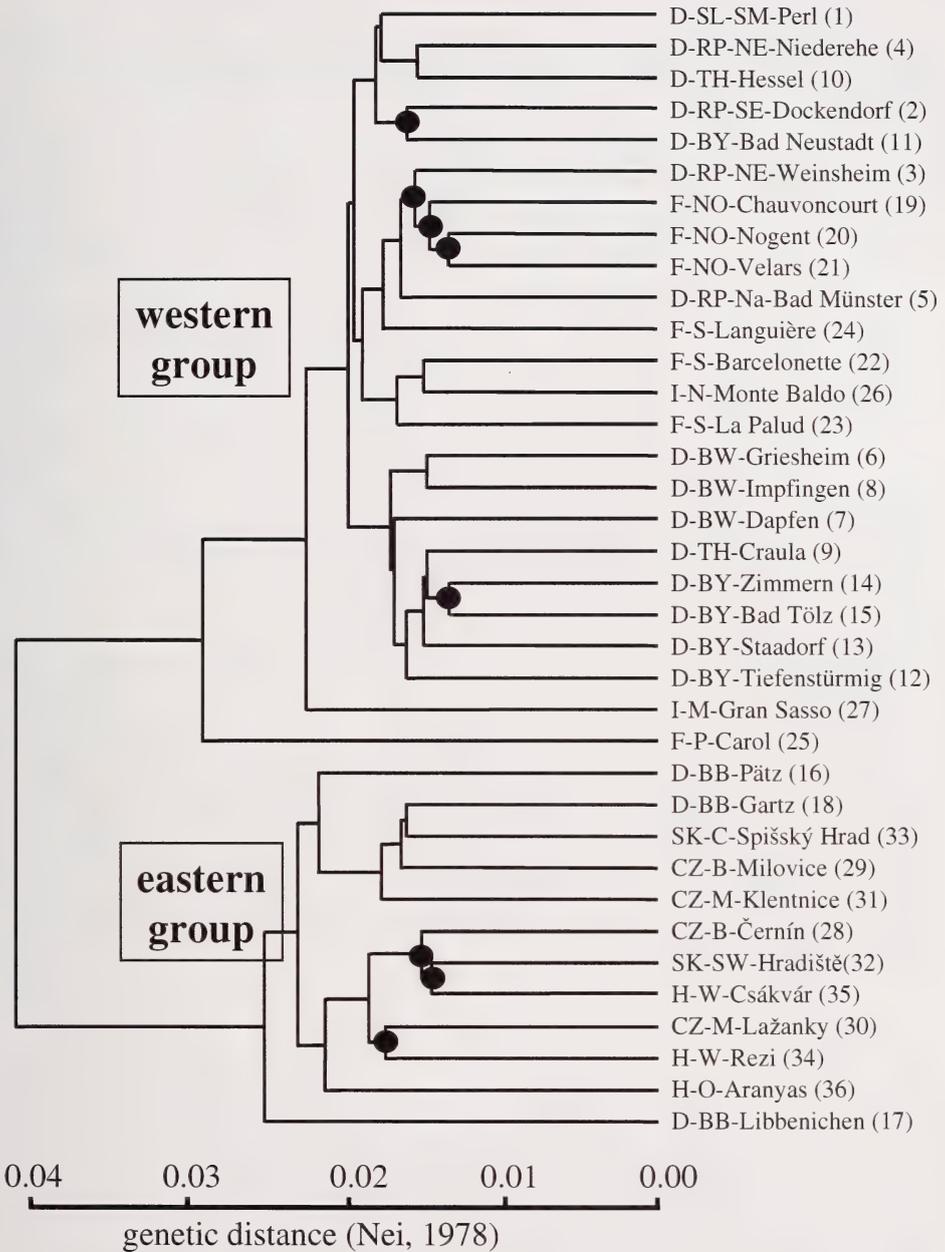
A highly significant differentiation between the studied populations was revealed by means of an exact test ( $p < 0.0001$ ). Based on all analysed loci, the genetic distances (Nei 1978) between samples ranged from 0.014 (Zimmern and Bad Tölz, Bavaria; Nogent sur Seine and Velars, north-eastern France) to 0.069 (Carol, Pyrenees and Černín, western Bohemia). A neighbor-joining and a UPGMA phenogram (Fig. 2), which were calculated based on these genetic distances, showed a clear division into a western and an eastern group. All samples from Brandenburg (NE Germany), the Czech Republic, Slovakia and Hungary clustered in the eastern group. The western group included all samples from France, Italy and Germany (excluding Brandenburg). Each group exhibited several alleles not found in the other group. Some of these alleles were geographically widely distributed within the respective group (e.g. Mdh II allele 7, Gpi allele 10 and Aat II allele 9 in the western group; Idh I allele 4 and Idh II allele 8 in the eastern group). The mean genetic distance (Nei 1978) between these two groups was 0.041 ( $\pm 0.010$  SD). The mean genetic distances within the western and the eastern groups were 0.020 ( $\pm 0.004$  SD) and 0.022 ( $\pm 0.003$  SD), respectively. They were significantly lower than the distances estimated between these two groups (both t-tests:  $p < 0.0001$ ).  $F_{ST}$  calculated for all populations was significantly different from zero ( $0.060 \pm 0.007$  SD). Within each group  $F_{ST}$  was much lower but still significant (west  $0.023 \pm 0.003$  SD; east  $0.029 \pm 0.006$  SD).

## Discussion

Intraspecific differentiation. – Our allozyme studies showed that *P. coridon* splits into two well distinguished genetic lineages in the study area. This is consistent with de Lesse's (1969) two chromosome groups: a western group with 87 or 88 chromosomes occurring in Italy, southern France and northern Spain, and an eastern group with 90 to 92 chromosomes in the Balkans. Phenotypic differentiation, based on adult wing patterns, between eastern and western populations appears to correspond to the allozyme differentiation (Schmitt in prep). The distribution of the two distinguished genetic lineages is shown in Fig. 1.

Each of these two genetic lineages of *P. coridon* seems to be monophyletic. This is supported by several group specific alleles within each lineage.

Comparing with other population genetic studies of butterflies, the genetic distance (Nei 1978) of 0.041 between the two large lineages of *P. coridon* indicates at least subspecific differentiation. Similar values were found in other butterfly taxa for which subspecies are accepted (e.g. Porter & Geiger 1988; Britten *et al.* 1995; Descimon 1995). The observed genetic distances and  $F_{ST}$  values within the two large genetic lineages were typical for butterflies without subspecies (e.g. Vawter 1977; Eanes & Koehn 1978;



**Fig. 2.** UPGMA phenogram of all analysed samples of *P. coridon* based on genetic distances (Nei 1978). All nodes are inhomogeneous on the 5% confidence level before Bonferroni correction (RxC  $\chi^2$  test). Those which were not significant after Bonferroni correction are marked with filled circles. Abbreviations: *First part*: country; *Second part*: B: Bohemia, BB: Brandenburg, BW: Baden-Württemberg, BY: Bavaria, C: Central, E: East, M: Moravia, NE: North-East, Pyr: Pyrenees, RP: Rhineland-Palatinate, S: South, SL: Saarland, SW: South-West, TH: Thüringen, W: West; *Third part (only for western Germany)*: Na: Nahe region, NE: northern Eifel, SE: southern Eifel, SM: Saar-Moselle region; *last part*: name of sampling locality

Hughes & Zalucki 1984; Zalucki *et al.* 1987; Rosenberg 1989; Goulson 1993; Johannesen *et al.* 1997). Therefore, we assume that western and eastern populations belong to two well distinguished lineages. We provisionally would regard these as subspecies or even subspecies complexes.

Reviewing the nomenclature of *P. coridon*, the presented data is not sufficient for a general taxonomic revision because no sample from the type locality, Graz, or its surroundings was included. Even the closest sample site, Rezi in western Hungary which belongs to the eastern genetic lineage, is located 150 east of Graz. Therefore, it is uncertain which group includes the nominate form.

The individuals from Brandenburg and other regions of East Europe and the north-eastern part of Central Europe are often somewhat larger and darker than more southern populations and therefore were separated for morphological reasons as *P. coridon borussia* (Dadd, 1908). However, we could not detect genetic differentiation of samples from Brandenburg to the others of the eastern lineage that would justify their subspecific separation (Fig. 2). Genetic differentiation among populations within the Brandenburg region was relatively high, possibly due to the marginal position of Brandenburg, where relatively isolated populations may have been subjected to increased genetic drift.

Genetic variability within populations. The observed genetic diversity within populations of *P. coridon* was high even for butterflies (Graur 1985; Packer *et al.* 1998; Schmitt 1999).

Literature data about butterflies indicate that taxa with strongly fragmented and small populations mostly express low allozyme diversity (e.g. Britten *et al.* 1994, 1995; Debinski 1994; Marchi *et al.* 1996), compared to widespread and common species which typically have high values (e.g. Goulson 1993; Porter & Geiger 1995; Porter *et al.* 1995; Schmitt 1999). *Polyommatus coridon* was abundant at nearly all sampling sites, so effects of genetic drift may be limited, despite the limited spatial extent of the habitat available in several regions.

### Acknowledgement

We thank our colleagues Dr. Harald Schreiber and Dr. Norbert Zahm from the University of the Saarland for the sample of *P. coridon* from Gran Sasso and to many other colleagues for their very friendly help in finding lots of the sampling localities and for several excursions done together. We also thank the local authorities in Saarbrücken, Trier, Koblenz, Neustadt (Weinstraße), Freiburg im Breisgau, Erfurt, Potsdam, Würzburg, Ansbach, Bayreuth, Regensburg, München and Verona and to Ministries of Environment in Prague, Bratislava and Budapest for permission to collect butterflies and work in several protected areas. Finally, we thank the referees for their comments which considerably improved the manuscript. We are also grateful to the Centre for Environmental Studies (ZFU) of the Johannes Gutenberg-University of Mainz and the Deutsche Forschungsgemeinschaft (DFG, grant number SE 506/6-1) for financial support and scholarship of the DFG-Graduiertenkolleg of the ZFU for T. Schmitt.

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## Book Review

**Gozmány, L. 2000: Holcopogonidae.** [German] – *In*: Gaedike, R. (ed.), *Microlepidoptera Palaearctica* **10**: 8–174, 162 figs. – Goecke & Evers, Keltern. – ISBN: 3-931374-20-3. Price: DM 100,00.

In the recent volume of the *MP* series, László Gozmány revises a rather small and unknown group of the superfamily Gelechioidea: the Holcopogonidae. This family comprises 34 species from the south-western Palaearctic Region, mainly in the Mediterranean, and one species in Mongolian deserts. Elsewhere, only three holcopogonid species occur in South Africa and one species in India and Sri Lanka. The small moths possess characteristic ciliated antennae and porrect labial palpi whose third segment characteristically forms an erect/upright needle. The most peculiar feature of this family is coprophagy, i.e. the larvae feed on excrements of herbivorous mammals. Thus, the larvae play an important role as dung decomposers in southern and eastern Mediterranean deserts and semideserts. *Oecia oecophila* is also known to feed on human excrements, which probably allowed this species to extend its range to Japan, the USA and even to Brazil. However, for most of the species there is no information available about their life habits and ecology, and even the range of each species is still poorly known. Future research on this group may result in interesting discoveries about the ecology of these moths as well as in the discovery of further new species. Gozmány provides for this purpose a fundamental monograph of the Holcopogonidae. His book begins with a general diagnosis of the family, including the history of its systematic treatment. For each species, the external morphology of the moths and the genitalia of both sexes (so far known) are described, the geographical distribution and a complete list of references is given. Drawings of the genitalia and colour figures of the moths conclude the work. All together, Gozmány established eleven new species, one new genus, one new synonym as well as six new combinations.

The 10<sup>th</sup> volume of the *Microlepidoptera Palaearctica* is dedicated to Hans Georg Amsel who originally founded the series together with Hans Reisser and František Gregor. It was Amsel's idea that a progress in scientific research on Microlepidoptera is possible only through the publication of comprehensive revisions to summarise the entire knowledge of morphology, ecology, zoogeography and systematics together with high quality figures of the moths and their genitalia. The first volume of this remarkable project was published in 1965 by Stanislaw Bleszynski about the Crambidae (now Crambinae: Pyraloidea, Crambidae). However, the size of each volume had two disadvantages. First, a single volume became more and more expensive, e.g. the ninth volume already costs DM 800,00. Second, such monographs can be completed just after a fairly long time. It is less promoting to the science of Microlepidopterology, if such books are published on average only every third and a half year. With the 10<sup>th</sup> volume, this concept has changed. The former double volume, one book for the text and one for the figures, is now amalgamated into one book with shorter but more poignant descriptions.

I hope that the new, economical brand of the *Microlepidoptera Palaearctica* which allows a moderate price for one volume will encourage more lepidopterists to study smaller moths. For this, I wish the new editor, Reinhard Gaedike, and the new publisher, Erich Bauer, much success for the continuation of the series.

*Matthias Nuß*

## The male genitalia of the butterflies placed in the subgenus *Neolysandra* of the genus *Polyommatus* (Lycaenidae)

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**Summary.** The male genitalia of the butterflies currently placed in the subgenus *Neolysandra* Koçak, 1977 of the genus *Polyommatus* Latreille, 1804 (Lycaenidae) are being illustrated and described and their differences are revealed and discussed. This information is presented in hope that, in parallel with other aspects not dealt with in the present paper, it may eventually be used toward a better understanding of the taxonomy of this group of butterflies.

**Zusammenfassung.** Die männlichen Genitalien der Bläulingsarten der Untergattung *Neolysandra* Koçak 1977 innerhalb des Genus *Polyommatus* Latreille, 1804 werden beschrieben. Unterschiede zwischen den Arten werden aufgezeigt. In Verbindung mit anderen, hier nicht berücksichtigten Daten könnten diese morphologischen Informationen zu einem besseren Verständnis der Taxonomie und Systematik der Gattung *Polyommatus* beitragen.

**Résumé.** L'armure génitale mâle des espèces actuellement placées dans le sous-genre *Neolysandra* Koçak, 1977 du genre *Polyommatus* Latreille, 1804 (Lycaenidae), est illustrée et décrite et les différences entre chacune d'entre elles sont ainsi révélées et commentées. Cette information est présentée afin que, parallèlement à d'autres aspects non discutés dans la présente contribution, elle puisse être utilisée dans le but d'une meilleure compréhension de la taxonomie de ce groupe de papillons.

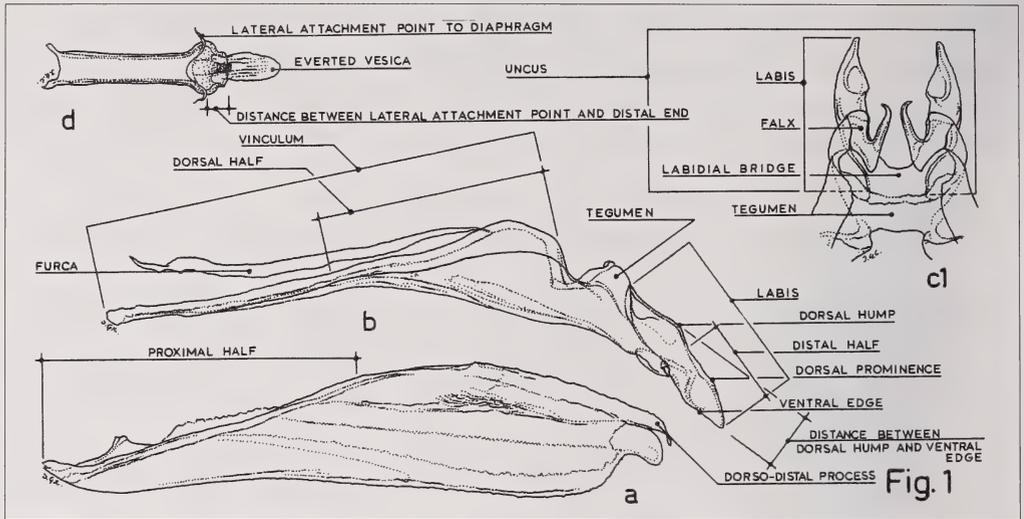
**Key words.** Lepidoptera, Lycaenidae, *Polyommatus*, *Neolysandra*, genitalia, taxonomy, Palaearctics.

### Introduction

The generic group taxon *Neolysandra* was established by Koçak (1977) as a subgenus of *Agrodiaetus* [Hübner, 1822]; type species by original designation *Lycaena diana* Miller, 1913. The reasons given for this action were based both on superficial characters ("Uns. [underside] of wings submarginal markings absent, rudimentar [sic! recte rudimentary], or few traces of lunules appear in a different shape at anal angle of hw [hindwing] (especially in female); uns. of hw. without basal spots"), as well as on characters of the male genitalia ("Male genitalia (Fig. 21) is [sic! recte are] characterized by larger and broader unci and slender subunci.").

Koçak also included in *Neolysandra* the species-group taxa *coelestinus* (Eversmann, 1843), *ellisoni* (Pfeiffer, 1931) and *corona* (Verity, 1936), presumably on what he believed to be exterior as well as structural similarities between these three taxa and *diana*. This practice was later also followed by Hesselbarth et al. (1995), but in their instance *Agrodiaetus* and *Neolysandra* were both placed as subgenera of the genus *Polyommatus* Latreille, 1804 and the taxon *fatima* (Eckweiler & Schurian, 1980) was added to *Neolysandra*.

The assignment of these taxa to *Neolysandra* is now generally accepted, the more so as all of them share similar exterior characters on the underside of the wings and all are *Vicia* feeders in their larval stages (Larsen 1974; Schurian 1980; Hesselbarth et al. 1995; Tolman & Lewington 1997; Tuzov et al. 2000).



**Fig. 1.** Explanatory drawing of male genitalia of a taxon of the subtribe Polyommata (here and in Figs. 2–8: *a* – side view of exterior face of left valva; *b* – side view of left side of genitalia with valvae and aedeagus removed; *b1* – side view of exterior face of left falx and immediately neighbouring elements; *c* – ventral view of right labis and falx, together with immediately neighbouring elements; *c1* – ventral view of labides and falces, together with immediately neighbouring elements; *d* – dorsal view of aedeagus; *e* – flat view of dorso-distal process of valva).

The taxa that have been selected by the present author for comparative purposes are those belonging to the subtribe Polyommata Swainson, 1827, whose aedeagus, when viewed either dorsally or ventrally, invariably possesses a bulbous distal end; a character that is also shared by *Neolysandra*. Taxa in the Polyommata that lack this character have been excluded from the present study. On the basis of the taxonomic arrangement used by Hesselbarth et al. (1995), the following entities possessing such an aedeagus have been taken into consideration: 65 taxa placed in the subgenus *Agrodiaetus* of the genus *Polyommatus*; the species group taxa *bellargus* (Rottemburg, 1775), *syriacus* (Tutt, [1910]), *dezinus* (de Freina & Witt, 1983), *ossmar* (Gerhard, [1851]), *corydonius* (Herrich-Schäffer, [1852]), *coridon* (Poda, 1761), *albicans* (Herrich-Schäffer, [1851]), *hispanus* (Herrich-Schäffer, [1852]) and *punctiferus* (Oberthür, 1876), all placed in the subgenus *Meleageria* de Sagarra, 1925, of the genus *Polyommatus*; the taxa *dorylas* ([Denis & Schiffermüller], 1775), *golgus* (Hübner, 1813), *nivescens* (Keferstejn, 1851), *atlanticus* (Elwes, 1905), *amandus* (Schneider, 1792), *thersites* (Cantener, [1835]) and *escheri* (Hübner, 1823), all placed in the subgenus *Polyommatus* of the genus *Polyommatus*.

The aforementioned group of butterflies, together with *Neolysandra*, possesses very uniform male genitalia, whose differences, when present, tend to be unpronounced and often subtle. These are expressed mostly by the shape of the labides (when these are being viewed laterally) and the length of the valvae, and to a lesser extent by the overall genitalia proportions, the shape of the valvae and the shape of the distal end of the

aedeagus, and can only be made apparent in undistorted genitalia preparations that have not been mounted under pressure.

A careful examination of the male genitalia of all *Neolysandra* species-group taxa revealed unexpected differences between them, whose significance at present is impossible to interpret. The purpose of this paper is to reveal these differences, in hope that this information, combined with other aspects not dealt with here, might eventually shed some more light on the taxonomy of this group of butterflies.

## Material and methods

The genitalia under consideration were dissected from specimens loaned from the joint collection of Willy De Prins, Alain Olivier and Dirk van der Poorten, of Antwerpen, Belgium, as well as from specimens in the author's collection. These were eventually stored in vials containing 80% alcohol, after having first been kept overnight immersed in a 10% KOH solution and eventually clarified.

The appendages were drawn directly in Indian ink under a WILD M5 stereomicroscope together with its drawing tube, without the previous rendering of an intermediate pencil drawing; this was done while these were kept immersed in 80% alcohol, free from pressure due to mounting, and were held in place by being propped against glass slides. In each drawing a scale is also provided and in all cases the left valva is placed at the start of it, so that it can be measured directly. In addition to this, the length of the right forewing is also included in order to provide a reference to the insect's overall size.

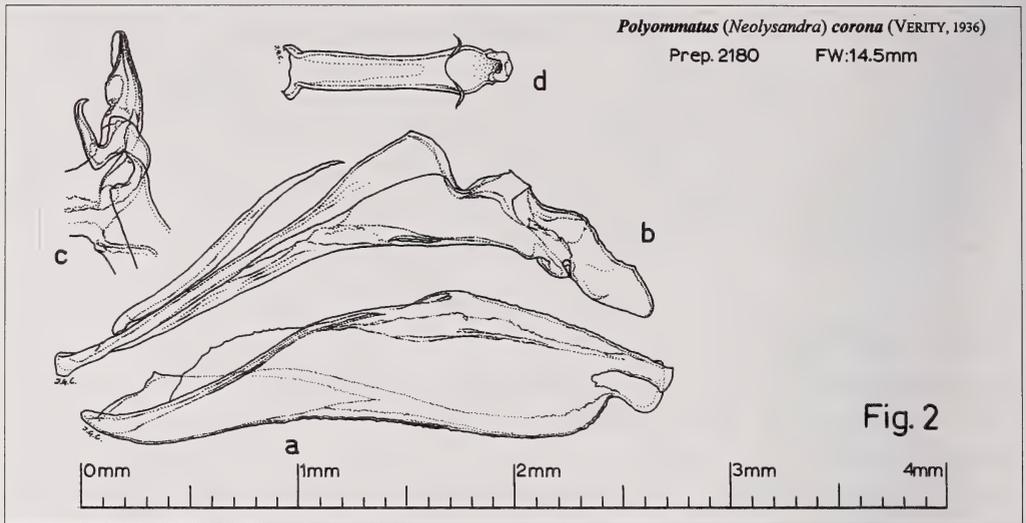
In all drawings but two (the explanatory drawing excluded), a flat view of the dorso-distal process of the valva is also shown under a magnification that is twice that being used for the rest of the appendages; the reason for not including this process in two of the drawings stems from the fact that when the relevant specimens were made available for dissection, the proper magnification lenses were not yet available.

For each *Neolysandra* species-group taxon, the genitalia of more than one specimen have been studied. In the case of *diana*, *corona* and *fatima*, which are rare in collections, these amount to two for each, in the case of *ellisoni*, to three and in the case of *coelestinus* and *dorylas*, to more than ten for each.

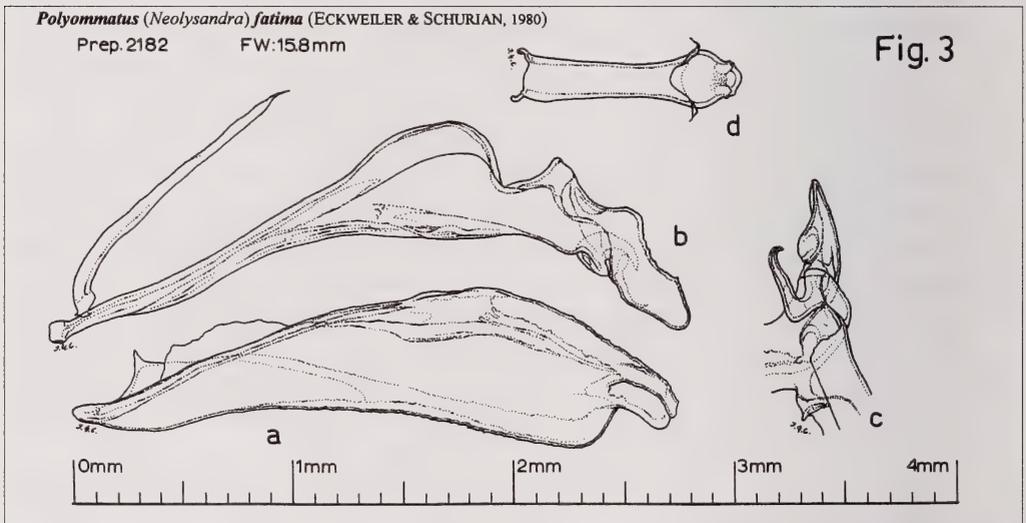
## Description of the genitalia

The genitalia nomenclature used follows to a great extent that of Higgins (1975), but certain terms had to be newly coined by the present author in order to better explain certain aspects relating to the drawings.

In the case of *corona* and *fatima* (Figs. 2 & 3), as well as in the case of *coelestinus* and *ellisoni* (Figs. 5, 6 & 7), the male genitalia show the same general pattern as that of the genitalia of all the taxa of the subgenus *Agrodiaetus* of the genus *Polyommatus*, as well as that of the genitalia of the taxa *escheri*, *thersites*, *amandus*, *dorylas* and its closely allied species, and *coridon* and its closely allied species. In all these cases and relative to *diana*, the proximal half of the valvae is slender, the distal half of the labides is devoid of any serrations (though it may possess in side view a single, poorly defined,



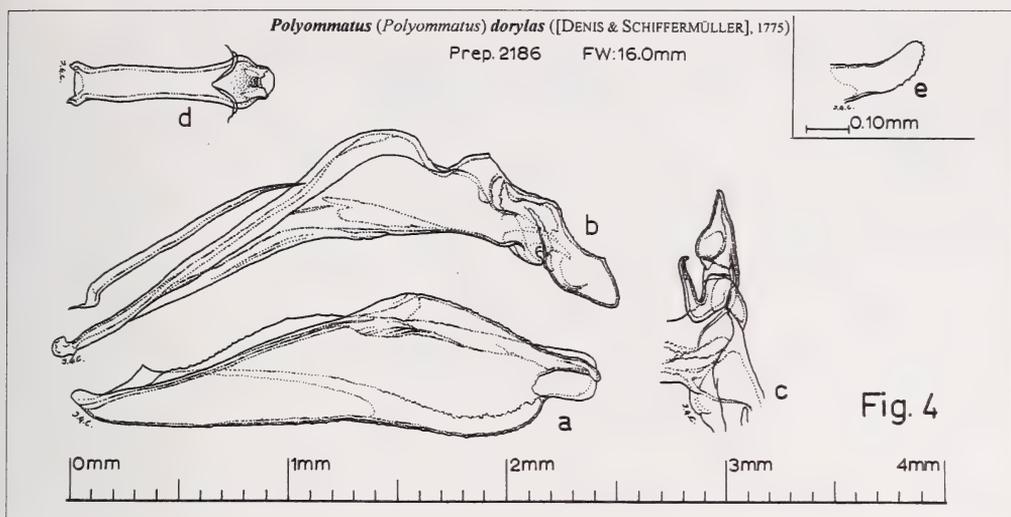
**Fig. 2.** Male genitalia of *Polyommatus (Neolysandra) corona* (Verity, 1936). Preparation No. 2180. Iran, Tehran, Dizin, Gardaneh Reshteh Ye Alborz, 2700–3500 m, 11–17.vii.1972.



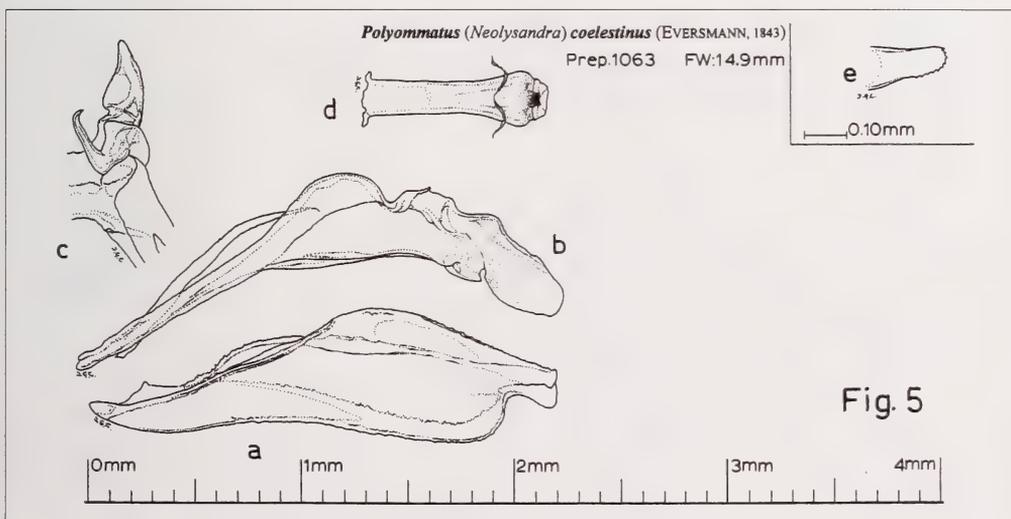
**Fig. 3.** Male genitalia of *Polyommatus (Neolysandra) fatima* (Eckweiler & Schurian, 1980). Preparation No. 2182. Turkey, Hakkari prov., Tali valley, 13 km SW of Hakkari, 1400 m, 20–21.vii.1992.

dorsal prominence), the distance between the lateral attachment points to the diaphragm and the distal end of the sclerotized part of the aedeagus is short, the distance between the dorsal hump and the ventral edge of the labides is short and the furca and vinculum are long.

In *corona* and *fatima*, the labides in lateral view are slender relative to *coelestina* and *ellisoni*, more or less distally pointed and possess in their distal half a dorsal pointed



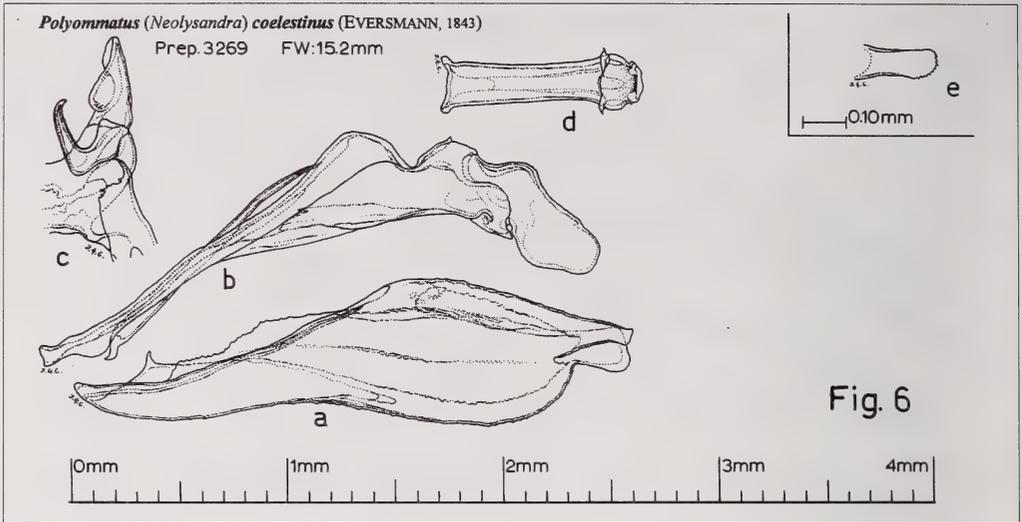
**Fig. 4.** Male genitalia of *Polyommatus (Polyommatus) dorylas* ([Denis & Schiffermüller], 1775). Preparation No. 2186. Turkey, Ardahan, 2500 m, Ilgardagi Geçidi, 1.viii.1993.



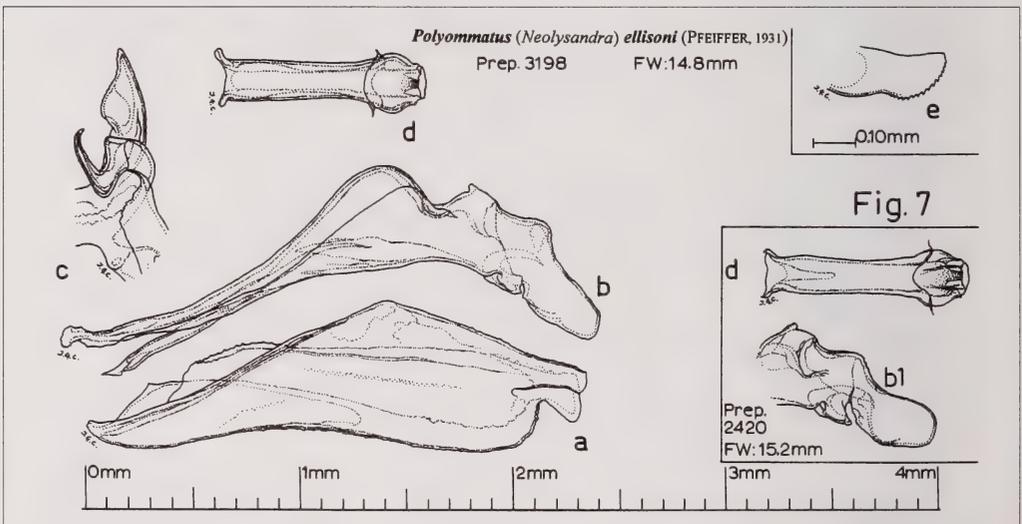
**Fig. 5.** Male genitalia of *Polyommatus (Neolysandra) coelestinus* (Eversmann, 1843). Preparation No. 1063. Saratov, 150 m, 27.v.1978.

prominence. Curiously enough, the male genitalia of these two taxa appear closer to those of the *dorylas* species-group (Fig. 4) than to those of any other afore-mentioned taxon, this being expressed by the shape of the labides in side view, as well as by the overall proportions of the appendages.

In *coelestinus* and *ellisoni*, however, the labides in side view are wide relative to those of *corona* and *fatima* (In Fig. 7, Prep. 3198, the labis appears more slender, but this is



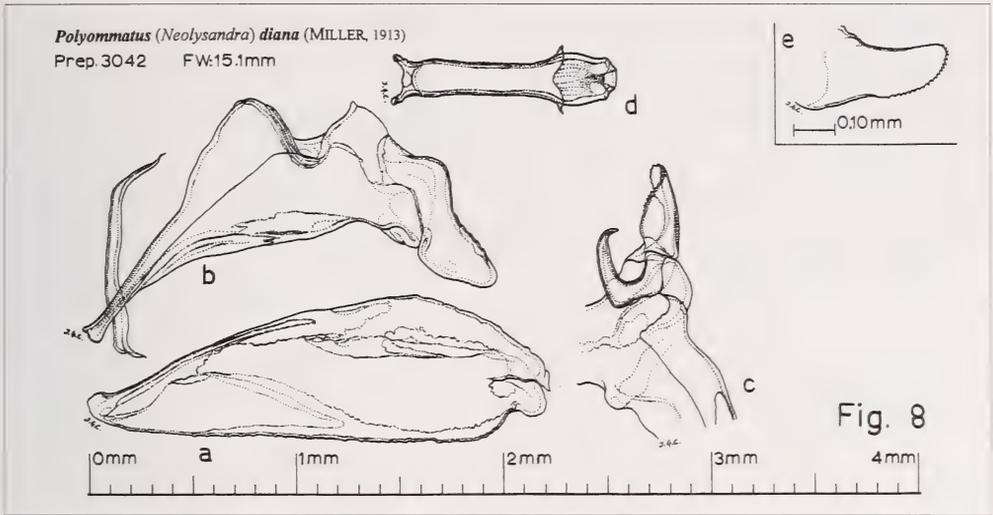
**Fig. 6.** Male genitalia of *Polyommatus (Neolysandra) coelestinus* (Eversmann, 1843). Preparation No. 3269. Greece, Peloponnisos, Mt. Helmos, 1000–1500 m, 10.vi.1972.



**Fig. 7.** Male genitalia of *Polyommatus (Neolysandra) ellisoni* (Pfeiffer, 1931). Preparation No. 3198. Lebanon, Mohafazat Bcharré, Les Cèdres (EL Arz), 1950 m, 4.vi.1998. Preparation No. 2420. Lebanon, Cedders of Bcharré, 1950 m, 12.vi.1967.

due to the fact that its sideways-tilted position resulted in a narrower projected area; this situation is remedied in Prep. 2420 of same Figure). They are more or less distally rounded and are devoid of any dorsal prominence along their distal half.

In *diana* (Fig. 8), the distal half of the labides has inwardly pointing serrations along its edges, and relative to *corona*, *fatima coelestinus* and *ellisoni*, the distance between the dorsal hump and the ventral edge of the labis is long, the distal end of the aedeagus



**Fig. 8.** Male genitalia of *Polyommatus (Neolysandra) diana* Miller, 1913. Preparation No. 3042. Turkey, Erzurum prov., 25–33 km NE of Erzurum, 1900–2000 m, 14–17.vii.1992.

(beyond the lateral attachment points to diaphragm), though bulbous in ventral or dorsal view, is long, the proximal half of the valva is wide, presenting a rather bulky appearance, and the furca and the vinculum are short, the latter also being wide along its dorsal half.

## Discussion

The male genitalia of the taxa placed in the subgenus *Neolysandra* possess characters that suggest the following grouping: a. That of *corona* and *fatima*, with seemingly greater structural affinities to *dorylas* than to any other member of the *Polyommata* that possesses a bulbous aedeagus, and with differences from *coelestinus* and *ellisoni* expressed primarily in the shape of the labides (more slender and pointed when observed in side view). b. That of *coelestinus* and *ellisoni*, characterized primarily by their wide and rounded labides, and c. that of *diana*, which appears to be the most differentiated taxon in the subgenus *Neolysandra*, possessing at the same time genitalia characters that seem unique, even when compared to those of taxa placed in the subgenera *Agrodiaetus*, *Polyommatus* and *Meleageria*.

These genitalia "discrepancies" probably suggest that more taxonomic work is yet needed in this group of butterflies and that a more comprehensive overview of the whole matter might eventually be achieved only by analyzing large suites of characters including DNA sequences.

## Acknowledgements

I would like to extend my thanks to Willy de Prins, Alain Olivier and Dirk van der Poorten for loaning me from their joint collection a good many of the specimens used in this endeavour and in particular to Prof. Dr. Konrad Fiedler and to Alain Olivier for invaluable advice.

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## Partial biennialism in alpine *Lycaena hippothoe* (Lycaenidae: Lycaenini)?

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**Summary.** Two growth strategies were found in caterpillars of alpine *Lycaena hippothoe eurydame* (Hoffmansegg, 1806). Laboratory experiments show that, following an obligatory winter diapause, most larvae develop into adults in the year after oviposition, whereas a minor proportion enters a second diapause. This fraction is higher at lower temperatures. We conclude to have found a temperature-triggered facultative biennialism, evolved as a bet-hedging strategy to cope with the unfavourable and unpredictable alpine environment.

**Zusammenfassung.** Bei Raupen des alpinen Tagfalters *Lycaena hippothoe eurydame* (Hoffmansegg, 1806) wurden zwei Wachstumsstrategien gefunden. Laborexperimente zeigten, daß sich im Anschluß an eine obligatorische Winter-Diapause zwar die meisten Raupen ohne weitere Verzögerung zu Imagines entwickelten, ein geringerer Teil jedoch nach einigen Tagen Fraßaktivität in eine zweite Diapause eintrat. Der Anteil der Individuen mit zweifacher Diapause war höher bei niedrigerer Temperatur. Hieraus wird auf einen temperaturabhängigen, fakultativ zweijährigen Entwicklungszyklus geschlossen, welcher als Strategie zur Risikostreuung unter den unwirtlichen und unvorhersagbaren Bedingungen des alpinen Lebensraumes verstanden werden kann.

**Résumé.** Deux stratégies de croissance ont été observées auprès de chenilles appartenant au taxon alpin *Lycaena hippothoe eurydame* (Hoffmansegg, 1806). Des expériences en laboratoire ont démontré que, suite à une diapause hivernale obligatoire, la plupart des larves se développent jusqu'à l'état adulte pendant l'année qui suit la ponte des œufs, alors qu'une proportion minoritaire entre en une seconde diapause. Celle-ci est plus élevée à des températures inférieures. Nous concluons à la découverte d'un cycle biennal facultatif conditionné par la température, qui a évolué comme réponse aux conditions défavorables et imprévisibles d'un environnement alpin.

**Key words.** *Lycaena hippothoe*, larval growth, life cycle, bet hedging, alpine environment.

### Introduction

Several (but overall few) insect species show the ecologically and evolutionarily fascinating phenomenon of delayed development with juvenile periods lasting for more than one year (e.g. Danks 1992; Stearns 1992; Wipking & Mengelkoch 1994). Within the Lepidoptera, many Ringlets (*Erebia* spp.) and Burnet moths (*Zygaena* spp.) comprise well-known examples (cf. Scott 1986; SBN 1987; Wipking & Mengelkoch 1994). An especially important factor promoting prolonged larval development is a short growing season, often combined with low average temperatures, as is the case in high-alpine environments or at higher latitudes (cf. Downes 1965; Butler 1982; Wipking & Mengelkoch 1994).

However, the coexistence of annual and biennial individuals within the same population is a decidedly rare phenomenon in the animal kingdom. The few examples include

salmonid fish (Gross 1985), Burnet moths (Wipking & Mengelkoch 1994), and some myrmecophilous insects (Thomas et al. 1998; Schönrogge et al. 2000). The latter two studies contain the first detailed descriptions of partial biennialism within the Lycaenidae (but see also Beuret 1956). However, the species referred to (*Maculinea rebeli*, *M. alcon*, *M. arion*) do not possess any trait previously related to prolonged growth. Here, a mixture of two growth strategies seems to be the most efficient way to exploit the limited, but steady, daily supply of food available to the cuckoo-feeding parasites (*M. rebeli*, *M. alcon*) of long-lived *Myrmica* ant colonies (Thomas et al. 1998), or, in case of predacious *M. arion*, an adaptation to the migratory behaviour of host ants (Schönrogge et al. 2000).

In this paper we describe a possible further example of a facultatively biennial life-cycle in a (myrmecoxenous) lycaenid butterfly, found in an alpine population of *Lycaena hippothoe* L.

## Methods

**Study organism.** *L. hippothoe* is a widespread temperate zone butterfly ranging from northern Spain in the west throughout much of the northern Palaearctic region eastwards to the easternmost parts of Siberia and China (Ebert & Rennwald 1991; Lukhtanov & Lukhtanov 1994). The animals for this study belonged to the alpine subspecies *L. hippothoe eurydame* Hoffmannsegg, 1806. Ten freshly emerged females were caught in the summer of 1998 (20.–26.7.) in the central Alps (Senales valley, northern Italy) at an altitude of about 1800 m and transferred to Bayreuth University. As in almost the whole range of *L. hippothoe* (cf. Lukhtanov & Lukhtanov 1994; Tolman & Lewington 1998), this population is monovoltine with adults being on the wing from mid-July to late August (Scheuringer 1972). Usually, *L. h. eurydame* larvae exhibit an obligatory dormancy hibernating in a rather early developmental stage (Fischer 2000; see below). **Experimental arrangement.** For oviposition captured females were maintained in an environmental cabinet at a constant temperature (25°C) and a photoperiod of L18:D6. They were placed individually in glass jars (1 litre) lined with moistened filter paper and the jars covered with gauze. Each jar contained a bunch of the larval food-plant *Rumex acetosa* L. (in H<sub>2</sub>O) as oviposition substrate as well as highly concentrated sucrose solution for adult feeding. Eggs were removed each day and pooled. Hatchlings were placed individually in transparent plastic boxes (125 ml) containing moistened filter paper and fresh cuttings of *R. acetosa* in ample supply. The boxes were checked daily and supplied with new food when needed. Dormant third instar larvae were transferred to another cabinet (T 4°C, photoperiod L8:D16) for hibernation. After a diapause of about five months larvae were randomly divided among four temperatures of 15, 20, 25, and 30°C, respectively (photoperiod L18:D6 throughout), and reared in the way described above until adult eclosion or until they had stopped feeding for at least two weeks. The latter were assigned to hibernation conditions again and observed for the following three months.

## Results and discussion

Following diapause, all *L. h. eurydame* larvae started to feed on *R. acetosa* leaves and moulted at least once. The majority of caterpillars developed without any further delay into adults. However, within each temperature group a certain proportion stopped feeding after a couple of days, obviously to enter a second diapause (Tab. 1). All of those survived, after being transferred to hibernation conditions again, for at least three additional months without feeding (after this period caterpillars were not observed any longer). The proportion of animals eventually denying further food intake was significantly higher at lower temperatures of 15 and 20°C (28.0%, n = 186) as compared to higher ones of 25 and 30°C (9.6%, n = 157;  $\chi^2_{1df} = 18.3$ , p<0.0001).

**Tab. 1.** Partially biennial life cycle in *L. h. eurydame*. Following diapause, larvae were randomly divided among four temperatures. In every group, some caterpillars stopped feeding after having moulted at least once. This proportion was significantly higher at low temperatures (15, 20°C) than at higher ones (25, 30°C). Given are absolute numbers and percentages of row totals (in parentheses).

[°C]	Number of larvae	
	developing into adults	entering second diapause
15	63 (77.8%)	18 (22.2%)
20	71 (67.6%)	34 (32.4%)
25	66 (91.7%)	6 (8.3%)
30	76 (89.4%)	9 (10.6%)

We therefore conclude to have found a temperature-modulated facultative biennialism in *L. h. eurydame*, where low temperatures, indicating unfavourable conditions for growth and development, seem to induce a higher rate of two-year developers. We suggest that adults producing a mixture of annual and biennial offspring gain bet-hedging benefits in case of particularly bad growing seasons (preventing offspring from reaching maturity and leading to death before onset of reproduction) or occasional catastrophes (cf. Thomas et al. 1998). The latter include years with occurrence of extremely early frost or snow cover. Hence, partial biennialism appears to be a strategy selected to cope with the unfavourable and unpredictable alpine environment (cf. Takahashi 1977; Hanski 1988; Danks 1992; Wipking & Mengelkoch 1994). In line with this reasoning, Beuret (1956) found incidental evidence for a comparable strategy in alpine *L. alciphron gordius* Sulzer 1776, but no evidence for a second larval diapause was ever found during own rearings with individuals of two other subspecies of *L. hippothoe*, viz. *L. h. hippothoe* and *L. h. sumadiensis* Szabó, 1956, originating from regions with more favourable climatic conditions (Fischer 2000).

About the instar which usually enters into (first) diapause there is some controversy in the literature. While SBN (1987) (and also Hesselbarth et al. (1995) for the related *L. candens* Herrich-Schäffer, 1844) claim that the second instar hibernates, Malicky (1970) noted that hibernation may occur in any larval stage. More recently, Bink (1992) explic-

itly stated that diapause occurs in the third instar. In large-scale rearings under controlled environmental conditions (Fischer 2000) the third instar indeed emerged as the dominant diapause stage, yet also diapausing fourth instars or subitaneous development were observed at variable rates depending on rearing temperatures. None of more than 1800 larvae from three different *L. hippothoe* populations ever went into diapause as second instar.

### Acknowledgements

We are indebted to E. Scheuringer (Rosenheim) for sharing his knowledge on the occurrence of *L. hippothoe* in the central Alps. This study was supported by grants from the Friedrich-Ebert-Foundation to K. Fischer.

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# Loss of flavonoid pigments with ageing in male *Polyommatus icarus* butterflies (Lycaenidae)

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**Summary.** *Polyommatus icarus* (Rottemburg, 1775) butterflies contain UV-absorbing flavonoid pigments sequestered from their larval hostplants. A comparison of freshly emerged laboratory-bred males with field-caught individuals of increasing wing wear, as a measure of age, revealed that the butterflies lose a substantial fraction of their flavonoid load, via loss of scales, during the first few days of their adult life-span. Possible consequences for intraspecific visual communications are discussed. Our findings show that the physiological status of butterflies, in addition to larval diet and sex, contributes to the pronounced intraspecific variation of flavonoid load, and thus UV wing pattern, in *P. icarus*.

**Zusammenfassung.** Falter von *Polyommatus icarus* (Rottemburg, 1775) enthalten aus der larvalen Nahrung sequestrierte Flavonoide als UV-absorbierende Pigmente. Ein Vergleich gezüchteter, frisch geschlüpfter Männchen mit Freilandfängen unterschiedlichen Alters und Abnutzungsgrades der Flügel zeigt, daß die Schmetterlinge schon innerhalb der ersten Tage ihrer adulten Lebensspanne einen Großteil der Flavonoide durch Schuppenverluste einbüßen. Mögliche Konsequenzen für die innerartliche visuelle Kommunikation werden angesprochen. Unsere Beobachtungen zeigen, daß neben der larvalen Nahrung und dem Geschlecht auch der physiologische Status der Tiere zur ausgeprägten innerartlichen Variabilität der Flavonoidbeladung und damit des UV-Flügelusters von *P. icarus* beitragen.

**Résumé.** Les adultes de *Polyommatus icarus* (Rottemburg, 1775) contiennent des pigments flavonoïdes absorbant la radiation UV, séquestrés de leurs plantes nourricières larvaires. La comparaison de mâles de culture en laboratoire fraîchement éclos à des individus ramassés dans la nature et frottés à divers degrés progressifs, en mesure de leur âge, a révélé que les papillons perdent une proportion substantielle de leur contenu en flavonoïdes, par la perte d'écailles, durant les premiers jours de leur vie adulte. Les implications possibles au niveau de leur communication visuelle intraspécifique sont discutées. Nos observations démontrent que l'état physiologique des papillons, complémentirement à leur nutrition à l'état larvaire et au sexe, contribue à la variation intraspécifique prononcée du contenu en flavonoïdes, et par conséquent à celle de la réflexion alaire des rayons UV, chez *P. icarus*.

Key words: Lycaenidae, *Polyommatus icarus*, flavonoid pigments, ageing, visual communications.

## Introduction

Wing colour patterns frequently play an important role in visual communication among butterflies. Differences between species in wing patterns may facilitate reproductive isolation, although many butterflies still recognize conspecifics even after major experimental manipulation (Silberglied 1984), suggesting that the importance of wing pattern differences for species recognition has frequently been overestimated. More often, intraspecific variation in brightness and intensity of colouration may serve as signal during mate choice or male-male interactions (Silberglied 1984; Brunton &

Majerus 1995). According to these authors conspicuous colour patterns of (usually) male butterflies (mimicry and aposematism being set aside) have largely evolved through intrasexual selection, although Darwinian intersexual selection (Smith 1984) and more complex interactions may also have been involved (Vane-Wright 1984; Vane-Wright & Boppré 1993).

Butterfly wing patterns are determined by two types of colours: structural colours due to interference and diffraction within specialized scales, and colours which result from absorption of specific spectral fractions of the light by pigments contained in the scales (Nijhout 1991). Since the eyes of most butterflies studied thus far are sensitive from the human-visible spectrum far into the UV-range (sensitivity typically stretches from 340 to 700 nm: Eguchi et al. 1982; Bernard & Remington 1991), any studies of biological functions of butterfly wing patterns must consider this entire spectral range (Silberglied 1984; Endler 1990).

Brightness and intensity of UV reflection patterns can decrease with ageing due to increasing wing wear (i.e. loss of scales) and may then affect mating opportunities (Rutowski 1985). We here report on a special case of such age-related changes. Numerous butterflies sequester flavonoids from their larval hostplants, and during metamorphosis incorporate these plant-derived pigments into their wings (Ford 1941; Nijhout 1991). Flavonoids may have various colours to the human eye (often yellow), but they all strongly absorb UV-light with two distinct maxima. One of these maxima lies in the range of 240–280 nm and is invisible to insects, but the other maximum is situated, depending on the specific chemical compound, in the range between 300–380 nm (Harborne 1991) and thus visible to UV-sensitive insect compound eyes.

Recent work on the sequestration of flavonoids by lycaenid butterflies has shown that (1) only particular hostplant flavonoids are stored by the larvae, while others are excreted; (2) lycaenid larvae are capable of metabolizing flavonoids, usually by means of glycosylation; (3) 60–80% of an adult butterfly's flavonoid load is situated in the scales of the ventral wing surfaces; and (4) females typically sequester larger amounts and concentrations of these phenolic pigments than males (Wiesen et al. 1994; Burghardt et al. 1997; Geuder et al. 1997; Schittko et al. 1999). As a result, adult butterflies of the common blue butterfly, *Polyommatus icarus* (Rottemburg 1775), for example, strongly vary with regard to their flavonoid content, depending on sex and hostplant used during the larval stages. This variation translates into differences in underside wing patterns in the UV-range (Knüttel & Fiedler 1999), and at least for females such variation is biologically significant. Females richer in flavonoids are more attractive to mate-searching males (Burghardt et al. 2000).

Against this background we set out to investigate how flavonoid load of adult butterflies changes with age and wingwear. Specifically we tested the hypothesis that flavonoid content of older, worn individuals would decrease due to the loss of flavonoid containing scales.

## Material and Methods

Butterflies of the summer generation were collected at various locations in northern Bavaria (around Würzburg, Bayreuth, and Regensburg). Since males are more easily found in the field, and in order to minimize damage to natural populations, only this sex was sampled for the present study. Butterflies were killed immediately after capture, frozen, freeze-dried and stored at  $-20^{\circ}\text{C}$  until needed for chemical analyses. Special care was taken not to inflict any damage to the specimens apart from their natural wingwear. To obtain butterflies with complete flavonoid load prior to any scale losses, we took males from a laboratory culture, whose parental stock also had originated from Würzburg. These butterflies had been raised in an environmental chamber at  $22.5^{\circ}\text{C}$  (see Burghardt & Fiedler 1996 for details), using flowers of *Lotus corniculatus* L. (a preferred hostplant of northern Bavarian populations: Ebert & Rennwald 1991, own field observations) as larval food.

Before analysis each butterfly was weighed to the nearest 0.1 mg (on an electronic balance), its forewing length measured to the nearest 0.1 mm (using precision calipers), and its wing wear was subjectively classified into one of the following four categories:

- I. Fresh, totally undamaged butterfly (here only reared males which were killed 1–2 h after eclosion);
- II. Light wing wear, loss of scales discernible (e.g. at fringes), but colour still brilliant blue (to the human eye);
- III. More severe wing wear, loss of scales distinct, but less than 5% of wing area missing, blue upperside colour fading;
- IV. Severely worn, pronounced scale losses all over, larger fractions of wing surface damaged (e.g. along margins), colouration dull.

For chemical analyses of the flavonoid content, each specimen was individually ground in a mortar and extracted in 90% methanol (MeOH) + 10%  $\text{H}_2\text{O}$ . To exhaustively recover soluble flavonoids, extraction was repeated three times over 24 h each under permanent stirring. The total extract was then filtered, particles removed using a centrifuge, and analysed by means of HPLC (GynkotekM480, equipped with column heater, temperature set at  $20^{\circ}\text{C}$ ; column: Eurospher 100-C18,  $125 \times 4$  mm) using a linear MeOH/ $\text{H}_3\text{PO}_4$  gradient (starting with 10%MeOH + 90%  $\text{H}_3\text{PO}_4$ , after 50 min: 100%MeOH, flow rate: 1ml/min; see Schittko et al. 1999 for further details).

Flavonoids were detected by UV-VIS spectroscopy (using a UVD 340S detector). As far as possible, flavonoid compounds were identified using a spectral library stored in the computer system of the HPLC equipment, or by comparison with flavonoids previously isolated and identified from larval hostplants (Burghardt 2000). However, for the purpose of the present study the total flavonoid load of butterflies was more important than identification of each substance, since all flavonoids contribute to the UV-wing pattern due to their absorption properties. To assess this complete flavonoid load as accurately as possible, all peaks in each HPLC chromatogram were individually checked for their characteristic bimodal UV spectrum, and each peak which showed UV absorption in both ranges characteristic for flavonoids (240–280 nm due to benzoyl ring, 300–

380 nm due to cinnamoyl double ring) was scored as a flavonoid. Quantification of flavonoid peaks was made possible by adding a known amount of one flavonoid (Kaempferol, Roth™, purity >98%) as internal standard to each extract prior to HPLC analysis. Free unglycosylated Kaempferol does not occur in *P. icarus* butterflies (Burghardt 2000) and hence does not affect the results. Calibrated by this internal standard, the area of each peak in a chromatogram could then be converted into a measure of amount, or concentration, of the respective compound. The total sum of all these compounds is subsequently referred to as 'flavonoid load', and the ratio of flavonoid load versus dry mass is referred to as 'flavonoid concentration'. Data were evaluated statistically using StatSoft (1999). Throughout the text, mean values are given  $\pm 1$ SE.

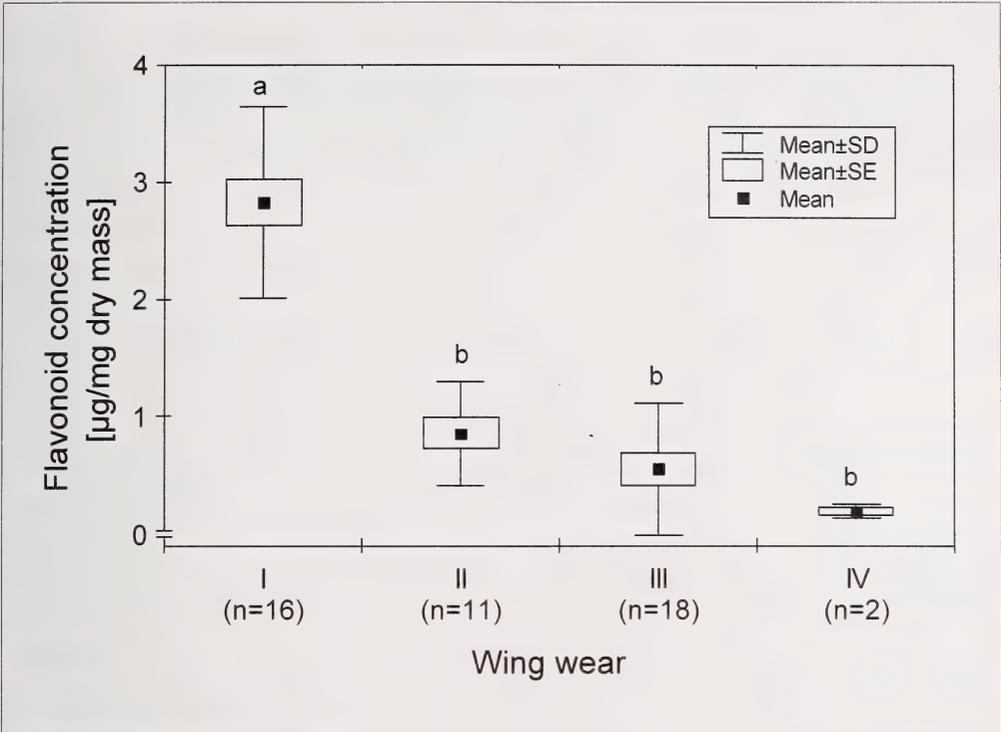
## Results

Freshly emerged male butterflies reared on *L. corniculatus* flowers were rather rich in flavonoids ( $26.48 \pm 1.60 \mu\text{g}$ , range: 16.33–36.87  $\mu\text{g}$ ), but even with slight wingwear flavonoid load decreased drastically ( $8.10 \pm 1.22 \mu\text{g}$ ; range: 2.54–15.67  $\mu\text{g}$ ) and further diminished with increasing wingwear. Two totally worn males contained less than 2  $\mu\text{g}$  flavonoids per individual. These differences were highly significant (Kruskal-Wallis test:  $H_{3,df} = 33.10$ ,  $p < 0.0001$ ). When controlling for body mass, the pattern with regard to flavonoid concentrations remained unchanged (Fig. 1).

Reared, freshly eclosed males were much richer in flavonoids than even moderately worn, field caught butterflies, despite the fact that the latter were significantly larger (fore wing length, field caught:  $15.97 \pm 0.15$  mm; reared:  $14.56 \pm 0.15$  mm; t-test,  $p < 0.01$ ). No significant differences, however, occurred with regard to dry mass (field caught:  $10.03 \pm 0.32$  mg; reared:  $9.36 \pm 0.35$  mg; t-test,  $p > 0.10$ ). Within neither of the wingwear classes I, II, and III (where enough individuals were available to allow for quantitative analysis) was there any significant (positive or negative) correlation between butterfly size (measured either as fore wing length or dry mass) and flavonoid richness (measured as total flavonoid load or concentration, respectively: Pearson correlations,  $p > 0.07$  in each case).

## Discussion

Our results show that, as expected, *P. icarus* butterflies lose UV-absorbing flavonoid pigments in the course of ageing. Progressive loss of pigmented scales is certainly the only significant mechanism responsible for such flavonoid losses. After metamorphosis no metabolism takes place within pigmented scales, and flavonoids are so robust against other means of degradation (e.g. photo-oxidation) that during the short lifespan of an adult *P. icarus* butterfly such effects are negligible. Age-related changes in the flavonoid load of butterflies have a couple of ramifications. First, it may be inappropriate to quantitatively estimate flavonoid load of field-caught specimens without accounting for butterfly age and wing wear. Not only is it problematic to draw conclusions in polyphagous species, when the larval feeding history of a specimen remains unknown (as for example in Wilson (1987), where hostplant relationships were in-



**Fig. 1.** Decrease of total flavonoid concentration [ $\mu\text{g}/\text{mg}$  dry mass] in individual males of *Polyommatus icarus* with increasing wing wear. I: undamaged, freshly eclosed male; to IV: strongly worn, tattered male (for definition of categories see text). Overall differences are highly significant (Kruskal-Wallis test:  $H_{3,df} = 33.94$ ,  $p < 0.0001$ ). Boxes marked with the same letter do not differ significantly (Tukey-Kramer test, significance level set as  $p = 0.05$ ).

ferred from – partly even erroneous – literature data). In addition to this qualitative source of uncertainty, butterflies apparently quickly lose a substantial fraction of their original flavonoid load contained in wing scales in the course of flight activity. Judging from own extensive field experience and mark-release-recapture studies, *P. icarus* males in the wing wear class II were probably just 1–3d old, and those in class III about 4–8d (Tillmanns 1995; Fiedler, unpublished observations).

Our representatives of wing wear class I (young, freshly emerged) had all been bred in the laboratory on a very favourable, flavonoid-rich diet (Burghardt 2000). We cannot be sure that all, or at least a majority of, our field-caught specimens had really fed on *L. corniculatus* as larvae, although during a detailed field study conducted at the campus of Würzburg university more than 70% of all observed ovipositions occurred on this plant species (Tillmanns 1995). In fact, the flavonoid profile of one male specimen (from Volkach near Würzburg) strongly suggests the larval hostplant in this case was *Medicago sativa* L. However, if raised on *M. sativa* inflorescences, flavonoid load of *P. icarus* butterflies is even higher than when fed *L. corniculatus* (Burghardt 2000). In a comparison among butterflies reared on six naturally used hostplants, flavonoid loads

and concentrations of specimens from *L. corniculatus* always scored at an average rank (Burghardt 2000). Hence, the choice of butterflies reared on this particular hostplant for comparison with field-caught individuals should not have exaggerated our results.

Second, wing wear in *P. icarus* males is not only reflected in a fading of the brilliant iridescent colour of the dorsal wing surfaces (which is brought about by structural colours and extends far into the UV-range), but also affects the absorption pattern of the ventral wing surfaces, and here notably the UV-absorption through flavonoids. For the visual system of insects capable of UV-vision, UV-absorbing pigments superimposed on a colour pattern in other parts of the spectral range can enhance colour saturation and thus visibility (e.g. Lunau 1992). This means that a fresh butterfly with intact reflectance colouration on the dorsal surface plus intensive and more saturated underside colour pattern should be more conspicuous to conspecifics in the field, for example over larger distances. We do not know yet whether in *P. icarus* intraspecific colour differences play a role in male-male interactions, or increase attractiveness of males for females during courtship. However, male-male combats are very common during patrolling flights of *P. icarus* (Lundgren 1977), and it is well conceivable that wing colouration and wingwear serve as signals in this context (cf. Brunton & Majerus 1995). Third, although our data shown above refer to male butterflies, females most likely experience similar losses of flavonoids (and of course other pigments) with progressive scale loss when ageing. In *P. icarus* (Wiesen et al. 1994; Burghardt et al. 1997; Schittko et al. 1999), as well as in the related *P. bellargus* (Rottemburg, 1775), females even sequester distinctly more flavonoids than males. Hence, the effect of these pigments on UV wing patterns is more pronounced in females, and consequently one should expect an even stronger difference between flavonoid-rich young individuals and older, worn females. For females sitting in the vegetation and waiting for mate-searching males which patrol through the habitat, richness in flavonoids substantially increases their attractiveness to the opposite sex (Burghardt et al. 2000). Thus, the older and more worn a female, the more may her chances decrease to be located by a male. A high flavonoid load, which renders a female more conspicuous to potential mates, could therefore assist in reducing her risk of pre-reproductive mortality (cf. Zonneveld & Metz 1991). Further experiments are required to assess whether among lycaenid butterflies richness in plant-derived flavonoid pigments signals 'quality' or 'youth' to potential mates (i.e. directly reflects some fitness components: Møller & Alatalo 1999), or rather just enhances visibility (i.e. provides superior stimulation of the visual capacities of conspecifics, cf. Ryan & Keddy-Hector (1992) for the reverse situation where females choose among competing males).

Our findings presented here demonstrate that interactions between lycaenid butterflies and flavonoids in their hostplants are even more complicated than previously thought. Apart from larval food and gender, the physiological status of a butterfly must also be considered as additional source of phenotypic variation in pigment load and thus UV wing pattern.

## Acknowledgments

We thank H. Knüttel, M. Obermayer and Dr. P. Seufert for providing specimens for this study. In an early phase of the investigations reported here, A. Tillmanns helped in assembling basic quantitative data on the behavioural biology of *P. icarus*. B. Kornmaier assisted with software-based analyses of UV-spectrum data. The district government of Oberfranken (Bayreuth) kindly issued a permit to study a legally protected species. This work was financially supported by the Deutsche Forschungsgemeinschaft (Fi 547/2-1 and Pr 229/8-2).

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## On the papers “Systema Glossatorum...” of Fabricius (1807) and “Die neueste Gattungs-Eintheilung der Schmetterlinge...” of Illiger (1807) and the consequences for authorship of several generic names

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**Summary.** The examination of the original of the paper “Die neueste Gattungs-Eintheilung der Schmetterlinge...” revealed, that the author of it is Illiger and not Fabricius as stated in the “Official Lists and Indexes of Names and Works in Zoology” (Melville & Smith 1987: 314). As a contribution to the stability of the names in the sense of the rules of the ICZN we propose to use the authorship for the genera as follows: [Fabricius in Illiger], 1807.

**Zusammenfassung.** Die Prüfung der Arbeit “Die neueste Gattungs-Eintheilung der Schmetterlinge...” am Original hat ergeben, dass sie von Illiger und nicht von Fabricius stammt, wie das in den “Official Lists and Indexes of Names and Works in Zoology” (Melville & Smith 1987: 314) vermerkt ist. Als Beitrag zur Stabilität der Namen im Sinne der Regeln der ICZN wird vorgeschlagen, für die Gattungen die Autorenschaft [Fabricius in Illiger], 1807 zu verwenden.

**Résumé.** Un examen du travail „Die neueste Gattungs-Eintheilung der Schmetterlinge ...“ a révélé que l’auteur en est Illiger et non Fabricius, ainsi qu’il est rapporté dans les „Official Lists and Indexes of Names and Works in Zoology” (Melville & Smith 1987: 314). Afin de contribuer à la stabilité des noms en conformité aux règles du Code, nous proposons d’établir comme auteur pour les genres concernés: [Fabricius in Illiger], 1807.

Key words. Nomenclature. Lepidoptera. generic names. authorship. Fabricius. Illiger

In Opinion 137 (ICZN, 1942) three generic names of butterflies (*Morpho*, *Helicopis*, and *Pontia*) attributed to Fabricius were given precedence over names published by Hübner. The “Official Lists and Indexes of Names and Works in Zoology” (Melville & Smith 1987) on p. 314 states: “Fabricius, (J. C.), 1807, ‘Die neueste Gattungs-Eintheilung der Schmetterlinge aus den Linnéischen Gattungen *Papilio* und *Sphinx*.’ Mag. f. Insektenk. (Illiger) 6: 277 - 295. (under the ruling given in Opinion 137 generic names published in that paper are to take precedence over any names published for the same genera earlier in 1807 by Hübner (J.) on the legends to plates in Volume 1 of the work entitled *Sammlung exotischer Schmetterlinge*). Direction 4.”

Having examined the original we found that the author of that paper is not Fabricius as stated in Opinion 137 but Illiger. The paper is anonymous (i.e. without stated author); however, there is ample indirect evidence that all unattributed papers in the “Magazin für Insektenkunde” are by Illiger himself.

This is in agreement with Bryk (1938b, 1939) who discussed the problem of Fabricius’ “Systema Glossatorum” in detail (see also Zinken 1831, Hagen 1862-63, Horn & Schenkling 1928-29, Tuxen 1967).

According to Bryk (l. c.) Illiger most likely was in possession of the manuscript of Fabricius' "Systema Glossatorum". Illiger published, probably without Fabricius' permission, the generic names which are proposed in this manuscript. Not only did he translate the Latin manuscript into German ("Ich liefere die Gattungsmerkmale von Fabricius treu verdeutscht"), but he also added characters which are not used by Fabricius ("füge aus der Beschreibung des Körperbaues die Angabe von der Fussbildung hinzu"). Furthermore, he did not accept the changes of several specific names which Fabricius intended to publish ("Ich habe die Artnamen der Ent. Systematica beibehalten; in dem Systema Glossatorum werden sie häufig mit andern, besonders mit den von der Pflanze genommenen Namen vertauscht, auf der die Raupe lebt.")

Subsequent to Illiger (1807) Zinken (1831) was the first who mentioned the "Systema Glossatorum". He explained that the paper in question was never issued, and that the seven sheets already printed did not leave the printing office in an official way. He named it as "Fabricii systema Glossatorum inedita". At least four copies of the printed part of the whole publication (7 printed sheets) left the printing office: one copy was obtained by Zinken ("...Diese sieben Bogen, von welchen ein Exemplar vom allgemeinen Untergange zu retten, ein glücklicher Zufall mir Gelegenheit gegeben hat..."), the existence of three others is indicated in Tuxen (1967): "Ein Exemplar, wie oben mit Titelblatt, in der Bibliothek des Zoologischen Museums zu Berlin [the facsimile of Bryk was made from this copy]; ein zweites, ohne Titelblatt, mit p. III-XII, 13-112, in der Königlichen Bibliothek in Kopenhagen [this is the copy mentioned by Hagen (1862: 222) to be in the library of Dohrn]; ein drittes, nur p. 1-80 im American Museum of Natural History, New York." One additional copy was in the hands of Illiger, maybe it is the one now in the Museum für Naturkunde in Berlin.

It is clear, that the paper sheets of Fabricius are not a published paper in the sense of the rules of the ICZN (Art. 8.1.2.). The first published version of the paper is by Illiger, in which he used the first seven sheets of Fabricius' text. This is why the indication in the "Official List and Indexes of Names and Works in Zoology" (Melville & Smith 1987: 314) is to be changed. The correct citation is:

[Illiger, J. C. M.] 1807: Die neueste Gattungs-Eintheilung der Schmetterlinge aus den Linnéischen Gattungen Papilio und Sphinx. - Magazin für Insektenkunde (Illiger) 6: 277 - 295.

As a consequence it would be necessary to use the generic names listed below with the author as Illiger instead of Fabricius, an alteration to previous use. As a contribution to the stability of the names in the sense of the rules we propose to use the generic names as follows:

*Acraea* [Fabricius in Illiger], 1807, Magazin für Insektenkunde (Illiger) 6: p. 284;

*Aegeria* [Fabricius in Illiger], 1807, l. c.: p. 288;

*Amata* [Fabricius in Illiger], 1807, l. c.: p. 289;

*Amathusia* [Fabricius in Illiger], 1807, l. c.: p. 279;

*Argynnis* [Fabricius in Illiger], 1807, l. c.: p. 283;

*Apatura* [Fabricius in Illiger], 1807, l. c.: p. 280;

- Biblis* [Fabricius in Illiger], 1807, l. c.: p. 281;  
*Brassolis* [Fabricius in Illiger], 1807, l. c.: p. 282;  
*Castnia* [Fabricius in Illiger], 1807, l. c.: p. 280;  
*Cethosia* [Fabricius in Illiger], 1807, l. c.: p. 280;  
*Colias* [Fabricius in Illiger], 1807, l. c.: p. 284;  
*Cynthia* [Fabricius in Illiger], 1807, l. c.: p. 281;  
*Danis* [Fabricius in Illiger], 1807, l. c.: p. 286;  
*Doritis* [Fabricius in Illiger], 1807, l. c.: p. 283;  
*Emesis* [Fabricius in Illiger], 1807, l. c.: p. 287;  
*Erycina* [Fabricius in Illiger], 1807, l. c.: p. 286 (a homonym of *Erycina* Lamarck, 1805);  
*Euploea* [Fabricius in Illiger], 1807, l. c.: p. 280;  
*Glaucopis* [Fabricius in Illiger], 1807, l. c.: p. 289 (a homonym of *Glaucopis* Gmelin, 1788);  
*Haetera* [Fabricius in Illiger], 1807, l. c.: p. 284;  
*Helias* [Fabricius in Illiger], 1807, l. c.: p. 287;  
*Helicopis* [Fabricius in Illiger], 1807, l. c.: p. 285;  
*Hipparchia* [Fabricius in Illiger], 1807, l. c.: p. 281;  
*Idea* [Fabricius in Illiger], 1807, l. c.: p. 283;  
*Laothoe* [Fabricius in Illiger], 1807, l. c.: p. 287-288;  
*Libythea* [Fabricius in Illiger], 1807, l. c.: p. 284;  
*Limenitis* [Fabricius in Illiger], 1807, l. c.: p. 281;  
*Lycaena* [Fabricius in Illiger], 1807, l. c.: p. 285-286;  
*Mechanitis* [Fabricius in Illiger], 1807, l. c.: p. 284;  
*Melanitis* [Fabricius in Illiger], 1807, l. c.: p. 282;  
*Melitaea* [Fabricius in Illiger], 1807, l. c.: p. 284-285;  
*Morpho* [Fabricius in Illiger], 1807, l. c.: p. 280;  
*Myrina* [Fabricius in Illiger], 1807, l. c.: p. 286;  
*Neptis* [Fabricius in Illiger], 1807, l. c.: p. 282;  
*Nymphidium* [Fabricius in Illiger], 1807, l. c.: p. 286;  
*Pamphila* [Fabricius in Illiger], 1807, l. c.: p. 287;  
*Paphia* [Fabricius in Illiger], 1807, l. c.: p. 282 (a homonym of *Paphia* Bolton, 1798);  
*Pontia* [Fabricius in Illiger], 1807, l. c.: p. 283;  
*Procris* [Fabricius in Illiger], 1807, l. c.: p. 289;  
*Thais* [Fabricius in Illiger], 1807, l. c.: p. 283 (a homonym of *Thais* Bolton, 1798);  
*Thecla* [Fabricius in Illiger], 1807, l. c.: p. 286;  
*Thymele* [Fabricius in Illiger], 1807, l. c.: p. 287;  
*Urania* [Fabricius in Illiger], 1807, l. c.: p. 279;  
*Vanessa* [Fabricius in Illiger], 1807, l. c.: p. 281;  
*Zelima* [Fabricius in Illiger], 1807, l. c.: p. 279 (a homonym of *Zelima* Meigen, 1800).

It is worth mentioning that Bryk (1938a) issued a facsimile of the copy which is housed in the Museum für Naturkunde in Berlin. Though published 130 years after Fabricius' death, this facsimile made the "Systema Glossatorum" available in the sense of the rules.

As he considered the original copy of 1807 to be available, Bryk (1930) listed several specific names with reference to Fabricius (1807) in synonymy. Although presented at

the VIIth Int. Congress of Entomology in Berlin in 1938, the reprint (Bryk 1938a) went mainly unnoticed (e. g. it was never registered in the "Zoological Record").

### Acknowledgments

We wish to express our thanks to Dr. K. Sattler (London), Dr. R. Meier (Copenhagen) for their kind advice. A. D. Liston kindly corrected the English.

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# An electron microscope look at wing scales in “greasy” Lepidoptera

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**Summary.** The ultrastructural consequences of “wing grease” in dried Lepidoptera specimens are examined and described for two cases (Agathiphagidae: *Agathiphaga vitiensis* Dumbleton, 1952 and Hepialidae: *Hepialus humuli*). The ultrastructure of the wing scales and of the wing surface are heavily obscured.

**Zusammenfassung:** Die Auswirkungen “verölter” Flügel auf die Feinstruktur von Schmetterlingsflügeln werden an zwei Beispielen beschrieben und illustriert (Agathiphagidae: *Agathiphaga vitiensis* Dumbleton, 1952 und Hepialidae: *Hepialus humuli*). Die Ultrastruktur der Flügelschuppen wird durch Verölung weitgehend verdeckt.

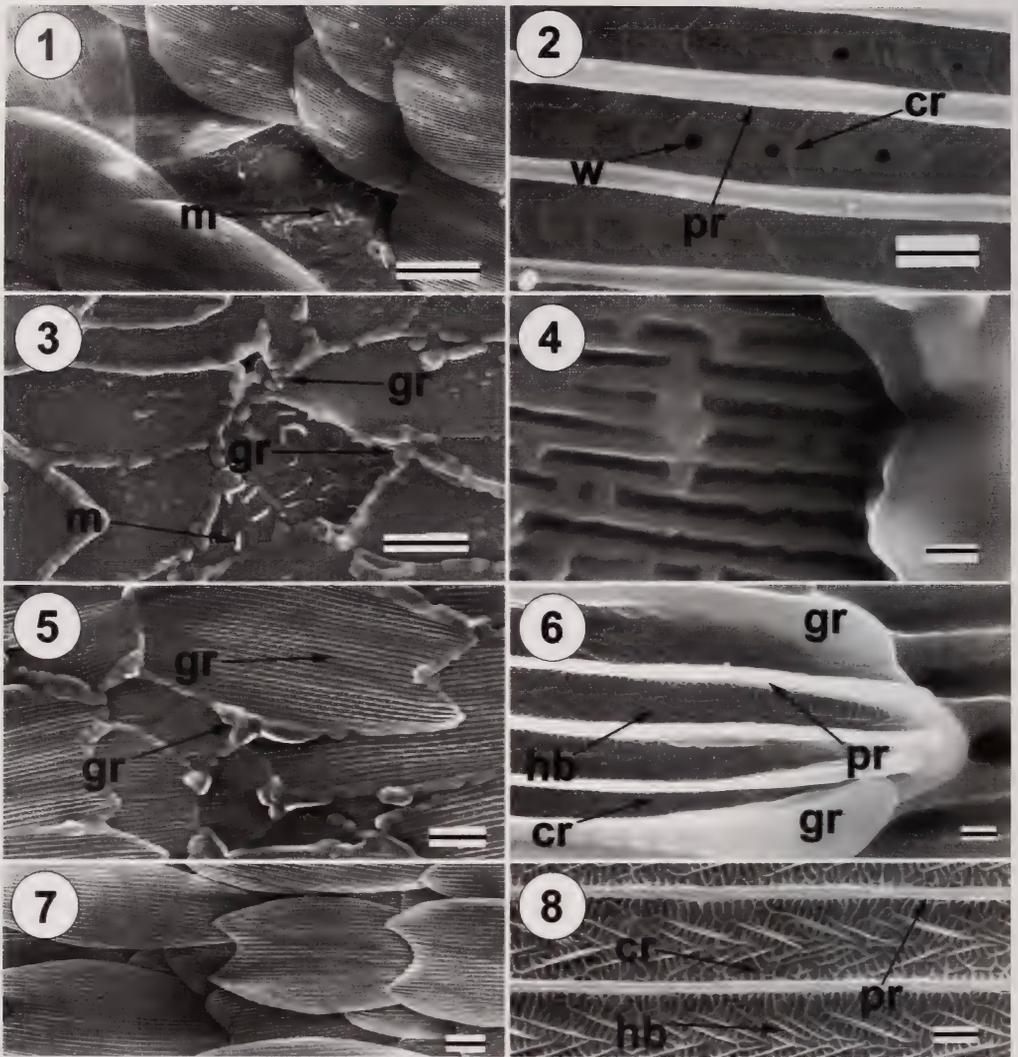
**Résumé.** Les conséquences ultrastructurelles du „graissage des ailes“ de spécimens de lépidoptères désséchés sont examinées et décrites pour deux cas (Agathiphagidae: *Agathiphaga vitiensis* Dumbleton, 1952 et Hepialidae: *Hepialus humuli* (Linné, 1758)). L’ultrastructure des écailles alaires et de la surface alaire sont fortement obscurcis.

**Key words:** Lepidoptera, wing scales, specimens, collections.

Greasiness in dried Lepidoptera is well known among lepidopterists as a very irritating phenomenon which can literally ruin collection specimens. It is due to fats exuding from the animals fat body, and it is most common in taxa with boring larvae (Wolff 1934). Not only does the phenomenon alter the overall appearance of the wing colours and patterns, hence making the specimen useless for macroscopical pattern/colour diversity studies; the phenomenon also obscures the fine details of the wing surface and of the wing scales. However, little attention has been given to the ultrastructural consequences of the grease. This note unveils some of these consequences as seen with the scanning electron microscope, and reports on the effects of cleaning the wings with organic solvents.

Dorsal forewing sectors from one greasy and one clean specimen of male *Hepialus humuli* (Linnaeus, 1758) and one greasy specimen of *Agathiphaga vitiensis* Dumbleton, 1952 were examined in a JEOL JSM-840 scanning electron microscope (SEM). Another forewing sector of the same *A. vitiensis* specimen was first cleaned in absolute ethanol (18 hours), subsequently in benzol (12 hours) and finally freeze dried before it was examined with SEM. The cleaned *A. vitiensis* wing sector was freeze dried to make sure that all benzol was removed from it before coating it with gold in a sputter coater (standard SEM preparation procedure). This may not be necessary when using some newer sputter coaters, but since especially some older models require totally dry material, I choose this extra step in the procedure.

The results demonstrate a remarkable difference between the greasy and the cleaned *H. humuli*. In the clean specimen (Figs. 1-2) sculptures such as longitudinal ridges, windows



**Figs. 1–8.** 1–4: *Hepialus humuli*. 1 – Clean wing scales and wing surface with microtrichia (m); 2 – Detail of 1 with windows (w), primary ridges (pr) and cross ribs (cr); 3 – Greasy (gr) wing scales and wing surface; 4 – Detail of 3. 5–8: *Agathiphaga vitiensis*. 5 – Greasy wing scales, note that some pr, cr and herring bone crests (hb) are visible; 6 – Detail of 5. 7 Cleaned wing scales; 8 – Detail of 7. (Reference bars: 1, 3, 5, 7 = 20  $\mu\text{m}$ . 2, 6, 8 = 1  $\mu\text{m}$ . 4 = 2  $\mu\text{m}$ ).

and cross ribs on the scales and microtrichia (Downy & Allyn 1975, Ghiradella 1998) on the wing surface are clearly visible. In the greasy specimen (Figs. 3–4), however, almost no scale ultrastructure is visible and even the microtrichia are largely obscured. The *A. vitiensis* specimen illustrated in Figs. 5–6 is not as heavily greased as the *H. humuli* specimen; on parts of the wing scale surface sculptures such as longitudinal ridges and herring bone crests (Kristensen 1970; Common 1973; Simonsen & Kristensen *in prep.*) are visible. After cleaning as described all the wing scale sculptures are visible again (Figs. 7–8).

In both examples the most conspicuous greasing effect is a deposition of fat along the scale margins. Such fat deposits are likely to occur at a rather early stage of greasiness development in preserved specimens, and their presence indicate that cleaning (e.g. as described) is mandatory before reliable ultrastructural observations can be made. It must be emphasised that moderate greasiness is *not* always obvious from low-magnification observation of Lepidoptera specimens.

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## Book Review

**Holloway, J. D., G. Kibby & D. Pegg** 2001. **The families of Malesian moths and butterflies.** Fauna Malesiana Handbooks 3, xi + 455 pp, 8 colour pls.: 8–174, 125 textfigs. – Brill Academic Publishers, Leiden. – ISBN: 90-04-11846-2. Price: € 118.00.

Though principally addressing Lepidoptera of the Oriental region, this new volume is also of great interest to readers concerned with other biogeographical realms. It is divided into four main sections. The introduction provides profound information about phylogeny, higher classification, biogeography and biology, but also informs about technical aspects of collecting, genitalia preparations, and important literature and reference collections relevant to the focal region, Malesia (i.e. SE Asia and Newguinea). The second section deals with external, and to a lesser degree internal, morphology of Lepidoptera, including early stages. In the third chapter a key to all major families is provided, supplemented with highly informative 'quick fixes' for sorting (tropical) Lepidoptera and their larvae to family level. Also some very thoughtful summary accounts of hostplant relationships are given. The fourth, and main, chapter (180 pp.) consists of brief accounts of all family level taxa (including those not occurring in Malesia) with many hints to diagnostic features as well as biological or biogeographical peculiarities. A selection of fine colour plates (by B. D'Abrera) gives a first glance of the family diversity of Malesian Lepidoptera. Appendices on species richness patterns, pest Lepidoptera, a very extensive and splendidly up-to-date list of references (close to 1000 entries), and indexes to morphological terms and names complete this volume.

This new book gives a succinct introduction into most aspects of the study of Lepidoptera and therefore will be of particular interest to those who are not (yet) experts on this insect order. In many respects it may replace the two treatments authored by I. F. B. Common (*Moths of Australia*, Brill, 1990) and M. J. Scoble (*The Lepidoptera*, Oxford University Press, 1992). In particular, due to its relatively moderate price it will be attractive for those just starting with the study of Lepidoptera or with a smaller budget. Treatments of systematics, biogeography, or diversity issues are of current-edge status. Though much of the information presented is also available elsewhere, this handy and most readable compilation, spiced with numerous new details from the first author's unrivalled field experience with Oriental Lepidoptera, makes this volume a most valuable addition to the book market. If I were asked by a student or colleague which book to choose to become acquainted with Lepidopteran diversity without going lost in detailed handbook length monographs, I would confidently recommend: take that new Holloway et al. volume.

Konrad Fiedler

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Higgins, L. G. & N. D. Riley 1980. A field guide to the butterflies of Britain and Europe. 4th ed. – Collins, London. 384 pp., 63 pls.

Robinson, G. S. & K. R. Tuck 1996. Describing and comparing high invertebrate diversity in tropical forest – a case study of small moths in Borneo. Pp. 29–42. – In: D. S. Edwards, W. E. Booth & S. C. Choy (eds.), Tropical rainforest research – current issues. – Kluwer Academic Publishers, Dordrecht.

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The first mention of any living organism should include the full scientific name with the author and the year of publication. For systematic papers authors should strictly follow provisions of the current edition of the *International Code of Zoological Nomenclature*. Otherwise, the nomenclature used should follow a recent list or other suitable work and this should be cited. New species group taxa must be carefully distinguished from their congeners (key and/or diagnosis); if they are compared only to members of a subordinate species group, the latter must be diagnosed. The abbreviations **gen. n.**, **sp. n.**, **syn. n.**, **comb. n.** or similar should be used to explicitly indicate all taxonomic innovations. In describing new genus-group taxa, the nominal type-species must be designated in its original combination and with reference to the original description immediately after the new name. New genus group or higher taxa are only accepted if their proposal is accompanied by explicit phylogenetic reasoning. In describing new species-group taxa, one specimen must be designated as the holotype; other specimens mentioned in the original description and included into the type series are to be designated as paratypes. Additional specimens considered but not regarded as paratypes should be listed in a separate paragraph. The complete data of the holotype and paratypes, and the institutions in which they are deposited (abbreviations are to be explained in advance), must be recorded in the original description. Localities should be cited in order of increasing precision as shown in the examples; in cases when label text is quoted, it should be included between inverted commas.

**Material.** Holotype ♂ Turkey, Hakkari, 8 km E. of Uludere, 1200 m, 10.vi.1984, van der Stoel leg. (ITZA). Paratypes: 7♂, 3♀ labelled as holotype; 1♂, 1♀ ‘Achalzich Chambobel 1910 Korb’ (NHMW); 2♂, 1♀ Iraq, Kurdistan, Sersang, 1500 m, L. Higgins leg. (BMNH); 1♂ Iraq, ‘Shaqlawa, 2500 ft, Kurdistan, 15/24 May 1957’, L. G. Higgins leg. (BMNH).

The editors urge, in line with the recent edition of the ICZN, all authors of newly described species-group taxa to deposit holotypes in publicly accessible collections. Inclusion of a clear statement about type depositions with the original description is mandatory. The derivation of new names is suggested to be explained in a paragraph *Etymology* indicating the gender for generic names and kind of specific names (adjective, noun in apposition etc.).

Papers not conforming with these requirements are liable to be returned to the authors. Twenty-five reprints of each paper will normally be supplied free of charge to the first author; additional copies may be ordered on a form enclosed with the proofs.

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# SOCIETAS EUROPAEA LEPIDOPTEROLOGICA e. V.

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# NOTA LEPIDOPTEROLOGICA

A journal devoted to the study of Lepidoptera  
Published by Societas Europaea Lepidopterologica (SEL)



Vol. 24 No. 3 2001

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# SOCIETAS EUROPAEA LEPIDOPTEROLOGICA e. V.

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ISSN 0342-7536

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# Nota lepidopterologica

A journal devoted to the study of Lepidoptera  
Published by the Societas Europaea Lepidopterologica e. V.



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**Halle / Saale, 21.12.2001**

**ISSN 0342-7536**

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## Ebbe Schmidt Nielsen 7 June 1950 – 6 March 2001



„Whom the gods love dies young“ is an ancient Greek saying that came to mind, as the news of Ebbe Nielsen's sudden passing spread through the global community of lepidopterists and biodiversity researchers. At age fifty his vigour and life style made him seem endowed with eternal youthfulness (although his heart had given him a serious warning in mid-1999), and numerous prestigious honours testified to his success as a scientist. By members of the *Societas Europaea Lepidopterologica* he will be remembered as one of the founders of the Society and, while he had moved to Australia almost two decades ago, he retained very close professional and personal links to colleagues in his native Denmark and in many other European countries.

Ebbe Schmidt Nielsen – just Ebbe to most lepidopterists worldwide – spent his childhood and youth in the countryside near Silkeborg in Central Jutland, one of the areas in Denmark where nature is at its most varied and attractive. His farmer/gardener parents instilled a general interest in natural history early in his life, and an enthusiasm for Lepidoptera developed during his secondary school days – along with an enthusiasm for literature and dance. This fascination with Lepidoptera was strongly nurtured by the inspiring books available to him (probably no other monograph of a national macro-moth fauna is at the same time as informative and entertaining as Skat Hoffmeyer's Danish-language trilogy *De Danske Spindere*, *De Danske Ugler* and *De Danske Målere*), as well as by interaction with other keen and knowledgeable Lepidoptera collectors, who met in *Århus Entomologklub*. Having finished school he spent his compulsory national service in the civil defence corps, where he rose to the rank of officer and acquired a familiarity with four-wheel-driver trucks, which he later put to good use during entomological expeditions to little-accessible parts of the globe.

In 1971 Ebbe enrolled as a biology student at Århus University, and he rapidly became a prominent member of the local entomological community; by 1973, for example he played a highly active role in the organising committee of the 16th Nordic Entomological Congress that was held in Århus under the joint sponsorship of the Århus Natural History Museum, the Århus University Zoology Institute, and the above-mentioned *Entomologklub*. These were the years of the ambitious 'International Biological Programme', to which the Danish contribution was an in-depth investigation of a beech stand ecosystem ('Kalø Hestehave', E of Århus) led by Århus University biologists. Ebbe joined the team, and his inventory of the Kalø Lepidoptera and

Neuroptera (another insect group in which he had taken an early interest) formed the basis of his *cand.scient.* (= M.Sc) thesis, completed in 1976. The inventory was largely based on an extensive light-trapping program, and some of the more interesting findings concerned the vertical stratification of the insects in question, as documented by material from traps located at different heights in the canopy. Unfortunately, only the smaller part of the study concerning the Neuroptera was published. Manuscripts based on the much larger Lepidoptera study were prepared, but remained uncompleted: Ebbe was always on the move, and his focus shifted to other facets of lepidopterology.

Biology at Århus University was still in a build-up phase in the mid-1970s, and the final courses for the *cand.scient.* degree had to be taken at the University in Copenhagen, to where Ebbe moved in 1974. Having already developed a taste for curation in the Århus Natural History Museum (which has very extensive holdings of Danish Lepidoptera, Macrolepidoptera in particular), he immediately started work in the Entomology Department of the Zoological Museum of Copenhagen University, and his and my previously peripheral acquaintance soon developed into a close and lasting friendship. Ebbe came to share my interest in 'Hennigian' phylogenetic systematics in general, and the evolution of the basal lepidopteran lineages in particular. In 1977 he became my first Ph.D. student, with a study program devoted to 'Nomenclatural, systematic and phylogenetic studies on *Incurvariina*'; the degree was awarded in 1980.

A glance at Ebbe's publication list reveals, however, that his thesis-related studies were far from his only entomological activities up to 1980. His broad interests in the Danish/N.European moth fauna led to a suite of noteworthy publications, largely written together with other workers. With his amateur lepidopterist friend Ole Karsholt he published in 1976 an annotated checklist of the Danish Lepidoptera, the first of several continental-European national Lepidoptera checklists that followed the Bradley/Fletcher/Whalley edition (1972) of the British *Kloet & Hincks* checklist. In the course of this collaboration the two developed an appreciation – very evident in their later activities – of the significance of this kind of publication and of the requirements for its production. They also jointly initiated the series of illustrated annual articles (published in *Entomologiske Meddelelser*) on findings of new, rare and/or little-known Danish micro-moths; these are continued as a genuine teamwork, and they have become models for similar publications in some other European countries. Further noteworthy joint articles by Ebbe and Ole Karsholt dealt with the nomenclatural significance of old N.European Lepidoptera collections (a line of work which in Ebbe's case culminated in his joint study with Gaden Robinson of the Linnean micro-moths), as well as with the peculiar *Ochsenheimeria* group of moths, then considered a family of its own. Ebbe also joined forces with the senior Danish amateur lepidopterist Ernst Traugott-Olsen, who had specialised in the *Elachista* group of genera – then one of the least accessible major groups of micro-moths in Europe. The profusely illustrated *Fauna Entomologica Scandinavica* monograph of its N.European members, which they published in 1977, proved to be a turning point in the study of the group, and it was followed by a number of joint articles on European elachistines. In the late 1970s Ebbe was instrumental in mediating contact and collaboration between the nepticulid workers in Sweden (Johansson, Gustafsson) and the nepticulid research group then

thriving at the Vrije Universiteit in Amsterdam. He thereby established the team which much later (1990) succeeded in publishing the impressive two-volume *Fauna Entomologica Scandinavica* treatment of the N.European nepticuloids and, as I wrote in my editorial foreword to that work: its completion in spite of many adversities was „in no small measure due to the tenacity and enthusiasm of Dr. Nielsen“.

Characteristically, Ebbe was also present – as the youngest of the attendees – in the small group of lepidopterists who met in Bonn in 1976 to found the *Societas Europaea Lepidopterologica*. Ebbe took part in the European Congresses of Lepidopterology until he emigrated downunder, and he had happily agreed to give one of the opening keynote talks at the 13th Congress in Denmark in 2002.

But proper phylogenetic-systematic studies must necessarily have a global scope, and Ebbe's interests were certainly not confined to just the European fauna. He and I had repeatedly talked about the strikingly poor representation of non-ditrysian moths then known from S.America, and we agreed that this fauna must simply have been inadequately sampled. Chances for doing better came in the late 1970s, when a group of Danish scientists (botanists and soil geographers) were planning a large-scale investigation in temperate Argentina and Chile. Ebbe joined the preparatory group at an early phase, and, thanks to his initiative, entomology came to figure prominently on the agenda of the *Mision Cientifica Danesa*, which operated in 1978-79 after considerable funding had been raised from public and private sources. Ebbe became a member of the leader team, and participated during the whole of the expedition. He was joined for periods by S. Langemark, O. Martin and B. W. Rasmussen, entomologists from the Copenhagen Zoological Museum, and he was also joined by Traugott-Olsen (participating at his own expense), who by then had settled in Marbella and was proficient in Spanish. The findings (and perhaps even more the non-findings!) of the *Mision* prompted Ebbe to organise yet another collecting trip to the same area in late 1981, after the completion of his Ph.D. On this second, and extremely successful tour he was accompanied by Ole Karsholt, who had then just been hired to an assistant curatorship in the Copenhagen Zoological Museum.

All the time and energy Ebbe invested in the *Mision* (and other activities) had to be taken from the preparation of his Ph.D. thesis, and when the latter was eventually submitted as the allotted time ran out (there are quite strict time limitations on theses in Denmark), parts of it were admittedly still in somewhat preliminary shape. And, again, complete publication of the thesis work fell by the wayside due to Ebbe's shifting priorities. In the following years he did publish a suite of sound revisionary treatments of selected incurvarioid genera (the most extensive being the 1985 review of *Nematopogon*), and the essentials of his analyses concerning incurvarioid high-level phylogeny appeared in the 1985 joint article with Don R. Davis, in which the first southern hemisphere prodoxid was described. However, substantial parts of his treatments of the individual incurvarioid families, with descriptions of interesting new genera (ironically some of them Australian) still remain unpublished.

But Ebbe had undoubtedly made the right choice in giving priority to the S.American initiative – it proved to be outstandingly fruitful for lepidopterology, and equally important for the development of his personal competences. The material gathered dur-

ing the two expeditions have rendered the Copenhagen Museum holdings of temperate S. American micro-moths the most important worldwide along with those of the US National Museum of Natural History, which were built up at the same time by Davis and his staff. The two parties actually met and collected together briefly in 1981, and both subsequently drew extensively on the material collected by the other – in joint as well as in separate publications. Very important findings were made of Neopseustidae, Incurvariidae and the new family Palaephatidae described by Davis (1986). The huge amassed material of Hepialidae formed the basis of the 1983 book *Ghost Moths of Southern South America* co-authored by Ebbe and Gaden Robinson. Above all, the Danish expeditions both indirectly and directly led to the description of the Heterobathmiidae and the elucidation of their life history – unquestionably one of the most exciting discoveries in 20th century systematic lepidopterology, and one with a special history.

While Ebbe was preparing for the first expedition to austral S. America, he mentioned the plans for this enterprise in a letter to the senior Austrian microlepidopterist Joseph Klimesch. Klimesch responded by saying that he had a material of S. American micros, which he had received several years earlier from a local collector (Shachovskoj) – there seemed to be some “Eriocraniidae” in it, so he would now send it to us: “perhaps we would find something of interest”. Our first (1979) publication on these moths was, then, largely completed by myself during Ebbe’s stay in S. America. But during this first expedition he did not find any new heterobathmiid material. Since we believed they were micropterigids, he probably had a wrong ‘search image’ (for a low-vegetation insect). It was not until he was in temperate S. America for the second time, jointly with Ole Karsholt, that they discovered the moths’ association with *Nothofagus*, and found both adults and larvae in great abundance. Indeed, when they were for some time using the same accommodation as Ebbe had used on the first trip, they discovered that a *Nothofagus* tree under which he had often had meals on the previous occasion had lots of *Heterobathmia* mines on it (and most probably has so every year). It really was the finding of the immatures that led us to realise that *Heterobathmia* is an independent basal moth lineage.

After completing his Ph.D. Ebbe continued work in the Copenhagen Zoological Museum on a postdoctoral fellowship, but hopes to associate him permanently with this institution dwindled, as drastic budget cuts from the early 1980s onwards prevented the filling of vacant positions. He therefore had to look for a career elsewhere in the world, and a great challenge presented itself in the form of the Lepidoptera curatorship at the Australian National Insect Collection (ANIC, a part of the Entomology Division of the CSIRO), which became vacant upon the retirement of its previous holder Ian F. B. Common. The fact that many lepidopteran groups have particularly interesting members in Australia, coupled with Common’s high international esteem, had made this position a very central one in the minds of systematic lepidopterists worldwide. Ebbe had an outstanding background for filling the position, with his documented knowledge of the order Lepidoptera in its entirety, combined with his extensive experience with planning and performing field work in areas that were difficult to access. His application was indeed successful, and his professional life in Canberra started in December 1982. His proven interest in southern hemisphere faunas was another strength in an Australian context. This interest eventually led him to found (jointly with the renowned US botanist Peter Raven) the successful *Southern Connections* association for systematists and ecologists concerned with Gondwana faunas and floras.

In Canberra Ebbe was fortunate to find a kindred spirit in E. D. (‘Ted’) Edwards, an ANIC assistant curator with an expert knowledge of the Australian Lepidoptera as

well as of field work in the Australian bush. He was also fortunate to come together with the Swiss-born micro-moth specialist Marianne Horak, who worked as a postdoctoral fellow in the ANIC; the two had met briefly before and now developed a partnership, which became very important to both, and which (in spite of Ebbe never being a ‘one woman man’) proved to be a lasting one. Ebbe and Marianne also retained close personal links to Ian Common and his wife Jill, and Ebbe made every effort to ensure that the CSIRO continued to support Common’s spectacularly successful retirement research.

In his own work on the Australian fauna Ebbe initially focussed on two of the region’s most intriguing taxa of primitive Lepidoptera, about which he and I had often talked: the small ‘ericroaniid-grade’ family Lophocoronidae (described by Common in 1973), and *Fraus*, which is the only genus in the Hepialidae that includes members with a sizable proboscis remnant. He procured important new material of these taxa during field work in Western Australia (together with Edwards), and we started joint work on them in 1983. But both of us had many other commitments and it was 1989 and 1996, respectively, before the publications appeared; however, the long gestation time undoubtedly enhanced the substance of both. The *Fraus* memoir was published as the first volume in the book series *Monographs on Australian Lepidoptera* which Ebbe initiated, and which subsequently has served as outlet for some very important publications. Volume 2 was the generic revision of the Australian Tineidae which Ebbe prepared in joint authorship with Gaden Robinson, and which may serve as a model of how to get a handle on a major faunal component without becoming overwhelmed by masses of undescribed species.

From a very early stage in his Canberra position Ebbe saw the need for a compilation of an annotated checklist of the Australian Lepidoptera to be a top priority, and his closest collaborators as well as other lepidopterists from Australia and abroad were soon collaborating on the project. The work took much longer to complete than initially expected – the publication finally came out in 1996 – but again the long gestation period undoubtedly benefited its quality. The preparation of the list went hand in hand with extensive re-curation of the ANIC Lepidoptera holdings, as well as with a major resource investment in photographic documentation of primary types of Australian Lepidoptera in museum collections worldwide. Not least, it sharpened Ebbe’s interest in, and attention to, the ways in which information contained in biological research collections can be made accessible and useful to broader user groups. This interest was linked to a clear appreciation of the need for continued development of existing collections, and for several years Ebbe took an active part in collecting trips to inadequately inventoried parts of the Australian continent.

Besides the Lepidoptera series, Ebbe also initiated the *Monographs on Invertebrate Taxonomy* and for several years he chaired the Advisory Committee of the journal *Invertebrate Taxonomy*; he also served on the editorial panel of other periodicals including *Insect Systematics and Evolution* (formerly *Entomologica Scandinavica*) and *Biodiversity and Conservation*. In a general way Ebbe was very interested in issues concerning dissemination of scientific work, in print as well as in electronic format, and he served as an adviser to a number of publishing companies;

it is in no small part due to him that *CSIRO Publications* owe their strong profile in entomology.

In 1990 Ebbe became 'Program leader' of the 'Biodiversity and Natural Resources Program' of CSIRO Entomology, as well as director of the ANIC. From then onwards his focus gradually shifted from Lepidoptera research to science policy – which I believe was the field in which laid his greatest talents. He was truly successful in conveying to decision makers at various levels the message about the value of research on biological diversity, and several important 'soft money'-funded projects in the ANIC were realised due to these skills. Much committed to the cause of ANIC and Australian science in general, he declined offers of highly prestigious leading positions at major museums elsewhere in the world. He received several honours for his achievements, including the Lepidopterists' Society's *Karl Jordan Medal* (1990), the Australian *Dave Rivett* and *Ian Mackerras* Medals and foreign memberships of the US National Academy of Science (1997 – a very rare distinction for a non-American!) and the Royal Danish Academy of Sciences and Letters (1998).

Problems arising because of Ebbe's occasional over-optimism about the rate of incoming external funds were probably behind his stepping down as program leader in the late 1990s, but he retained the ANIC directorship and grew into an even more prominent figure in international circles. He became a highly influential member of the Major Systematic Entomology Facilities Group (of which he had been a co-founder), and was much involved with activities under the International Convention on Biological Diversity. In 2000 he became Secretary/Treasurer of the Council of the International Congresses of Entomology – an office to which he was particularly happy to be elected. Most importantly, from his position as head of the Australian delegation to the OECD Megascience Forum Working Group on Biological Informatics he became one of the principal driving forces behind the establishment of the potentially very important 'Global Biodiversity Information Facility' (GBIF). In fact, it was *en route* from Canberra to the Toronto meeting in March 2001 where the GBIF formally came into being that Ebbe died from a massive heart attack in California. The news of his death cast a dark shadow over the meeting, and a spontaneous decision was made by the delegates to establish within the GBIF budget an *Ebbe Nielsen Prize* – to be awarded annually to a young scientist for innovative merging of biodiversity research and IT technology. Ebbe had dearly hoped that Australia would become host country for the GBIF secretariat, and had invested much energy in making the Australian bid a strong one, which indeed it was. It is ironic that the majority of GBIF member countries a few months after his death nevertheless voted for his native Denmark to host the secretariat, but this outcome generated the feeling that Ebbe had thereby "come home", just as the bodily remains of this true cosmopolitan had come home to the family grave site in Jutland.

Ebbe was a forthright person. His outlook was genuinely international, and he spoke languages other than his native one with assertiveness. He was a renaissance figure, with an immense appetite for life and a great knack of enjoying its pleasures. He had an awe-inspiring working capacity so, his profound scientific commitment and all his achievements notwithstanding, he found time for pursuing his numerous other inter-

ests: time for reading, for orienteering, for listening to music, for going to cinemas and theatres, for gourmet cooking, dining and wining. Above all, he had time for people – and people mattered to him. His extraordinary success as a scientist and a science politician was to a large extent due to his similarly extraordinary social intelligence. He was generous in dealing with fellow researchers – and fellow humans in general. It is no coincidence that almost all of his more significant publications appeared in joint authorship with other workers. Ebbe's own written contributions were in several cases minor ones, but his participation in the projects were often of very crucial importance for their initiation and/or completion. He benefited from the collaborations, his collaborators benefited, and science benefited.

Ebbe Schmidt Nielsen was for a quarter-century a very visible, active, joyful and stimulating player on the global scene of lepidopterology, museology and biodiversity research/policy. Life will be less hectic on that scene, now he has departed. It will also be less inspired – and much less fun.

Ted Edwards, Marianne Horak, Ole Karsholt and Gaden Robinson gave much appreciated assistance with the preparation of this obituary article. A complete list of Ebbe S. Nielsen's scientific publications will be published in a forthcoming special issue of *Invertebrate Taxonomy* dedicated to his memory.

NIELS P. KRISTENSEN



## New species, distribution records and synonymies of plume moths (Lepidoptera, Pterophoridae) from the Palaearctic region

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**Abstract.** Six new species of Pterophoridae are described, namely, *Stenoptilia kosterini* sp. n. from Kamchatka, *S. dubatolovi* sp. n. from Turkmenistan, *Amblyptilia zhdankoi* sp. n., *Marasmarcha aibasovi* sp. n. and *Porrittia herzi* sp. n. from Kazakhstan, *Merrifieldia nivella* sp. n. from Tajikistan. New distribution records for provinces of Russia and former Soviet republics are given for 41 Pterophoridae species. Four species are newly synonymized: *Agdistis detruncatum* Zagulajev & Blumental, 1994 syn. n. with *A. gerasimovi* Zagulajev & Blumental, 1994, *Platyptilia diversicila* Filipjev, 1931 syn. n. with *Buszkoiana capnodactylus* (Zeller, 1841), *Gillmeria uralskiensis* Gibeaux, 1995 syn. n. with *G. armeniaca* Zagulajev, 1984, and *Oxyptilus perunovi* Ustjuzhanin, 1996 syn. n. with *O. chrysodactyla* (Denis & Schiffermüller, 1775).

**Zusammenfassung.** Sechs neue Arten der Familie Pterophoridae werden aus dem Gebiet der früheren Sowjetunion beschrieben (*Stenoptilia kosterini* sp. n. aus Kamchatka, *S. dubatolovi* sp. n. aus Turkmenistan, *Amblyptilia zhdankoi* sp. n., *Marasmarcha aibasovi* sp. n. und *Porrittia herzi* sp. n. aus Kasachstan, sowie *Merrifieldia nivella* sp. n. aus Tadschikistan). Für 41 weitere Arten werden neue Verbreitungsnachweise erbracht. Vier nominelle Arten wurden neu synonymisiert: *Agdistis detruncatum* Zagulajev & Blumental, 1994 syn. n. mit *A. gerasimovi* Zagulajev & Blumental, 1994, *Platyptilia diversicila* Filipjev, 1931 syn. n. mit *Buszkoiana capnodactylus* (Zeller, 1841), *Gillmeria uralskiensis* Gibeaux, 1995 syn. n. mit *G. armeniaca* Zagulajev, 1984, und *Oxyptilus perunovi* Ustjuzhanin, 1996 mit *O. chrysodactyla* (Denis & Schiffermüller, 1775).

**Resumé.** Six nouvelles espèces de Pterophoridae sont décrites, à savoir *Stenoptilia kosterini* sp. n. du Kamchatka, *S. dubatolovi* sp. n. du Turkménistan, *Amblyptilia zhdankoi* sp. n., *Marasmarcha aibasovi* sp. n. et *Porrittia herzi* sp. n. du Kazakhstan, et *Merrifieldia nivella* sp. n. du Tadjikistan. De nouvelles données de répartition, relatives aux diverses provinces de Russie et des anciennes républiques soviétiques, sont présentées pour 41 autres espèces de Pterophoridae. Quatre noms sont nouvellement désignés comme synonymes: *Agdistis detruncatum* Zagulajev & Blumental, 1994 syn. n. de *A. gerasimovi* Zagulajev & Blumental, 1994, *Platyptilia diversicila* Filipjev, 1931 syn. n. de *Buszkoiana capnodactylus* (Zeller, 1841), *Gillmeria uralskiensis* Gibeaux, 1995 syn. n. de *G. armeniaca* Zagulajev, 1984 et *Oxyptilus perunovi* Ustjuzhanin, 1996 syn. n. de *O. chrysodactyla* (Denis & Schiffermüller, 1775).

**Key words.** Lepidoptera, Pterophoridae, plume moths, USSR, Russia, Siberia, Central Asia, taxonomy, new species, new synonymys, new records

The present work makes available new taxonomic data and distribution records for Pterophoridae from the territory of the former Union of Soviet Socialist Republics (USSR). In the first section, six new species are described. In the second section, four new synonymies are established and distributional records for 41 species are given. The paper is based on materials preserved in the author's collection as well as in the collections of the Zoological Museums of Sankt Petersburg and Novosibirsk. The type specimens of the taxa being described are preserved as follows: The holotypes of *Stenoptilia kosterini* sp. n., *S. dubatolovi* sp. n., *Amblyptilia zhdankoi* sp. n., *Marasmarcha aibasovi* sp. n., *Porrittia herzi* sp. n. are preserved in Siberian Zoological Museum at the Institute of Systematics and Ecology of Animals of Siberian Division of the Russian Academy of Sciences (Novosibirsk), the holotype of *Merrifieldia nivella* sp. n. is deposited in the collection of Zoological Institute of the Russian Acad-

emy of Sciences (Sankt Petersburg), the paratypes are located in these two institutes and in the private collection of the author.

## I. Descriptions of new species

### *Stenoptilia kosterini* sp. n.

(Figs. 1, 7–8)

Material. – Holotype: ♂, S Kamchatka, 2 km SW of Ust'-Bol'sheretsk, 10.VIII.1992 (Kosterin leg.); Allotype: ♀, Kamchatka, settlement Klychevskoe on the Kamchatka River, 5.VIII.1908 (A. Derzhavin, leg.) Paratypes: 1 ♂, same data as the holotype; 5 ♂, same data as the allotype.

**External characters.** – Frons covered with tightly pressed dark-brown scales forming a conical tuft 2–2.5 times shorter than eye diameter. Labial palpi brown, rather short, with a length equal or slightly shorter than eye diameter; they look like dense brushes, apically skewed and pointed. Antennae thin, brown. Thorax and tegulae brown, with some admixture of white scales. Wing span: 18–21 mm (18 mm in holotype). Fore wings brownish-grey. At cleft base there are two elongate dark-brown spots, sometimes fused. On the first lobe in its middle part there is a slanting dark-brown band, outer of which there is a distinct white streak which continues, there being wider, on the second lobe. Between wing base and cleft there is an obscure elongate dark-brown spot, in some specimens reduced. Fringe inside cleft is lighter than wing ground colour. On fringe of the first lobe there are two dark-brown spots, at apex and on lower angle of the lobe. Fringe of the second lobe also has two dark spots: at apex and in middle of outer margin. Hind wings evenly brown-grey, with fringe of the same colour. Legs brown with whitish inner side.

**Male genitalia.** – Valva with a convex upper margin, Apical part of valva curved smoothly, its apex blunt. Uncus relatively wide, with a rounded apex; hardly (at 1/4 of its length) protruding behind tegumen hind margin. Arms of anellus short, bent at an angle of 125°, with blunt apices. Aedeagus slightly shorter than valva, cornutus weakly expressed. Basal processus of aedeagus directed perpendicular to coecum.

**Female genitalia.** – Ostium slightly widened at base, outline of its body even, without concavity, margins of its base somewhat stretched out and sharpened. Antrum tube-like, disposed along body axis, almost thrice as short as ductus, gradually narrowing to ductus. Hind margin of lamella praevaginalis straight, situated almost in the middle of ductus. In middle part of ductus bursae there is a sclerotized string. Signa narrow, with non-toothed margins. Apophyses posteriores narrow throughout their length, long, reaching ostium. Papillae anales of oval shape; bursa drop-shaped.

**Fig. 1.** *Stenoptilia kosterini* sp. n., holotype, male, S Kamchatka, Ust'-Bol'sheretsk, imago. – **a.** color photograph; – **b.** black-and-white photograph.

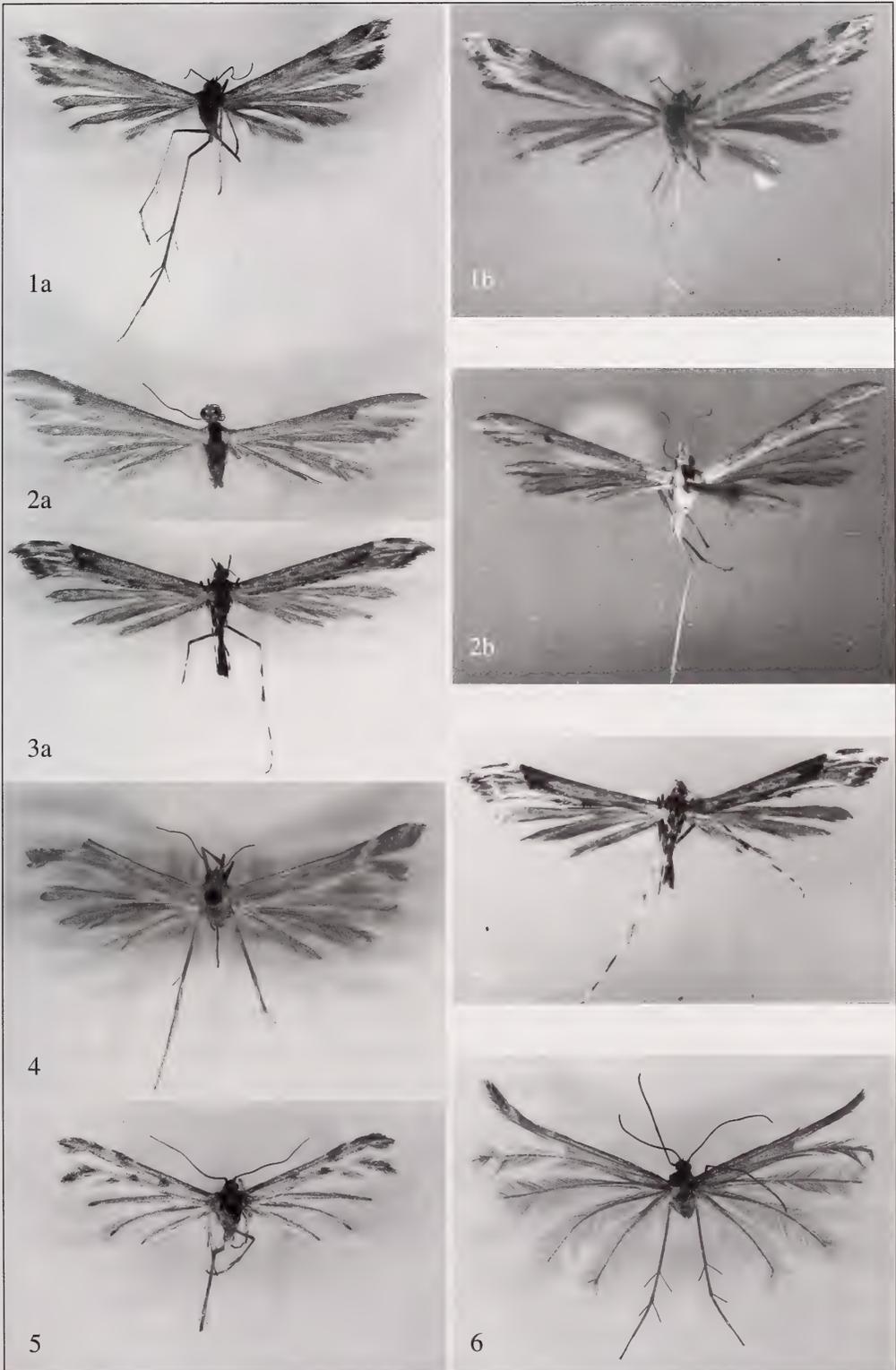
**Fig. 2.** *Stenoptilia dubatolovi* sp. n., paratype, female, Turkmenistan, the Kuhitangh Mountains, imago. – **a.** color photograph; – **b.** black-and-white photograph.

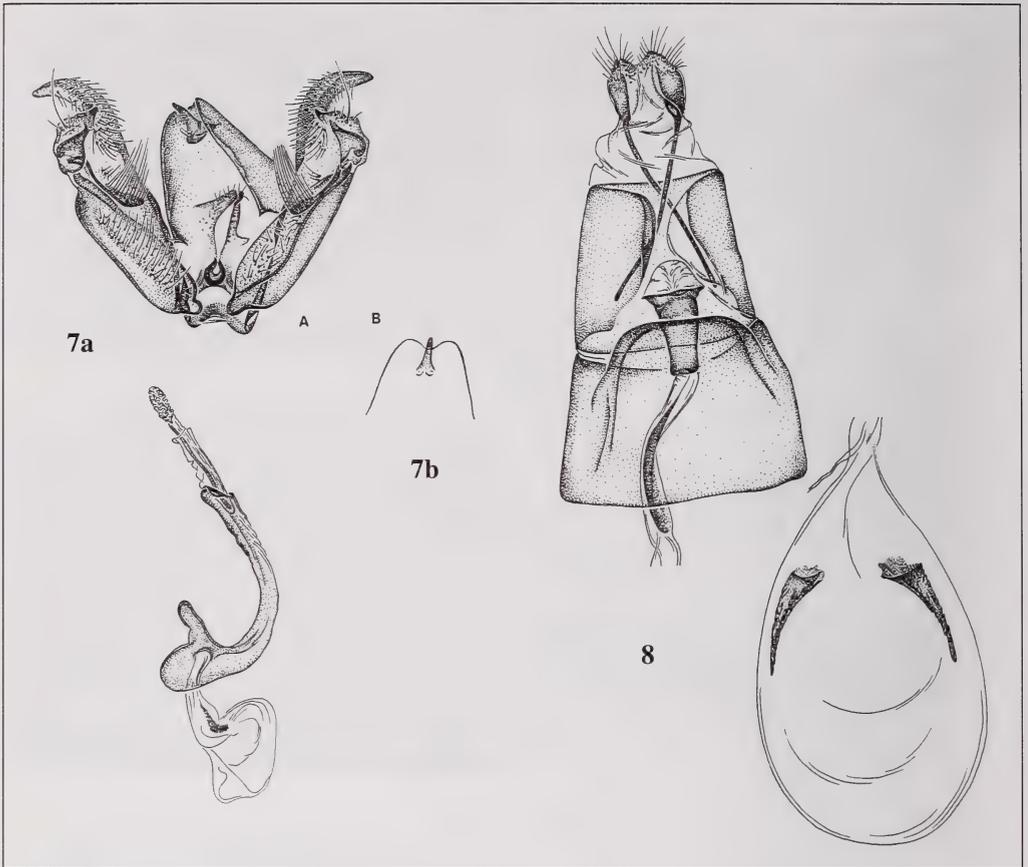
**Fig. 3.** *Amblyptilia zhdankoi* sp. n., paratype, female, Kazakhstan, Lake Issyk, imago. – **a.** color photograph; – **b.** black-and-white photograph.

**Fig. 4.** *Marasmarcha aibasovi* sp. n., holotype, female, West Kazakhstan, Urda, imago.

**Fig. 5.** *Porrittia herzi* sp. n., paratype, male, Turkmenistan, the Kuhitangh Mountains, imago.

**Fig. 6.** *Merrifieldia nivella* sp. n., holotype, male, Tadzhikistan, the Pamirs, imago.





**Fig. 7.** *Stenoptilia kosterini* sp. n., holotype, male genitalia. – a. ventral view. – b. uncus and tegumen viewed frontally; – **Fig. 8.** *Stenoptilia kosterini* sp. n., allotype, female genitalia.

**Diagnosis.** – By the wing pattern the new species is close to *S. millieridactyla* (Bruand, 1861) and *S. latistriga* (Rebel, 1916) but differs from them by the genitalia structure. In the male genitalia, the valva shape, short arms of anellus and short uncus resemble those of *S. bipunctidactyla* (Scopoli, 1763), but the aedeagus structure is different: the basal processus is directed perpendicular to the coecum, whereas in *S. bipunctidactyla* it is slanting to the aedeagus. Besides, the new species differs from the mentioned one by the genitalia structure of females and much different wing colouration. By the female genitalia the new species is close to *Stenoptilia islandica* (Staudinger, 1857), from which it differs by a more smooth transition of antrum to ductus and an even margin of the antrum base, while in *S. islandica* the margin is concave. Beside, in the new species the signae are larger, as long as the antrum, while in *S. islandica* they are 1.5 times as short. The male genitalia and wing pattern also distinguish these two species significantly.

Comparison of the new species with a Japanese *Stenoptilia admiranda* Yano, 1963 provides significant differences in the male and female genitalia structures. In the new species the uncus protrudes behind the tegumen margin while in *S. admiranda* Yano it

just reaches the margin. In the female genitalia *S. kosterini* sp. n. has a short antrum, only one third in length compared to the ductus bursae, while in *S. admiranda* it is long, twice longer than the ductus bursae.

**Range.** – Kamchatka.

**Habitat.** – Two males, including the holotype, were collected by O. Kosterin on a marshy coastal plain at the western coast of South Kamchatka (8 km east of the coast, about 30 m) covered with fruticulose (*Empetrum nigrum* Linnaeus, 1758, *Chamaedaphne calyculata* (Linnaeus) Moench, 1794, *Betula exilis* Sukaczew, 1911) - sedge (*Carex* spp.) marshes with sparse bushy *Betula ermanii* Chamisson, 1831 and *Alnus hirsuta* (Spach) Fischer ex Ruprecht, 1857 (not *Alnus fruticosa* Ruprecht, 1845), on a meadow patch rich in herbaceous plants (among flowering plants noted are *Cirsium kamschaticum* Ledebur ex DeCandolle, 1838, *Senecio cannabifolius* Less., 1831, *Acronitum maximum* Pallas ex DeCandolle, 1847, *Pedicularis resupinatum*, *Gentianella auriculata* (Pallas) Gillet, 1957). The other specimens were collected in the Central Kamchatka Depression, a territory of Kamchatka most isolated from the severe influence of the surrounding cold seas, but, judging from a general map, the Kluchevskoe environs as well abounds of marshes.

**Etymology.** – The species is named in honour of the naturalist and biologist Oleg Engel'sovich Kosterin (Novosibirsk) who collected this species.

### *Stenoptilia dubatolovi* sp. n.

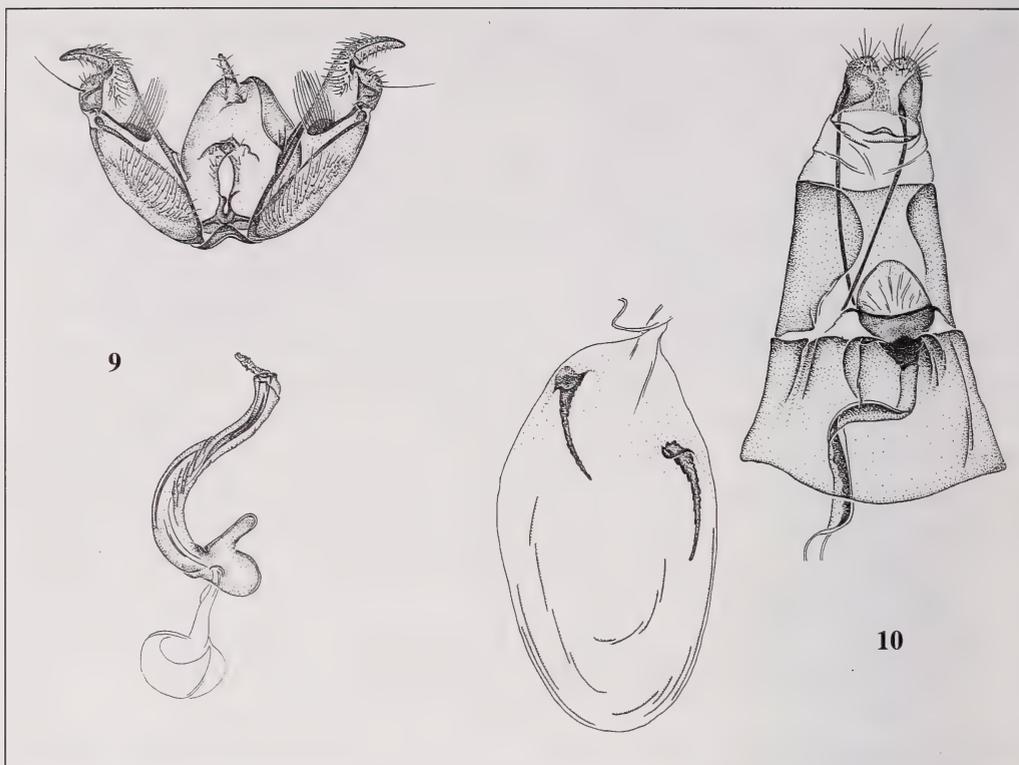
(Figs. 2, 9–10)

**Material.** – Holotype ♀, Turkmenistan, Kuhitangh Mts., Dzheilyau Plateau, foot of Airi-Baba Mt., about 2200 m, 13.VII.1991 (V.V. Dubatolov leg.) Paratypes: 1 ♂ the same label; 2 ♂, the same label but 2150 m, attracted by light, 21.V.1991; 1 ♂ and 1 ♀, Turkmenistan, 5 km of Bazar Depe, ruins Khodzha Karaul, 10.V.1991 (V.V. Dubatolov leg.).

**External characters.** – Frons covered with tightly pressed brownish-grey scales forming a small tuft 3 times shorter than eye diameter. Labial palpi brownish-grey, rather short, with a length equal or slightly greater than eye diameter; they look like dense brushes, somewhat widened apically. Antennae thin, brown. Thorax and tegulae also brownish-grey. Wing span: 17–21 mm (17 mm in holotype). Fore wings brownish-grey; at cleft base there are a dark-brown spot as if formed by two fused quadrangular spots. Between wing base and cleft there is another elongate dark-brown spot, in some specimens weakly expressed or reduced. Fringe inside cleft is lighter than wing ground colour. On fringe of the first lobe at apex there is a dark-brown spot. Fringe of the second lobe also has two dark spots: at apex and in middle of outer margin, the latter may be reduced or absent. Hind wings evenly brown-grey, with fringe slightly lighter on all the three lobes. Legs of the same colour as wings, may be somewhat lighter on inner side.

**Male genitalia.** – Valva with a straight upper margin, with apical part smoothly curved, its apex blunt. Uncus narrow, stick-like, protruding behind tegumen hind margin on 2/3 of its length. Arms of anellus short, with bluntly rounded apices. Aedeagus slightly shorter than valva, distally of its basal process much narrower than coecum; cornutus well expressed. Basal process of aedeagus is slanting to coecum.

**Female genitalia.** – Ostium wide, 2–2.5 times wider than antrum. Antrum very short, slightly narrowed to ductus spring, looks like a trident crown. In middle part of



**Fig. 9.** *Stenoptilia dubatolovi* sp. n., holotype, male genitalia. **Fig. 10.** *Stenoptilia dubatolovi* sp. n., paratype, female genitalia.

ductus bursae there is a sclerotized string. Signa thin, with a toothed inner margin. Apophyses posteriores slightly curved, long, reach ostium.

**Diagnosis.** – The new species is most close to *Stenoptilia elkefi* Arenberger, 1984, from which it differs by structure of both the male and female genitalia. In *Stenoptilia dubatolovi* sp. n. the uncus is narrow, stick-like and is pointed bluntly while in *S. elkefi* the uncus is noticeably swollen at base and pointed apically. In the female genitalia the new species well differs from *S. elkefi* by the shape of antrum, in the former it resembles a tridental crown while in the latter it is cup-like.

Concerning the female genitalia, by a short antrum the new species approaches also to *Stenoptilia millieridactyla* (Bruand, 1861), but the antrum shape is different as resembling a cup rather than a crown, and it bears no teeth. In the male genitalia, by short arms of anellus and a blunt valva apex the new species resembles *S. bipunctidactyla* from which it differs with an uncus more protruding forward, a slightly curved (but not bow-shaped) apical part of the valva, and a basal processus of aedeagus which is slightly slanting to the coecum, while in *S. bipunctidactyla* it is slanting to the opposite site.

**Range.** – Turkmenistan, the Kuhitangh Mountains.

**Habitat.** – The moths were collected in the upper part of a gorge slope on the Dzhailau Plateau, in the upper part of the arboreal juniper altitudinal belt with dominance of highland xerophytic plants, at altitudes above 2000 m. This species develops at least in

two broods. The moths were collected at daytime as well as attracted by light at night. **E t y m o l o g y .** – The new species is named in honour of Vladimir Viktorovich Dubatolov (Novosibirsk) who collected this species.

*Amblyptilia zhdankoi* sp. n.

(Fig. 3, 11–12)

**Material.** – Holotype: ♂, Kazakhstan, 50 km east of Alma-Ata, Zailiiskii Alatau Mts., Lake Issyk, 1700 m, 20.IX.1994 (A.B. Zhdanko leg.). Paratypes: 4♂, 1♀, the same label.

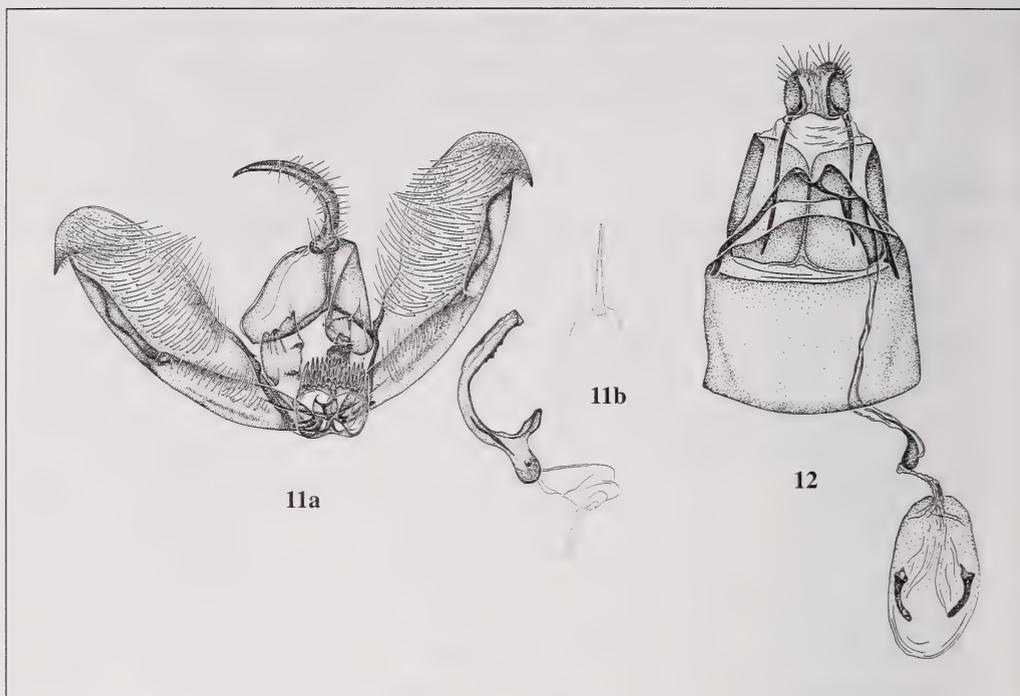
**External characters, Males.** – Frons covered with tightly pressed brownish-grey scales forming a small tuft with length equal or slightly less than eye diameter. Labial palpi thin and rather long, twice as long as eye diameter, their outer side brown and inner side whitish. Antennae thin, brownish-grey; thorax and tegulae also brownish-grey. Wings elongate, rather narrow, wing span 26–27 mm (26 mm in holotype). Fore wings brownish-grey, with somewhat lighter first lobe and darker brown costal margin; at cleft base there is a dark-brown spot; second lobe with a weakly expressed light vertical stroke in centre. Fringe inside cleft light-grey, with an admixture of brownish hairs; fringe of fore wing anal margin whitish, only at its middle with a small bunch of dark-brown hairs. Hind wings evenly greyish-brown with a grey fringe which contain an admixture of brown hairs only at base on hind margin of the third lobe. Hind legs yellowish, with brown rings at spores and middle parts of femora and tibia.

**Female.** – Frons with a longer tuft which is 1.5 longer than eye diameter. Wing span 30 mm. As different from males, fore wing pattern more contrasted. Distal part of first lobe of fore wing has a slanting white band, it continues on second lobe; light vertical stroke on second lobe more developed than in males. Fringe of fore wing anal margin light-grey, in middle part with distinct patches of dark-brown scales. Hind legs with more developed dark-brown circles.

**Male genitalia.** – Cucculus on valva with a pointed apex directed downward. Uncus narrow, strongly pointed at apex. Hind margin of vinculum has a dense brush of setae along hind margin. Arms of anellus short and wide, of an angular shape, with triangular apices. Saccus without distinct incisions on inner margin, relatively even, only slightly concave in central part, it widens proximally and sharply narrows apically. Aedeagus bent at a straight angle, its proximal part on its inner margin bears small teeth. Basal processus directed perpendicularly to aedeagus.

**Female genitalia.** – Vaginal plate saddle-shaped with long ends which continue into apophyses anteriores, which are slightly curved but do not form angular projections. Apophyses posteriores straight, narrow and thin. Papillae anales of oval shape. Ductus bursae thin, weakly sclerotized, weakly swollen and bearing a sclerite just before confluence with bursa copulatrix. Antrum shifted to the right, heavily sclerotized, it reaches fore margin of tergite VIII. Bursa copulatrix prolonged with two horn-like signa.

**Diagnosis.** – In the male genitalia, the shape of the valva and cucculus resemble those of *Amblyptilia grisea* Gibeaux, 1996, but the new species differs from it by the vinculum shape and a presence of angular teeth on the inner margin of the proximal part of the aedeagus, while in *A. grisea* dentation is observed as well on its outer side. By



**Fig. 11.** *Amblyptilia zhdankoi* sp. n., holotype, male genitalia. – a. ventral view. – b. uncus and tegumen viewed frontally. **Fig. 12.** *Amblyptilia zhdankoi* sp. n., paratype, female genitalia.

the shape of saccus, with an even inner margin, it is close to *A. acanthadactyla* Hübner [1813] 1796, but differs from it by a pointed uncus and wide arms of anellus. In the female genitalia, by a crescent-shaped vaginal plate and a presence of a swelling with a sclerite in the ductus bursae the new species is close also to *A. acanthadactyla* but differs from it by the apophyses anteriores, which do not form angular projections.

From a very common North Eurasian species *Amblyptilia punctidactyla* Haw. the new species well differs both in external appearance and in the male genitalia, by a narrow apically pointed uncus and wide arms of anellus.

**R a n g e .** – Kazakhstan, the Zailiiskii Alatau Mts.

**H a b i t a t .** – The moths were collected at daytime, on a clearing in a Tien Shan spruce (*Picea schrenkiana*) forest on a western slope, at 1700 m.

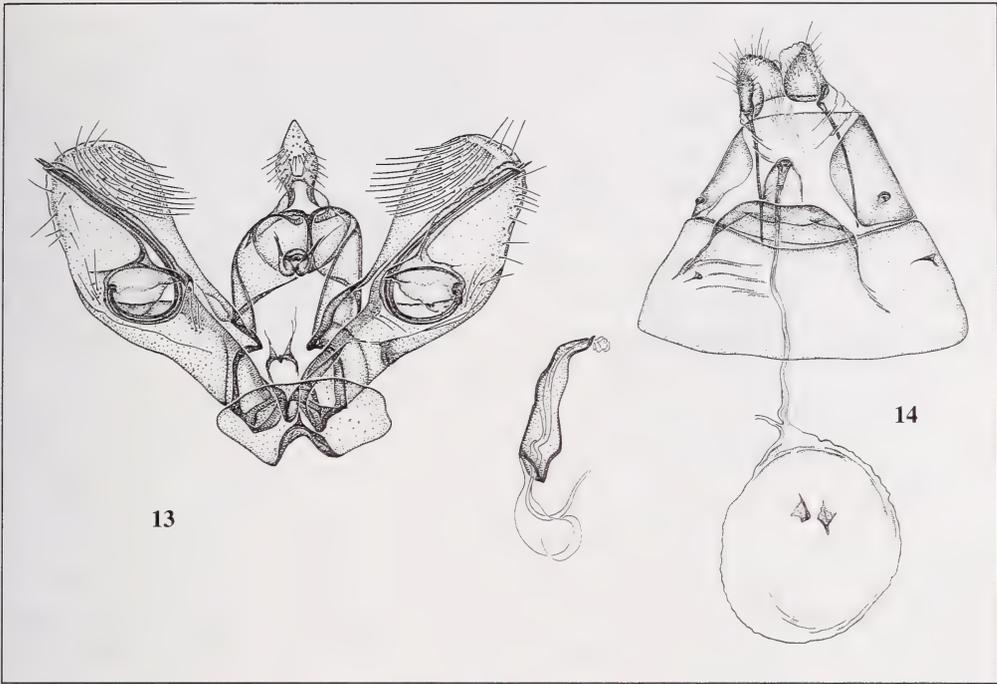
**E t y m o l o g y .** – The species is named in honour of the lepidopterist Alexandr Borisovich Zhdanko, Alma-Ata, who collected these moths.

***Marasmarcha aibasovi* sp. n.**

(Figs. 4, 13–14)

**Material.** – Holotype: ♂, West Kazakhstan, environs of v. Urda, 27.VII.1971 (Ch. A. Aibasov leg.)  
Paratypes: 1 ♂, 2 ♀, the same locality, 22–28.VI.1971; 1 ♀, Turgai Province, 23 km N of town Turgai, 22.VI.1973 (Ch. Aibasov leg.).

**External characters.** – Frons covered with tightly pressed yellowish-brown scales. Labial palpi light-brown, straight, adpressed to frons, 1.5 times longer than eye diameter.



**Fig. 13.** *Marasmarcha aibasovi* sp. n., paratype, male genitalia (ventral view). **Fig. 14.** *Marasmarcha aibasovi* sp. n., paratype, female genitalia.

Antennae thin, light-brown. Thorax and tegulae yellowish-brown. Wing span 24-26 mm (26 mm in holotype). Fore wings light-brown, at cleft base and in central part of fore lobe there are whitish bands (not in all specimens of the type series they are distinct, probably due to insufficient preservation of specimens). Outer fringe of both lobes light, only beneath second lobe it is brown. Hind wings evenly light-brown, somewhat darker than fore wing. Fringe light-brown on all the three lobes. Legs yellowish-brown.

**Male genitalia.** – Valvae symmetrical, in middle part of valva there are needle-like processes wound into a ring, their free ends reaching valva apex. Valva outer margin slightly rounded apically; middle part of valva, which bears the processes, noticeably widened. There is a dense brush of long hairs on valva apex directed to its inner margin and reaching middle of valva. Uncus generally triangular but with a deep wrist. Saccus with a pointed apex. Gnathos horseshoe-shaped. Tegumen, as viewed from behind, looks like composed of two hemispheres. Aedeagus twice as short as valva, in distal part sharply bent and narrowed just before apex.

**Female genitalia.** – Antrum narrow, tube-shaped, somewhat wider than ductus bursae at its confluence. Antevaginal plate, on which antrum resides, rather wide, smoothly tapering to a flat and wide apex. Apophyses posteriores flattened, narrow, almost reach VIII tergite fore margin. Papillae anales with straight outer margin and convex inner margin. Bursa copulatrix oval-shaped with two signa which resemble triangular hoods with skewed apices and dentate outer margin. Ductus seminalis emerges from bursa base.

**Diagnosis.** – By the general wing colouration the new species resembles *Marasmarcha samarcandica* Gerasimov, 1930 but differs from it by the absence of the whitish lightened area in the central part of both lobes of the fore wing. In the male genitalia, by the shape of needle-like processes it resembles *M. ehrenbergiana* (Zeller, 1841) but differs in the valva apex; in the new species it is rounded, without projections, while in *M. ehrenbergiana* projections are present; besides, in the new species the uncus has a triangular apex while in *M. ehrenbergiana* the apex is skewed. There are also differences in aedeagus structure: in *M. ehrenbergiana* it is relatively straight while in the new species it is curved. In the female genitalia, by a narrow ductus and the shape of papillae anales the new species is close to *Marasmarcha pulchra* (Christoph, 1885), but differs from it well by the shape of antrum and signa.

By the male genitalia structure, especially by the shape of the aedeagus and the needle-like processes on the valvae wound into a ring, the new species somewhat resembles *M. asiatica* (Rebel, 1906), however it well differs from it by the absence of an incision on the uncus apex and the shape of the valvae. In *M. asiatica* the upper margin of the valva is strongly convex, in the new species it is only slightly rounded. Besides, in *M. asiatica* the valva apex is pointed while in *M. aibasovi* **sp. n.** it is smoothly rounded.

In the male genitalia structure there is also a proximity to *M. cinnamomea* (Staudinger, 1870), in which the uncus is of a similar shape and the needle-like processes on the valvae wound into a ring are also present. But in the latter species these processes protrude behind the valva margins, while in the new species they do not reach them. These species well differ also in the shape of the valvae. In *M. aibasovi* **sp. n.** the valva apex is bluntly rounded while in *M. cinnamomea* it is distinctly stretched out. Besides, in the new species the aedeagus is sharply bent in the distal part while in *M. cinnamomea* it is straight, without bents. In the new species in the female genitalia the antrum is long, narrow, tube-like while in *M. cinnamomea* it is short, of a ring-like shape.

**Range.** – West Kazakhstan.

**Habitat.** – The moths were collected at daytime in open semidesert-steppe habitats.

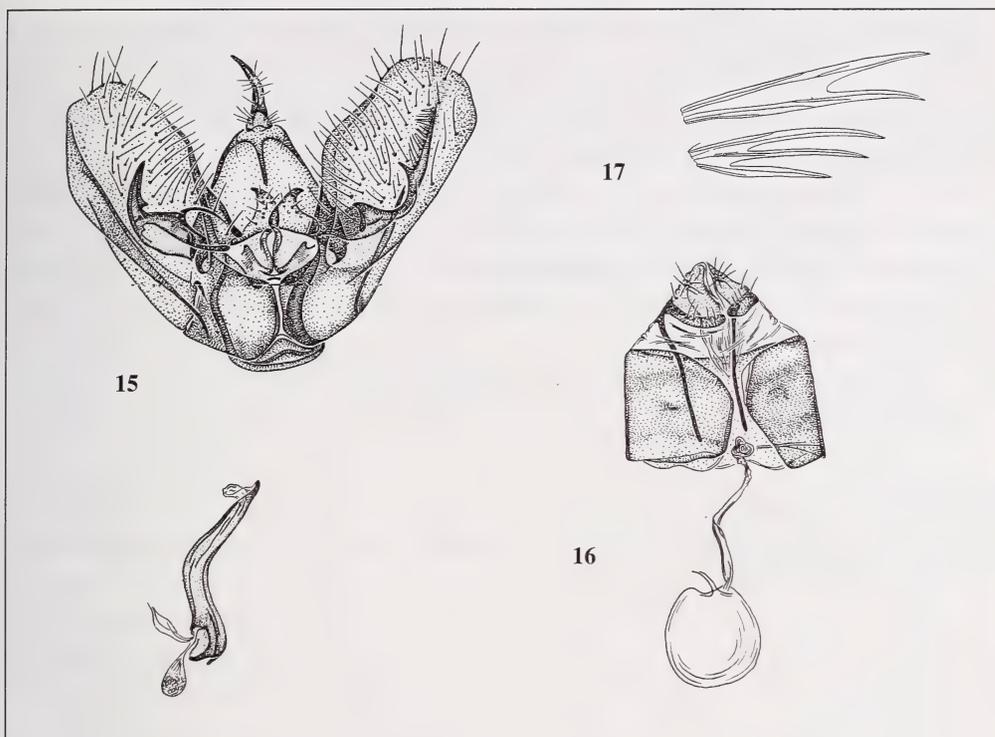
**Etymology.** – The new species is named in honour of the Kazakh lepidopterist Kh. A. Aibasov.

***Porritia herzi* sp.n.**

(Figs. 5, 15–17)

**Material.** – Holotype: ♂, SW Kazakhstan, Karatau Mt. Range, 7 km N of v. Kentau, 21.V.1992 A. Zhdanko leg. Paratypes: 1 ♂, Uzbekistan, Samarkand, 12.IV.1892, O. Herz leg.; 7 specimens, SW Kazakhstan, Karatau Mt. Range, 7 km N of v. Kentau, 7-9.V.1994, V. Zolotuhin leg.; 1 ♀, S Uzbekistan, Ghissar Mts., 40 km SE of town Shakhrisabe, Kyzyl-darya River valley, 21.V.1994, V. Zolotuhin leg.; 1 ♂, Turkmenistan, Kuhitangh Mts., Kara-Belent mt. at settl. Bazar-Depe, 1650 m, 10.V.1991, V.V. Dubatolov leg.

**External characters.** – Head covered with adpressed greyish-brown scales. Labial palpi straight, short, hardly exceeding eye diameter, they, as well as thorax and tegulae, of the same colour. Wing span 16-18 mm. Fore wings light-grey with somewhat lighter first lobe but with a suffusion of brown scales along costal margin. There are four brown spots: two at fore lobe costal margin, one at cleft apex, and one between wing base and cleft base. Fringe checkered, with alternating brown and white areas.



**Fig. 15.** *Porrittia herzi* sp. n., holotype, male genitalia (ventral view). **Fig. 16.** *Porrittia herzi* sp. n., paratype, female genitalia. **Fig. 17.** *Porrittia herzi* sp. n., paratype, wing venation.

Hind wings light-brown with admixture of light scales, fringe evenly light-grey. Legs whitish, with sparse brown specks.

**Male genitalia.** – Valvae asymmetrical: harpe on left valva looks like a hook bent at right angle, that on right valva resembles a deer horn. Uncus crescent-shaped, pointed apically. Arms of anellus short and wide, their apices rounded smoothly but end with pointed hooks. Aedeagus arch-like curved in its middle part, pointed at apex, it is 1.5 times shorter than valva.

**Female genitalia.** – Ostium broadened, almost rectangular, beneath with a small projection in central part, which is more sclerotized than ductus bursae. Ductus bursae thin, membranous. Apophyses posteriores rather short. Papillae anales of a triangular shape. Apophyses anteriores absent. Bursa copulatrix without signa.

**Diagnosis.** – The venation of this species suggests that it belongs to the genus *Porrittia* Tutt, 1905. This genus so far embraced two species, a widely distributed *Porrittia galactodactyla* (Denis & Schiffermüller, 1775) and a very peculiar and restricted Arabian *Porrittia imbecilla*. The new species has a certain similarity to *P. galactodactyla* by a mottled colouration but has a darker ground colour and differing disposition of spots. In the male genitalia the shape of the left harpe resembles that of *P. galactodactyla* but in the new species the harpe bears internally a tooth-like projection while in *P. galactodactyla* it lacks this projection. The female genitalia structures are also some-

what similar in these species but differ substantially by the shape of antrum. From the other species, *Porritia imbecilla* Meyrick, 1925, the new species differs both externally and by the genitalia structure. The mentioned species has a wing span of 8-11 mm while in *Porritia herzi* **sp. n.** it is 16-18 mm. In the male genitalia the left harpe is straight, awl-like in *P. imbecilla* and hook-like in the new species.

**R a n g e .** – SE Turkmenistan (the Kuhitangh Mts.), S Uzbekistan, SW Kazakhstan (the Karatau Mts.).

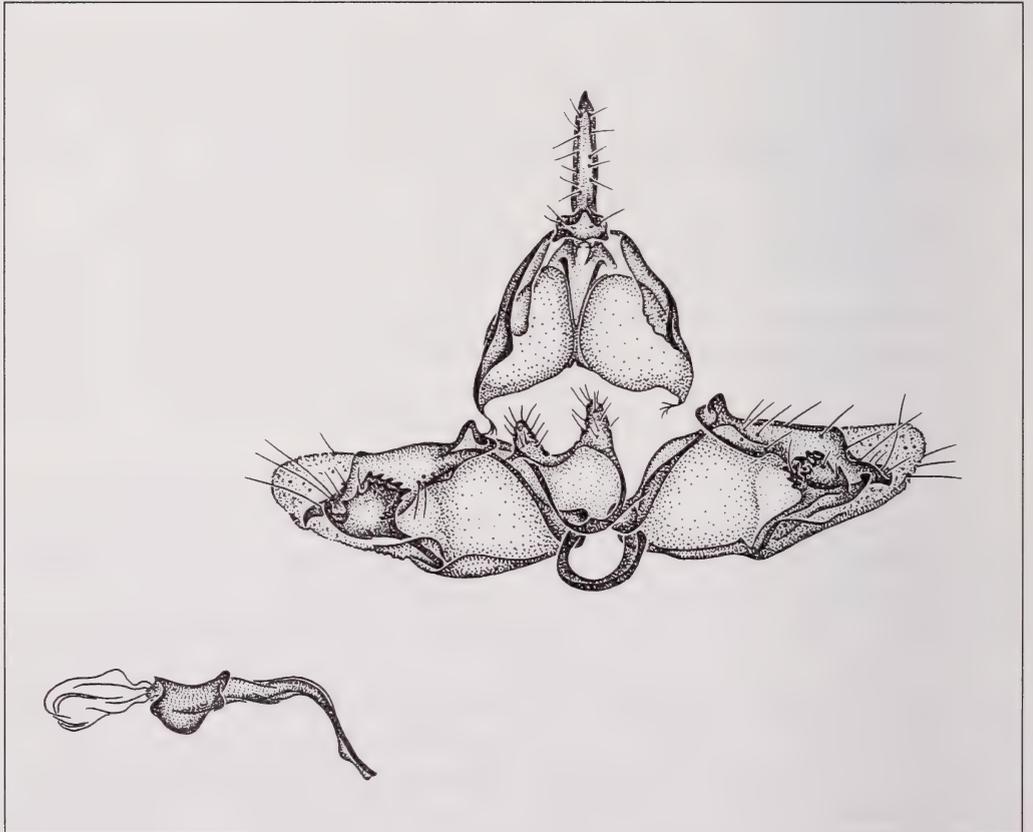
**H a b i t a t .** – The moths are met with at altitudes of 900-1600 m, in the Kuhitangs Mts. in Turkmenistan they were collected in the almond altitudinal belt; they fly from the middle of April to May.

**E t y m o l o g y :** The species is named in honour of O. F. Herz (1852-1905) who collected this species during his journey to Bukhara in April 1892.

***Merrifieldia nivella* sp. n.**

(Fig. 18)

**Material.** – Holotype: ♂, Tajikistan, the Pamirs, 15 km NE of the terminus of Fedchenko Glacier, Kaindy River, about 3500 m, 18.VIII.1958, Gorodkov leg.



**Fig. 18.** *Merrifieldia nivella* **sp. n.**, holotype, male genitalia (ventral view).

**External characters.** – Head covered with appressed dark-grey scales. Labial palpi very short, equal eye diameter, set rather widely apart. Antennae dark-grey, smooth. Fore wings cleft almost to a half of their length. Wing span 19 mm. Fore wings covered with brown and white scales that makes them ash-grey, without any pattern. Fringe mostly grey, only with a patch of white hairs at cleft base. Hind wings and their fringe evenly grey. Hind legs grey.

**Male genitalia:** Valvae symmetrical, at base with a harpe of a complicated structure, which look like a crest with erected processes and a narrow convex blade protruding behind inner margin of valva. Valva apex membranous, weakly sclerotized. Arms of anellus narrowed to apex. Uncus slightly curved, pointed apically, aedeagus wavy, bent with a pointed apex, its basal part noticeably widened.

**Diagnosis.** – By the wing shape this species resembles representatives of the genus *Merrifieldia* Tutt, 1905, while the genitalia structure is quite different from any other species of the subfamily Pterophorinae known from the Palaearctic. It might deserve segregation into a new genus, but such a step should only be taken once females and more males are known for closer study. Affiliation with the genus *Merrifieldia* was suggested by Dr. C. Gielis (pers. comm.). Unfortunately, the area where the holotype was collected is nowadays practically inaccessible.

**Range.** – Pamir.

**Habitat.** – Single known moth was collected at 3500 m.

## II. New synonymies and distribution records of Palaearctic plume moths

### *Agdistis sissia* Arenberger, 1987

**Material.** – Azerbaijan: 1♂, Nakhichevan, 19.VI.1977 (collector unknown). Armenia: 2♂. Vedi environs, Horovan desert, 9.VI.1997 (A. Dantchenko leg.).

Described from Turkey (Arenberger 1987); for the first time found in Armenia and Azerbaijan.

### *Agdistis asthenes* Bigot, 1970

**Material.** – 3♂, 2♀, SE Kazakhstan, Uigurskii District, 15 km NW of v. Chundzha, Yasenevaya Roshcha cordone, attracted by light, 22-28.V.1991 (P. Ustjuzhanin leg.).

Described from Mongolia (Bigot 1970); for the first time found in Kazakhstan.

### *Agdistis falkovitchi* Zagulajev, 1986

**Material.** – Kazakhstan: 1♀, SE Kazakhstan, Uigurskii District, 15 km NW of v. Chundzha, Yasenevaya Roshcha [Ash Grove] cordone, attracted by light, 24.VI.1990 (I. Kostjuk leg.). Mongolia: 1♀, Kobdo Aimak, Elkhon, 20 km SE of v. Altai, attracted by light, 26.VII.1970 (leg. Kerzhner & Chogsomzhav).

Described from Uzbekistan, reported also for Turkmenia (Zagulajev 1986). Here reported for Kazakhstan and Mongolia.

### *Agdistis gerasimovi* Zagulajev & Blumental, 1994

*Agdistis detruncatum* Zagulajev & Blumental, 1994. Entomologicheskoe obozrenie, LXXIII, 1, 133-135. Holotypus, ♀, "Bukhara, Chargush, 27.V.1928, A. Gerasimov", "Coll. Zool. Inst., St. Petersburg, gen.praep. N.13072 ♀, det. Zagulajev & Blumental". **Syn. n.**

Material. – Tajikistan: 18 specimens, 180 km S of Dushanbe, Tigrovaya Balka Nature Reserve, 6-9.VIII.1991 (V. Zolotukhin leg.). Turkmenistan: 2♂, env. of town Bairam-Ali, attracted by light, 9 and 13.VIII.1991 (A. Mironov leg.).

Described from Uzbekistan (Zagulajev & Blumental 1994). Here reported for Turkmenistan and Tajikistan.

### ***Agdistis mevlaniella* Arenberger, 1972**

Material. – 1♂, SE Kazakhstan, Uigurskii District, 15 km NW of v. Chundzha, Yasenevaya Roshcha cordone, attracted by light, 22.V.1991 (P. Ustjuzhanin leg.); 1♂, SE Kazakhstan, Taldy-Kurgan Province, Sarkand District, environs of v. Topolevka, attracted by light, 31.VII.1957, (V. Kuznetsov leg.); 1 specimen, W Kazakhstan, Aktyubinsk Province, Uil River, 12.VI.1970 (Aibasov leg.).

Described from Turkey (Arenberger 1972), reported also for the Caucasus (Arenberger 1995) and Tajikistan (Zagulajev 1986). Now found in Kazakhstan.

### ***Agdistis turkestanica* Zagulajev, 1990**

Material. – 1♀, Turkmenistan, Chardzhou Province, settlement Teze-Durmush, 24.VI.1973 (M. Daricheva leg.).

Described from Kazakhstan (Zagulajev 1990), now found in Turkmenistan.

### ***Agdistis paralia* (Zeller, 1847)**

Material. – 2♀, Turkmenistan, Geok-Tepe, 9-10.VI.1981 (G. Krasilnikova leg.).

Described from Sicily (Zeller 1847), reported for N Africa (Caradja, 1920), S Europe (Arenberger 1995), Israel (Amsel, 1935), Malta (Prola & Racheli 1984), Greece (Staudinger 1870). Here reported for Turkmenistan.

### ***Agdistis flavissima* Caradja, 1920**

Material. – 1♂, Turkmenistan, environs of town Bairam-Ali, attracted by light, 13.VIII.1991 (A. Mironov leg.).

Described from NW China (Caradja 1920). Here reported for Turkmenistan.

### ***Platypylia ardua* McDunnough, 1927**

Material. – 1♂, Chukotka, Chaplinskii sources, 14.VII.1960 (collector unknown).

The species was described from Canada (McDunnough 1927). Here it is for the first time reported for Eurasia as it was found in Chukotka.

### ***Platypylia euridactyla* Zagulajev & Filippova, 1976**

Material. – 1♂, Chita Province, environs of v. Kyra, attracted by light, 6.VII.1990; 1♀, the same label, 14.VII.1997 (A. Bidzilya, I. Kostyuk).

Described from the Amur region (Zagulajev & Filippova 1976), known also from NE China (Manchuria) as *Platypylia manshurica* (Buszko 1977). First record from Transbaikalia.

***Platyptilia tesseradactyla* (Linnaeus, 1761)**

Material. – 4 specimens, E Kazakhstan, Markakol' District, a pass through Matobai Mt. Range at the southern bank of Lake Markakol', 5.VII.1996 (V. Zinchenko leg.).

This species is widely distributed in the Palaearctic but was not so far recorded from Kazakhstan.

***Buszkoiana capnodactylus* (Zeller, 1841)**

*Platyptilia diversicilia* Filipjev, 1931, Lepidopterologische Notizen. XI.- Comptes Rendues de l'Acad. Sci. U.R.S.S. 10: 337–342, 5 figs. **Syn. n.**

Material. – Holotype: ♂, «Krym, Sochinskii r-n, Golovinskaya dacha, na svet» [Crimea, Sochi District, Golovinskaya dacha, attracted by lights], collector and date unknown. (prep. genit. No 10889). Note: The original label is somewhat confusing since Sochi is not in Crimea but on the Black Sea coast of the Caucasus (the Krasnodarskii Krai Province).

*Platyptilia diversicilia* was described from the North Caucasus (Filipjev 1931). Examination of the holotype of this species, preserved in the Zoological Institute, Sankt Petersburg, showed their identity to *Buszkoiana capnodactylus* Zeller.

***Gillmeria armeniaca* (Zagulajev, 1984)**

Material. – 1♂ - Armenia, Erevan, 12-16.VI.1934 (M. Ryabov); 1♂ - Russia, Saratov Province, Engels District, 7 km S of town Engels, steppe, attracted by the light, 8.V.1998 (V. Anikin); 1♂ - NW Kazakhstan, the road Ural'sk-Aktyubinsk, 40 km SE of v. Novoalekseevka, 27.V.1998 (A. Danchenko); 5 specimens - NW Kazakhstan, Turgai Province, the Kaindy River floodland, steppe, 8-13.VI.1973 (Ch. A. Aibasov).

*Gillmeria uralSKIensis* Gibeaux, 1995, Phegea 23 (2) (1.VI.1995):91-92, figs. 1, 9-13. **Syn. n.**

*G. uralSKIensis* was described from NW Kazakhstan. Comparison of figures at the original description (Gibeaux 1995) and the specimens collected in NW Kazakhstan closely to its type locality with a specimen of *Gillmeria armeniaca* (Zagulajev 1984) from Armenia have shown undoubtedly that the former is identical to the latter.

***Oxyptilus chrysodactyla* ([Denis & Schiffermüller], 1775)**

*Oxyptilus perunovi* Ustjuzhanin, 1996, Atalanta (May 1996) 27 (1/2): 385-386, fig. 2 a, b. **Syn. n.**

It was an abnormal specimen with reduced brachioli in the male genitalia which was erroneously described as a new species (Ustjuzhanin 1996). This synonymy was indicated to me by Dr. C. Gielis (pers. comm.).

***Procapperia orientalis* Arenberger, 1988**

Material. – Tajikistan: 1 specimen, Ghissar Mts., 30 km N of Dushanbe, settlement Kondora, 1500 m, attracted by light, 19.IX.1991, 2♂, the same label, 26.IX.1991 (P. Ustjuzhanin leg.); 1♀, 18.VII.1987 (R. Sherniyazova leg.). Turkmenistan: 1♀, West Kopet-Dag Mts., town Kara-Kala, attracted by light, 19.IV.1982 (P. Ustjuzhanin leg.).

Described from Kashmir, India (Arenberger 1988 b), reported for Uzbekistan and Kirghizia (Gibeaux 1996). We have found this species also in Tajikistan and Turkmenia.

***Procapperia kuldshaensis* (Rebel, 1914)**

*asiatica* Zagulajev, 1986, Trudy zool. Inst., Leningrad 67: 87–90, figs. 8–10. (Arenberger, 1988 a).

Material. – 22 specimens, Kemerovo Province, Novokuznetsk District, 5 km NEE of v. Kuzedeevo, at railway station Ushchelye, Kondoma River right bank. a rocky cliff foot, 25.VII.1996 (O. E. Kosterin, O. G. Berezina).

The moths were very abundant but only on *Dracocephalum nutans* Linnaeus, 1758 plants (probably a larval foodplant), which at that time had finished flowering.

Ranges in Anterior and Central Asia, Altai and Tuva (Ustjuzhanin 1996). Here is reported for the Gornaya Shoriya Mts. (a northern extension of the Altai Mts.) in Kemerovo Province.

***Paracapperia anatolicus* (Caradja, 1920)**

Material. – Armenia: 3♂ 2♀, Khosrov Nature Reserve, 2500–3000 m, 7.VIII.1996 (A. Dantchenko leg.); 1♂, Lake Sevan, 23.VII.1997 (K. Efetov leg.). Tajikistan: 1♀, the Ghissar Mts., 30 km N of Dushanbe, settlement Kondora, 1500 m, attracted by light, 2.VII.1985 (R. Sherniyazova leg.). Turkmenistan: 1♀, West Kopet-Dag Mts., 50 km E of town Kara-Kala, settlement Ai-Dere, attracted by light, 26.IV.1982 (P. Ustjuzhanin leg.).

Described from Turkey (Caradja 1920), known also from Spain (Bigot & Picard 1986). Here I report it for Armenia, Tajikistan, and Turkmenistan.

***Amblyptilia grisea* Gibeaux, 1996**

Material. – Tajikistan: 1♂, the western Zaalaiskii [Transalai] Mts., 10–15 km E of settlement Lyakhsh, 4000 m, 27.VII.1987 (A. Lastukhin leg.). Kazakhstan: the Western Altai Mts., Ivanovskii Mt. Range, 20 km SE of town Leninogorsk, 1500–1700 m, 3.VI.1996 (R. Dudko, A. Vorontzov leg.). Russia: 1♀, SE Altai, 7 km NE of Zhumaly River mouth, a right tributary of Dzhazator River 2600 m, 9.VI.1998 (leg. V. Zinchenko).

Described from Alma-Ata, Kazakhstan (Gibeaux 1996), here reported from Tajikistan and the Altai Mts. (E Kazakhstan and Siberia, Russia).

***Stenoptilia pterodactyla* (Linnaeus, 1761)**

Material. – 1♂, Primorie, the Usuriiskii Bay coast, Bol'shoi Kamen', 23.VII.1974 (V. Zhierikhin leg.)

This species is widely distributed throughout the Palearctic but for the Far East of Russia is reported now for the first time.

***Stenoptilia islandica* (Staudinger, 1857)**

Material. – 1♂1♀, Yakutia, Tiksi, spotty tundra, 2.VIII.1957; 1♀, Apuka River upper flow, 600 m, 12.VII.1959 (K. Gorodkov leg.); 2♂ 3♀, Chukotka, 40 km NE of settlement Provideniya, 21.VII.1991 (Y. Tchistjakov leg.); 1♂, SE Altai Mts., Ukok Plateau, 2200 m, 3.VII.1995 (A. Bidzilya leg.).

Described from Iceland (Staudinger 1857), known also for Scotland, Norway and Sweden (Gielis 1996), here for the first time reported for Asia: SE Altai Mts. and Transpolar Siberia.

***Stenoptilia veronicae* Karvonen, 1932**

*agutsana* Ustjuzhanin, 1996, *Atalanta* 27: 374–376, Plate 3, fig. 4 a-c (Ustjuzhanin, 1999)

Material. – 2 specimens, Polar Ural, environs of town Labytnangi, 23.VII.1995; 11 specimens, Polar Ural, 141 km on railroad Seida-Labytnangi, Sob' River floodland, 27-30.VII.1995 (I. Lyubchanskii); 1 ♂, 1 ♀, Ust'-Ordynsk Buryat Autonomous Region, 20 km S of v. Ust'-Ordynskoe, attracted by light, 2.VIII.1984 (S. Sinev leg.); 1 ♂, Yakutia, Indigirka River basin, 300 km NNE of settlement Khandyga, Suntar River lower reaches at hydrology station, 5.VII.1995 (V. V. Dubatolov leg.); 1 ♀, Central Yakutia, Aldan River basin, village Megino-Aldan, 20 km downstream of Amga River mouth, 30.VI.1982 (E. L. Kaimuk); 1 ♂, Amur Province, environs of Blagoveshchensk, 4.VIII.1995 (A. N. Streltsov leg.); 1 ♀, Southern Primorye, Pogranichnyi District, v. Barabash-Levada, 3.VIII.1989 (E. Belyaev leg.).

The species was earlier known from North Europe (Gielis 1996). It is also found in the Altai Mts. (Ustjuzhanin, Gielis in litt.) and in E Siberia, from where it was described as *S. agutsana* Ustjuzhanin 1996 (for synonymy see Ustjuzhanin 1999). Now recorded from further regions of Siberia, the Polar Ural and the Russian Far East.

***Stenoptilia parnasia* Arenberger, 1986**

Material. – Armenia: 1 ♀, Armenia, Aragatz. valley Ambert, 2500-3400 m, 17. -24.VII.1996; 1 ♀, Aiotzorskii Mt. Range, settlement Gnishek, 2000-2400 m, 20. -25.VII.1998 (A. Dantchenko leg.).

Described from Greece (Arenberger 1986), here reported for Armenia.

***Stenoptilia alai* Gibeaux, 1995**

Material. – 1 ♂, 3 ♀, Kazakhstan, Zailiiskii Alatau Mts., Maloe Almaatinskoe gorge, 2500 m, 26.VII.1957 (A. Danilevskii, V. Kuznetsov leg.)

Described from Tajikistan (Gibeaux 1995), here reported for Kazakhstan.

***Stenoptilia inexpectata* Gibeaux, 1995**

Material. – 11 specimens, Turkmenistan, Central Kopet-Dagh Mts, 15 km W of Firyuza, Dushak Mountain, 3-11.VII.1990 (leg. V. Dubatolov).

The species was described based on its holotype from Kirghizia (the Terskei Alatau Mts.) and a paratype from the Russian Far East: Ussuri, Chabarowka (Gibeaux, 1995). Their conspecificity seems very dubious, taking into account the distance of 7000 km and principally different habitats. By comparison with the holotype, here I report *S. inexpectata* for Turkmenistan.

***Stenoptilia caradjai* Gibeaux, 1995**

Material. – Kazakhstan: 1 ♀, Malaya Almaatinka River, 1450 m, 26.VII.1937 (collector unknown); 1 ♂, Tyshkantau Mts., 8.VII.1992 (A. Zhdanko leg.).

Described from Tajikistan: Alai (Gibeaux 1995), now also found in Kazakhstan.

***Stenoptilia aktashiensis* Gibeaux, 1996**

Material. – Tajikistan: 1 ♀, Ghissar Mts. Anzob Pass, 3600 m, 14.VIII.1946 (Gusakovskii leg.); 1 ♀, 30 km N of Dushanbe, Kondara Gorge, 1100 m, 21.VI.1984; 5 specimens, the same label, 20.VII - 3.VIII.1985 (R. Sherniyazova leg.); 1 ♀, 26.VII.1991 (P. Ustjuzhanin leg.). Uzbekistan: 7 specimens, 60 km SEE of Tashkent, Chatkal'skii Nature Reserve, 7-20.X.1992 (V. Zolotuhin leg.). Turkmenistan: 9 specimens, 5 km

of Bazar-Depe, office of the Kuhitangh Nature Reserve, 1700 m, 10.V.1991; 8 specimens, Kuhitangs Mts., Dzheilyau Plateau, 2200 m, 13.VII.1991; 9 specimens, the Airi-Baba Mt., 14.VII.1991; 1 ♀, Central Kopet-Dag Mts, settlement Firyuza, 25.V.1991 (V. Dubatolov leg.). SW Kazakhstan: 1 ♂, 15 km N of Kentau, Karatau Mt. Range, 900 m, 6.V.1994 (V. Zolotuhin leg.).

Described from Kirghizia: the Terskei Alatau Mts (Gibeaux 1996). Found also in Tajikistan, Uzbekistan, Kazakhstan, and Turkmenistan.

***Merrifieldia caspia* (Lederer, 1870)**

Material. – 1 ♀, Tajikistan, Iskander-Datya River gorge, 1700 m, attracted by light, 25.VI.1965 (M. Falkovich leg.).

Described from Iran (Lederer, 1870), known also from India, Turkey, China, Turkmenia, Uzbekistan, Kirghizia (Arenberger 1995), now found in Tajikistan.

***Merrifieldia malacodactyla* (Zeller, 1847)**

Material. – 1 ♀, SE Kazakhstan, Taldy-Kurgan Province, Sarkand District, 8 km E of settlement Topolevka, attracted by light, 2.VII.1957 (V. Kuznetsov leg.).

A species widely ranging throughout the Palaeartic which, however, is here for the first time reported for Kazakhstan.

***Wheeleria elbursi* (Arenberger, 1981)**

Material. – Armenia: 3 specimens, surroundings of Erevan, v. Migry, 7.V.1937 (M. Ryabov leg.); 1 ♀, Khosrov Nature Reserve, 2500-3000 m, 7.VII.1996; 8 specimens, Vedi environs, Horovan desert, 9.VI.1996 (A. Dantchenko leg.).

Described from Iran (Arenberger 1981), known also from Turkey (Arenberger 1995), here for the first time reported from Armenia.

***Wheeleria kabuli* (Arenberger, 1981)**

Material. – 2 ♀, Azerbaijan, Nakhichevan', 19.VI.1977 (collector unknown).

Described from Afghanistan (Arenberger 1981). Here for the first time reported for Azerbaijan.

***Tabulaeophorus ussuriensis* (Caradja, 1920)**

Material. – 2 ♂, Chita Province, left bank of the Budyumkan River 5 km upstream of its mouth, open Mongolian oak/Dahurian birch/larch/pine mixed forest on a ridge crest, 1.VIII.1997 (V. Dubatolov leg.).

Described from Primorye (Caradja 1920), found in Transbaikalia.

***Tabulaeophorus marptys* (Christoph, 1872)**

Material. – Russia: 2 ♂, Chita Province, 50 km N of Chita, v. Burgen', attracted by light, 18-19.VI.1995 (I. Kostjuk, O. Kostjuk, M. Golovushkin). Kazakhstan: 1 ♂, Zailiiskii Alatau Mts., Maloe Almaatinskoe Gorge, 2500 m, 27.VII.1957 (V. Kuznetsov, A. Danilevskii leg.); 1 ♂, Turgai Province, Kaindy River, 5.VI.1973; 2 specimens, Aktyubinsk Province, Kush River, sands, June 1971 (Aibasov leg.); 2 specimens, NW Kazakhstan, road Ural'sk-Aktyubinsk, 40 km SE of v. Novoalekseevka, 27.V.1998 (A. Dantchenko leg.).

Described from the southern Volga Basin (Christoph 1872), reported also for Mongolia (Zagulajev & Pentschukovskaja 1972), Altai and Tuva (Ustjuzhanin 1996, as *Wheeleria kaszabi* Bigot); now found in Transbaikalia and Kazakhstan.

***Tabulaeophorus decipiens* (Lederer, 1870)**

Material. – 1 ♀, Tajikistan, Ghissar Mts., 30 km N of v. Dushanbe, Kondara Gorge, attracted by light, 15.IX.1991 (P. Ustjuzhanin leg.).

Described from Iran (Lederer 1870), known also from Armenia and Kirghizia. Here I report it for Tajikistan.

***Tabulaeophorus parthicus* (Lederer, 1870)**

Material. – Turkmenistan: 2 ♂, Central Kopet-Dag, 15 km W of Firyuza, Dushak Mt., 9.VII.1990 (V. Dubatolov leg.). Armenia: 1 ♂, environs of Vedi, Horovan Desert, 9.VI.1997 (A. Dantchenko leg.).

Described from Iran (Lederer 1870); known also from Turkey, Syria, Israel, Jordan, Afghanistan, Azerbaijan (Arenberger 1995). Here reported for Turkmenistan and Armenia.

***Tabulaeophorus sesamitis* (Meyrick, 1905)**

Material. – Turkmenia, Bakharden District, Ipai-Kala Gorge, attracted by light 23.VII.1973 (G. Krasilnikova).

Described from Burma (Meyrick 1905), known also from India and Afghanistan (Arenberger 1995), here for the first time reported for Turkmenistan.

***Tabulaeophorus hissaricus* (Zagulajev, 1986)**

Material. – 1 ♂, Uzbekistan, 60 km SEE of Tashkent, Chatkal Nature Reserve, 1-2.VIII.1991 (V. Zolotuhin leg.).

Described from the Ghissar Mts. in Tajikistan (Zagulajev, 1986), here for the first time reported for Uzbekistan.

***Calyciphora nephelodactyla* (Eversmann, 1844)**

Material. – 1 ♂, NW Kazakhstan, Akshata Mts., northern environs of settlement Uil, 3-4.VI.1998 (A. Dantchenko leg.).

Described from the southern Volga Basin (Eversmann, 1844), known also from South Europe, Turkey, Syria, Georgia (Arenberger 1995), here for the first time reported for Kazakhstan.

***Calyciphora xerodactyla* (Zeller, 1841)**

Material. – 3 specimens, Kemerovo Province, Novokuznetskii District, 8 km E of v. Kuzedeevo, 440 m, 23-24th July 1995; 3 specimens, same locality, 17.VII.1996 (leg. O. E. Kosterin & O. G. Berezina).

Ranges in Europe and Turkey, reported for Irkutsk (Arenberger 1995).

A female specimen reported by me for Taishet (Central Siberia) as *C. nephelodactyla* (Eversmann, 1844) (Ustjuzhanin 1996) in fact belongs to this species. Now found at the foothills of the Gornaya Shoriya Mts., Kemerovo Province, in relic lime (*Tilia sibirica* Fischer) forests which are very moist and are characterized by tall herbaceous undergrowth.

### ***Calyciphora marashella* Zagulajev, 1986**

Material. – 1 ♀, Armenia, Aragatz, valley Ambert, 2800-3400 m, 24-30.VIII.1996 (A. Dantchenko leg.).

Known from the first description from Turkey (Zagulajev 1986). I report it for the first time from Armenia.

### ***Hellinsia nigridactylus* (Yano, 1961)**

Material. – Chita Province: 1 specimen, 12 km SW of v. Gazimurskii Zavod, 2 km SW of v. Dogye, a forb meadow at birch forest, at dusk, 23.VII.1997; 1 ♂, Budyumkan River left bank 5 km upstream of its mouth, open Mongolian oak/Dahurian birch/larch/pine mixed forest on a ridge crest, 26.VII.1997 (leg V. Dubatolov, O. Kosterin & O. Berezina).

Described from Japan (Yano, 1961), known also from Manchuria (Buszko 1977), the Russian Far East: Primorye, Sakhalin (Ustjuzhanin 1996); here reported for SE Transbaikalia.

### ***Hellinsia chrysocomae* (Ragonot, 1875)**

Material. – Uzbekistan: 2 specimens, 60 km SEE of Tashkent, Chatkal Nature Reserve, 5 and 29.V.1992; 2 ♀, the same label, 13-14.VI.1992. Russia: 1 ♂, Primorye, v. Yakovlevka, 12.VIII.1926 (leg. Djakonov & Filipjev).

Widely distributed over Europe, the Caucasus and Central Asia (Kirghizia, Afghanistan, Mongolia) (Arenberger, 1995), in Siberia known from Irkutsk (Ustjuzhanin 1996). I report it here for Uzbekistan and the southern Far East of Russia.

Finally, some taxa which I described earlier (Ustjuzhanin 1996) turned out to be junior synonyms. This synonymy was recently published in Russian (Ustjuzhanin 1999) and is listed here again to make these taxonomic changes more widely known in the international literature:

*Platyptilia johnstoni* Lange, 1940 = *P. tschukotka* Ustjuzhanin, 1996.

*Platyptilia melanoschista* Fletcher, 1940 = *P. alexandri* Ustjuzhanin, 1996.

*Fuscoptilia* Arenberger, 1991 = *Snellenia* Ustjuzhanin, 1996.

### **Acknowledgements**

The author expresses his gratitude to the colleagues who collected the materials and courteously offered them for this study: V. V. Dubatolov, V. K. Zinchenko, O. E. Kosterin, O. G. Berezina, R. Dudko (Novosibirsk), R. V. Yakovlev (Barnaul), V. V. Zolotuhin (Ulyanovsk), A. A. Lastukhin (Cheboksary), A. Dantchenko (Moscow), S. Yu. Sinyov, A. L. Lvovsky, V. G. Mironov (Sankt Petersburg), A. N. Streltsov (Blagoveschensk), G. A. Krasilnikova, M. A. Daritcheva (Ashkhabad, Turkmenistan), A. B. Zhdanko (Alma-Ata, Kazakhstan), R. M. Sherniyazova (Dushanbe, Tadjikistan), A. V. Bidzilya, I. Yu. Kostjuk, M. I. Golovushkin (Kiev, Ukraina). He is also very grateful to A. K. Zagulajev for permission to study the

materials of the Zoological Institute of the Russian Academy of Sciences, Sankt Petersburg, to C. Gielis for a fruitful discussion and indications of synonymies, to O. Kosterin for critically reading the paper and translating it into English. Special gratitude is expressed to V. N. Kovtunovich (Moscow) for the genitalia drawings and colour photographs of the new species.

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## *Titanio caradjae* (Rebel, 1902) comb. n., transferred from Brachodidae (Sesioidea) to Crambidae (Pyraloidea)

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**Summary.** *Brachodes caradjae* (Rebel, 1902) is transferred from Brachodidae (Sesioidea) to *Titanio* Hübner, [1825] (Pyraloidea: Crambidae: Odontiinae). The holotype as well as male and female genitalia are figured. In this context, we give short insights into the systematics of the Odontiinae and provide the hypothesis, that the diagnostic characters 'structurae squamiformes' and 'structurae lamelliformes' given by Leraut & Luquet (1982) for the Eurrhypini Leraut & Luquet, 1982 can be regarded as synapomorphies of this tribe. Further, we present a possible third synapomorphy for the Eurrhypini, a paired ruffled membrane situated ambilateral to the 'structurae squamiformes' of the vinculum.

**Zusammenfassung.** *Brachodes caradjae* (Rebel, 1902) wird von den Brachodidae (Sesioidea) zu *Titanio* Hübner, [1825] (Pyraloidea: Crambidae: Odontiinae) transferiert. Der Holotypus sowie die männlichen und die weiblichen Genitalia werden abgebildet. In diesem Zusammenhang geben wir einen kurzen Einblick in das System der Odontiinae und unterbreiten die Hypothese, daß die von Leraut & Luquet (1982) aufgezeigten diagnostischen Merkmale der Eurrhypini Leraut & Luquet, 1982, die 'structurae squamiformes' und die 'structurae lamelliformes', als Synapomorphien dieser Tribus gewertet werden können. Desweiteren zeigen wir eine dritte mögliche Synapomorphie für die Eurrhypini, eine paarige, geriffelte Membran beidseitig der structurae squamiformes' des Vinculums.

**Résumé.** *Brachodes caradjae* (Rebel, 1902) est transféré de la famille des Brachodidae (Sesioidea) au genre *Titanio* Hübner, [1825] (Pyraloidea: Crambidae: Odontiinae). L'holotype, ainsi que les armures génitales mâle et femelle, sont illustrés. Dans ce contexte, nous effectuons une brève analyse de la systématique des Odontiinae et présentons l'hypothèse que les caractères diagnostiques 'structurae squamiformes' et 'structurae lamelliformes', énumérés par Leraut & Luquet (1982) pour les Eurrhypini Leraut & Luquet, 1982, peuvent être considérés comme synapomorphies de cette tribu. Nous présentons, de plus, une éventuelle troisième synapomorphie des Eurrhypini, à savoir une membrane en paire, ambulatérale aux 'structurae squamiformes' du vinculum.

Key words. *Titanio caradjae*, Pyraloidea, Crambidae, Odontiinae, Sesioidea, Brachodidae, Turkey, reclassification, phylogeny

### Introduction

In 1902, Rebel described *Atychia caradjae* from Kulp, former Armenia, in the family Tineidae. Heppner (1979) showed that the generic name *Atychia* Latreille, 1809, the type genus of Atychiidae, is a junior homonym of *Atychia* Ochsenheimer, 1808, now known to be a junior synonym of *Adscita* Retzius, 1783 (Zygaenidae). Therefore, Heppner (1979) proposed for Atychiidae the new family name Brachodidae with the type genus *Brachodes* Guenée, 1845. Subsequently, Heppner (1981) combined *Atychia caradjae* Rebel, 1902 with *Brachodes* Guenée, 1845.

An examination of the holotype of *Atychia caradjae* Rebel, 1902 revealed that this species does not belong either to the Brachodidae or to any other family of Sesioidea. The presence of an abdominal tympanal organ of the pyraloid type with a praecinctorium and the cranially open bullae tympani indicates that this species belongs to the family Crambidae within Pyraloidea (cf. Minet 1982; Maes 1985). Within Crambidae, *caradjae* appears to be part of the subfamily Odontiinae according to the conspicuously projected

frons, the absence of chaetosemata, the valvae of the male genitalia which are radially fluted (cf. Munroe 1961, 1972), and the gnathos arms which are basally fused with the tegumen.

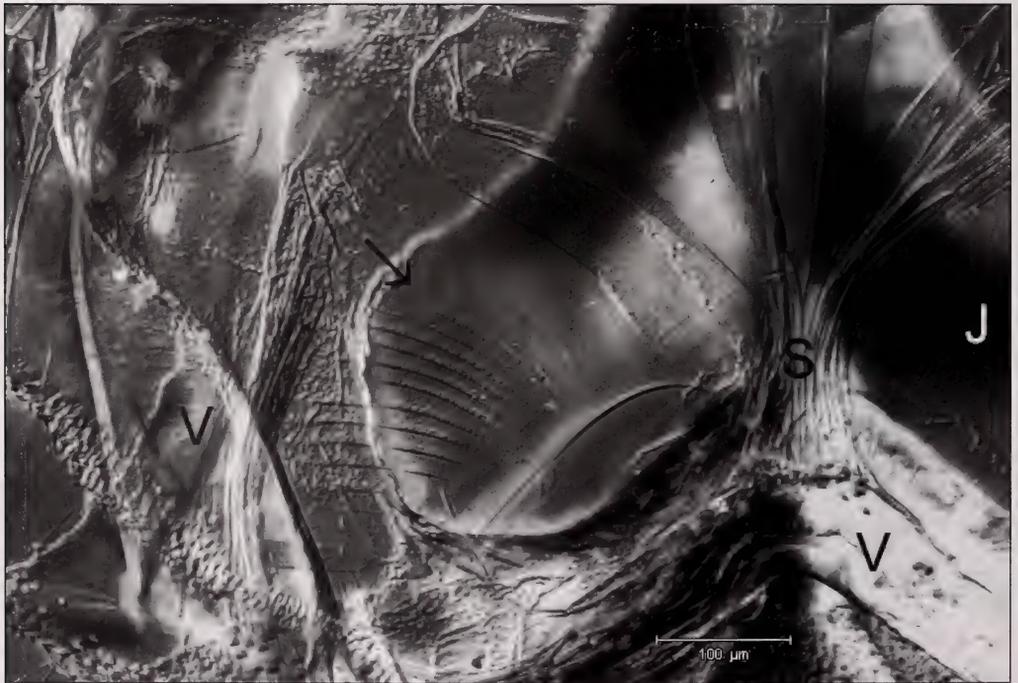
We here transfer *Atychia caradjae* Rebel, 1902 to the genus *Titanio* Hübner, [1825] within Odontiinae, discuss this generic placement and provide a redescription of the species. In this context, we outline some phylogenetic aspects of the two odontiine tribes Odontiini Guenée, 1854 and Eurrhypini Leraut & Luquet, 1982.

### Methods

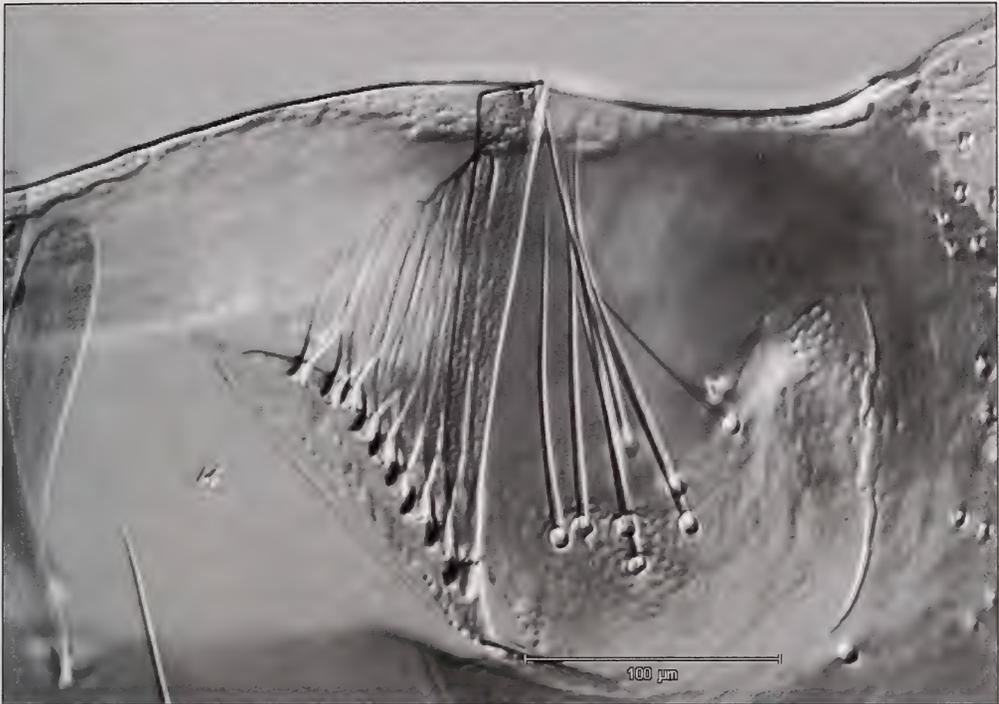
The preparation of genitalia followed Robinson (1976) and Nuss (1999). Genitalia were investigated using the microscope Nikon Eclipse 600. Images of the genitalia have been taken with the photomicrographic equipment Nikon H-III, details (Figs. 1–2) taken using interference contrast and three dimensional computer microscopy with extended focus option (digitaloptics, Jena).

### Systematics of Odontiinae Guenée, 1854

Within Odontiinae, there are 367 species described worldwide (Heppner 1991) placed in more than 100 genera (Fletcher & Nye 1984; Nuss, unpubl.). Munroe (1961, 1972,



**Fig. 1.** *Eurrhypis pollinalis* ([Denis & Schiffermüller], 1775). Caudal view on the left side of central part of male genitalia showing two synapomorphies of Eurrhypini, the 'structurae squamiformes' (S) arising in the middle of the vinculum (V) and the 'ruffled membrane, laterally of this structure (indicated by the arrow); both characters are situated caudally to the juxta (J). (GU Nuss 933-00; extended focus-option: 61 planes with an interplanal distance of 2  $\mu\text{m}$ , object depth 123  $\mu\text{m}$ ).



**Fig. 2.** *Eurrhysis pollinalis* ([Denis & Schiffermüller], 1775). Dorsal view on the VIII sternite showing synapomorphy of Eurrhypini, the 'structurae lamelliformes' (GU Nuss 933-00; extended focus-option: 29 planes with an interplanal distance of 1 μm, object depth 27 μm).

1973), who revised the North American Odontiinae, established a system in which the shape of the frontal projection plays a major role. Although the frontal projection is a useful diagnostic character, we do not share this typological concept which results in so many monotypic genera.

Leraut & Luquet (1982) established two tribes within Odontiinae, the Odontiini Guenée, 1854 and the Eurrhypini Leraut & Luquet, 1982. The latter are supposedly monophyletic by two possible synapomorphies in the male genitalia, the 'structurae squamiformes' (Fig. 1) and the 'structurae lamelliformes' (Fig. 2). The 'structurae squamiformes' are scales arising in the middle of the vinculum and the 'structurae lamelliformes' are an assemblage of sensillae chaeticae and spatulate scales on the VIII sternite (cf. Leraut & Luquet 1982: fig. 16). Additionally, there is a paired membrane situated ambilateral to the 'structurae squamiformes'. Each of these membranes is cut 17 times by very fine transversal cracks (Fig. 1). In *Eurrhysis pollinalis* ([Denis & Schiffermüller], 1775), the distance between two neighbouring cracks is 12 μm (Fig. 1) (♂ Germany, Dresden-Lößnitz, 29.v.1916, Möbius leg., coll. Museum für Tierkunde Dresden, GU Nuss 933). We consider this structure as a third synapomorphy of the Eurrhypini. Beside the Palearctic genera *Emprepes* Lederer, 1863 and *Eurrhysis* Hübner, [1825], these characters were also found in the Nearctic genera *Jativa* Munroe,

1961, *Mimoschinia* Warren, 1892, and *Pseudoschinia* Munroe, 1961 which therefore are also associated with the Eurrhypini here.

The Odontiini remain probably paraphyletic since no synapomorphic character is recognised for this group so far. Odontiine taxa belonging to this tribe are therefore recognised by the absence of the three synapomorphies listed above for Eurrhypini. Both, the type-species of *Titanio*, *T. normalis* (Hübner, 1796) (♂ South Ukraine, Nowo-Aleksejewka, 7.vii.1943, M. Sälzl jr. leg., Zoologische Staatssammlung, Munich) as well as *caradjae* Rebel, 1902, lack these synapomorphies and therefore belong to the tribe Odontiini.

Furthermore, *T. normalis* and *caradjae* present a similar shape of the frontal projection of the head and show a good correspondence of genitalia morphology. Although we cannot find any generic definition which completely fits the morphology of *caradjae*, we provisionally transfer *Atychia caradjae* Rebel, 1902 to *Titanio* Hübner, [1825] to prevent the establishment of a further odontiine genus before this subfamily has been revised.

***Titanio caradjae* (Rebel, 1902) comb. n.**

(Figs. 3–5)

*Atychia caradjae* Rebel, 1902: 122–123, pl. 4 fig. 11a–b.

Material examined. Holotype (by monotypy) ♀ (Fig. 3) “Kulp | Sud Kars | (Armenien) | VI. 1901”, “*Atychia* | *caradjae* Rbl | ♂ [sic]. Type”, “Holotype | *Atychia* ♂ [sic] | *caradjae* | Rbl. | ROMANIA”, “GU 781 | prep. Nuss 1997”, Muzeul de Istorie Naturala “Grigore Antipa”, Bucuresti. ♂: Syria sept., Taurus, Marasch, 20. v. 1928, leg. L. Osthelder, GU Kallies 156-96, Zoologische Staatssammlung, Munich.

**Head.** – Frons with a rounded, sharply edged prominence; ocelli present; chaetosemata absent; labial palpi short, porrect; maxillary palpi absent (reduction!); conspicuous pilifer; proboscis basally scaled; upper side of antenna scaled, underside setose; occiput with a collar consisting of white, elongated upright scales; head and palpi ventrally white scaled; upper side of head, thorax and abdomen black with a leaden shine.

**Wings** (Fig. 3). – Forewing length 3 mm (male), 4.5 mm (female); forewings scaled vermilion light; basal area, median line, and tip of termen shining lead-coloured; fringe basally greyish brown, distally light brown, at apex whitish; hindwings proximally greyish-brown, remaining part vermilion light, fringe greyish brown. Underside paler, without lines, basally greyish-brown; forewings in the middle and at the costa vermilion light, at dorsum and at termen whitish, fringe as on upper side; hindwings uniform vermilion light.

**Male genitalia** (Fig. 4). – Uncus distally bilobed, setose; base of gnathos fused along entire ventral edge of tegumen, distally thick and pointed, slightly dentate; juxta large trapezoid, distally double pointed and dentate, dorso-basally joining a long and slender structure, which is distally bilobed and dentate; vinculum broad U-shaped but thin, saccus enlarged; valvae simple, dorso-basally strongly sclerotised, distally conspicuously broadly ovate, as typical for Odontiinae; aedeagus straight, with three long cornuti.

**Female genitalia** (Fig. 5). – Corpus bursae membranous, ovoid; ductus bursae short, membranous, posterior part strongly sclerotised; ostium with sclerotised surrounding; ductus seminalis arises from sclerotised part of ductus bursae; VIIIth segment with a ring of hairs; ovipositor short; papillae anales short, thick, strongly bilobed, setose.

**Diagnosis.** – Among Palaearctic Odontiinae, this species is unique in possessing vermilion coloured wings with basal area, median line, and tip of termen in forewings shining lead-coloured. With *T. normalis*, it has in common the enlarged juxta with the bimodal, dentate tip. Further taxonomic studies are necessary to show the phylogenetic relationships of *T. caradjae*.



**Fig. 3.** *Titanio caradjae* (Rebel, 1902) **comb. n.**, holotype ♀.



**Fig. 4.** *Titanio caradjae* (Rebel, 1902) **comb. n.**, ♂ genitalia (GU Kallies 156-96).



**Fig. 5.** *Titanio caradjae* (Rebel, 1902) comb. n., ♀ genitalia (GU Nuss 781-97).

**Distribution.** – Only known from the type locality Kulp (= Tuzluca, Prov. Igdir, Turkey) and the eastern Toros mts. (Prov. Kahramanmaras, Turkey).

#### **Acknowledgements**

We are grateful to Wolfgang Speidel (Bonn) for interesting discussions about Odontiinae and critical comments on the manuscript, to Yuri Nekrutenko (Kiev) for corrections and comments on the manuscript and to Dorel-Marian Rusti (Bucarest) as well as Axel Hausmann, Andreas Segerer and Ulf Buchsbaum (Munich) for the loan of specimens.

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## Additions to the fauna of Gelechiidae (Gelechiinae: Teleiodini and Gelechiini) of Europe

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**Summary.** Four new species of gelechiid moths, viz. *Recurvaria costimaculella* sp. n. (Italy), *Teleiodes albiluculella* sp. n. (Greece), *Teleiodes traugotti* sp. n. (Spain) and *Mirificarma minimella* sp. n. (Greece) are described. *Teleiodes gallica* Huemer, 1992 is considered as a new subjective synonym of *Teleiodes italica* Huemer, 1992. Furthermore *Schneidereria pistaciella* Weber, 1957 (Greece, Ukraine) is recorded for Europe, and a new combination, *Altenia mersinella* (Staudinger, 1879) comb. n., is given. Adults as well as genitalia structures of the species are figured.

**Zusammenfassung.** Vier neue Gelechiidenarten, nämlich *Recurvaria costimaculella* sp. n. (Italien), *Teleiodes albiluculella* sp. n. (Griechenland), *Teleiodes traugotti* sp. n. (Spanien) und *Mirificarma minimella* sp. n. (Griechenland) werden beschrieben. *Teleiodes gallica* Huemer, 1992, wird als neues subjektives Synonym von *Teleiodes italica* Huemer, 1992, behandelt. Weiters wird *Schneidereria pistaciella* Weber, 1957 (Griechenland, Ukraine) erstmals für Europa gemeldet und eine neue Kombination, *Altenia mersinella* (Staudinger, 1879) comb. n., eingeführt. Die Imagines sowie Genitalstrukturen der behandelten Arten werden abgebildet.

**Resumé.** Quatre nouvelles espèces de Gelechiidae, *Recurvaria costimaculella* sp. n. (Italie), *Teleiodes albiluculella* sp. n. (Grèce), *Teleiodes traugotti* sp. n. (Espagne) und *Mirificarma minimella* sp. n., sont décrites. *Teleiodes gallica* Huemer, 1992 est considéré comme étant un nouveau synonyme subjectif de *Teleiodes italica* Huemer, 1992. De plus, *Schneidereria pistaciella* Weber, 1957 (Grèce, Ukraine) est rapporté d'Europe et une nouvelle combinaison générique, à savoir *Altenia mersinella* (Staudinger, 1879) comb. nov., est introduite. Les adultes, ainsi que les armatures génitales des espèces traitées, sont illustrés.

**Key words.** Lepidoptera, Gelechiidae, Teleiodini, Gelechiini, Europe, new species, new synonymy, new combination.

### Introduction

The gelechiid fauna of the tribes Teleiodini and Gelechiini from Europe has been reviewed recently and a total of 151 species has been recorded (Huemer & Karsholt 1999). However, during the printing stage of this book and since its publication, additional species, some of them still undescribed, have been recognized in various private and institutional collections. To enable a safe identification of the above tribes in Europe we give diagnoses and figures of adults and genitalia of the additional species.

### Abbreviations of museums and private collections

AREN	coll. E. Arenberger, Vienna, Austria.
NM	Naturhistorisches Museum, Vienna, Austria.
SUTT	coll. R. Sutter, Bitterfeld, Germany.
TLMF	Tiroler Landesmuseum Ferdinandeum, Innsbruck, Austria.
ZMKU	Zoological Museum, Kiev, Ukraine.
ZMUC	Zoologisk Museum, University of Copenhagen, Denmark.
ZSM	Zoologische Staatssammlung, Munich, Germany.

## Systematic part

In order to facilitate comparison with the taxa dealt with by Huemer & Karsholt (1999) the same layout is used for both descriptions and illustrations as in that book. Unfortunately, text-figures 19–24 in Huemer & Karsholt (1999), depicting the last abdominal segments of males, have been published incorrectly after the proof-reading stage. Text-figs. 19–21 should be corrected to 22–24. The last three were produced twice (see also text-figs. 25–27), whereas text-figs. 19–21 were omitted by the printers.

### *Recurvaria costimaculella* sp. n.

(Figs. 1, 9–10)

*Material examined.* Holotype ♂, Italy, 'Sicilia, Mistretta Mercuore, 700 m, 21.–30.VI 1952 J. Klimesch' (ZSM). Paratypes: 1 ♂, same data as holotype (ZSM); 2 ♂, ditto, but 1.–6.vii.1952 (GEL 888 P. Huemer) (TLMF; ZSM).

*Diagnosis.* – Adult (Fig. 1). Wingspan 12–13 mm. Segment 2 of labial palp black (cream whitish on inner surface) with white tip; segment 3 white with black ring before middle. Antenna shortly ciliate, black, indistinctly ringed with lighter brown. Head whitish grey in middle, blackish brown at lateral margins; thorax and tegula concolorous with forewing. Forewing elongate, light grey, mottled with grey-brown; prominent black mark running from base of costa along fold to 2/5; another prominent black patch at costa before middle, with small black spot at lower margin; tornal and costal spots brownish black, indistinct, with a vertical, black streak between them; termen with scattered black scales; fringes grey. Hindwing light brownish grey, with light grey fringes. *Similar species.* – The prominent black mark on the light grey forewing is unique among European Gelechiidae. The forewing markings of the related *R. thomeriella* (Chrétien 1901) are somewhat similar, but on a much darker background. *R. toxicodendri* Kuznetsov, 1979, from Far East Russia slightly resembles *R. costimaculella* in wing markings, but the genitalia are clearly different, and the two species may not even be congeneric. *Male genitalia* (Figs. 9–10). – Sternite VIII with two broad lateral lobes, deeply emarginate medially; tergite VIII very small; uncus long and moderately narrow; tegumen strongly widened anteriorly; valva very long and slender, extended distally to about tip of uncus; posterior margin of vinculum with pair of moderately short digitate processes, anteriolateral margin with long rod-like projection; aedeagus very short, fused with vinculum near posterior margin.

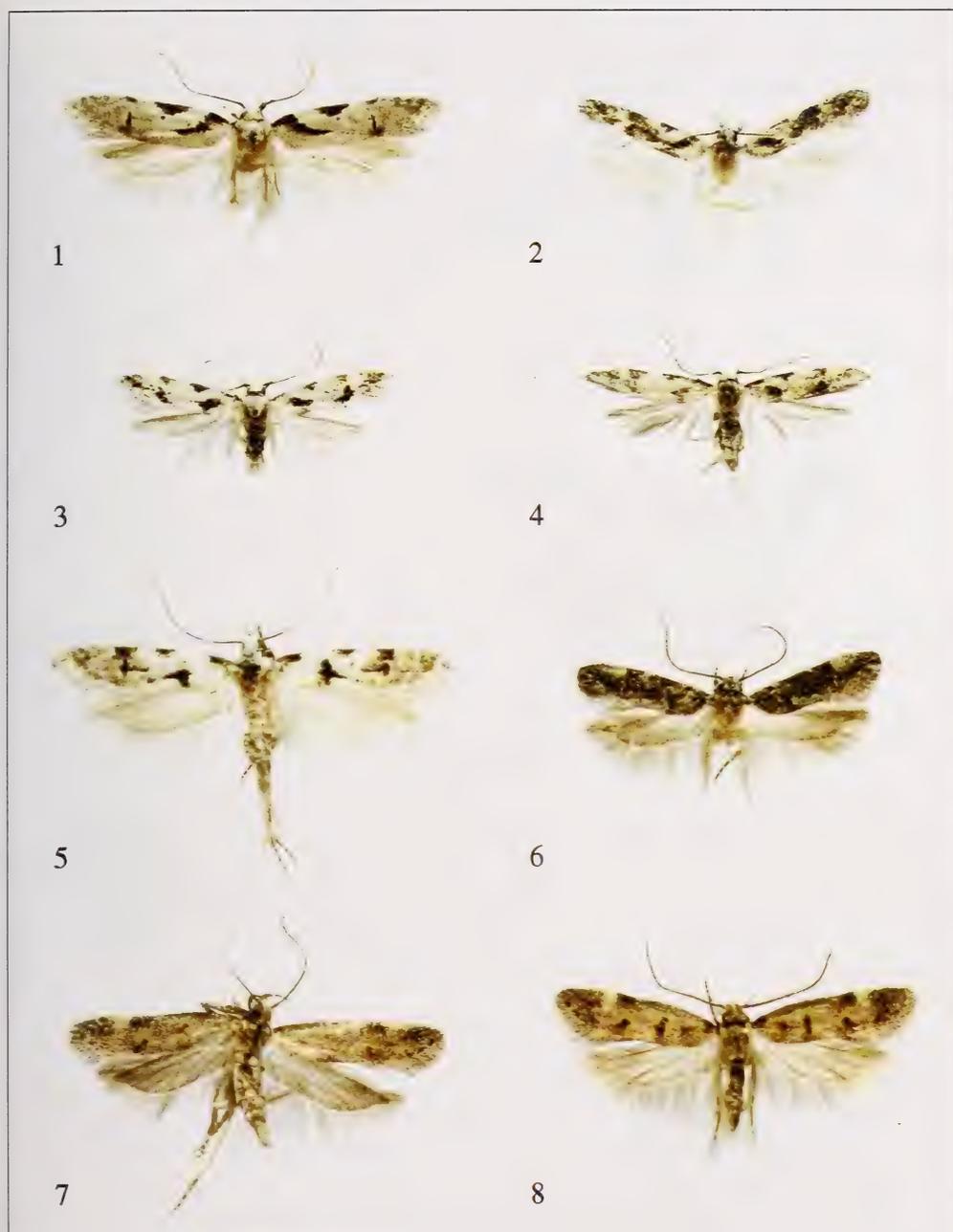
*Female.* – Unknown.

*Distribution.* – Only known from Sicily.

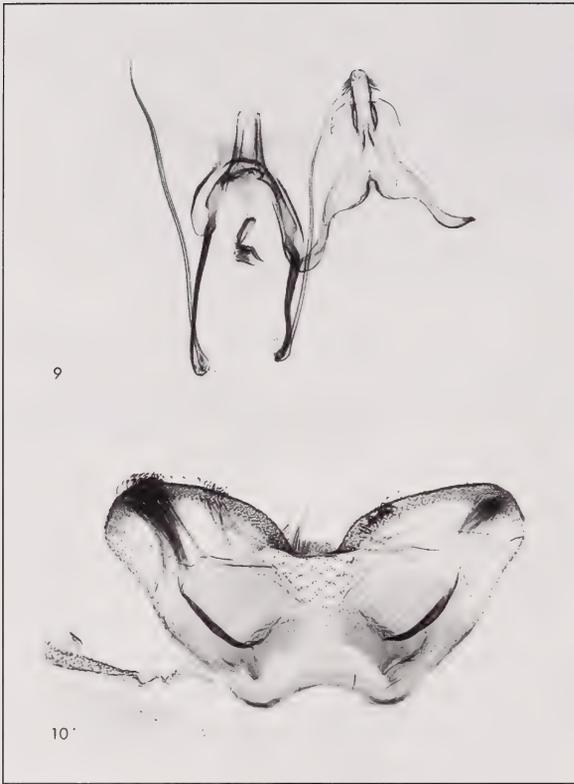
*Biology.* – Host-plant and early stages unknown. The type-series was collected from late June to early July.

*Etymology.* – Named after the peculiar costal marking of the forewing.

*Remarks.* – *Recurvaria costimaculella* sp. n. is clearly related to *R. thomeriella* (Chrétien). This is evident from the similarity of the peculiar shaped male abdominal sternite VIII, the strongly projected vinculum and the valvae. However, the two species differ in the strongly different shape of the tegumen and uncus. In the absence of a generic revision both species are only tentatively assigned to *Recurvaria*.



- Fig. 1. *Recurvaria costumaculella* sp. n., male, Italy, Sicily. 12 mm.  
 Fig. 2. *Schneidereria pistaciella* Weber, male, Ukraine, Crimea. 9.5 mm.  
 Figs 3-4. *Teleiodes albiluculella* sp. n., males, Greece, Crete. 10 mm.  
 Fig. 5. *Altenia mersinella* (Staudinger), female, Syria. 13 mm.  
 Fig. 6. *Teleiodes traugotti* sp. n., male, Spain, Andalusia. 10 mm.  
 Fig. 7. *Mirificarma minimella* sp. n., female, Greece, Pelopónnisos. 12 mm.  
 Fig. 8. *Mirificarma* sp. (cf. *minimella*) Male, Greece, Rhodos. 12 mm.



**Figs. 9–10.** *Recurvaria costimaculella* sp. n., male genitalia/abdominal segment VIII. – **Fig. 9.** paratype, Italy, GEL 888 (genitalia) (TLMF). – **Fig. 10.** ditto (segment VIII).

***Schneidereria pistaciella* Weber, 1957: 68**

(Figs. 2, 11–12, 26–27)

Material examined. – Ukraine, 2 ♂, 1 ♀, Crimea, Karadagh, 11.viii.1987, leg. Yu. Budashkin (GU 98/807 P.O. Huemer); 3 ♂, 1 ♀, ditto, but 5.–8.viii.1996, leg. A. Bidzilya (gen. slide 1836 H. Hendriksen, GU 99/868 P. Huemer) (ZMKU, ZMUC). Greece, 1 ♂, Lakonia, 7 km sw Monemvasia, 8.viii.1980, leg. Christensen (GU 00/907 P. Huemer) (ZMUC); 1 ♂ Chios, Limnia, 15 m, 29.viii.1996; 1 ♂, 1 ♀, ditto, but 19. & 25.ix.2000, leg. Sutter (GU 5055, 6384, 6385 R. Sutter) (SUTT).

**Diagnosis.** – Adult (Fig. 2). Wingspan 9–10 mm. Segment 2 of labial palp black mottled with light grey on outer and lower surface, cream whitish on inner and upper surface; segment 3 white, with black rings at base, at middle and near apex. Antenna shortly ciliate in male, black, indistinctly lighter ringed. Head, thorax and tegula whitish grey mottled with black. Forewing elongate, blackish mottled with whitish scales; two somewhat indistinct whitish, outwards oblique bands near base; an indistinct, blackish transverse fascia near base and one such at three-quarters; in middle of wing a few black spots and some orange scales; fringes grey with many black and whitish scales. Hindwing slender, light grey with concolorous fringes.

**Similar species.** – The small size, the slender wings and the lack of raised scales on the forewings separates *pistaciella* from other European Teleiodini.

**Male genitalia** (Figs. 11–12). – Sternite VIII broad, sub-rectangular, only weakly emarginated distomedially; tergite VIII long, tongue-shaped with pair of long coremata laterobasally; uncus sub-oval, apically rounded; gnathos large, tongue-shaped; tegumen

deeply emarginate anteriorly with widening and very broad lateral parts; valva long, weakly bulbous at base, strongly curved; vinculum strongly reduced; juxta extended posteriorly with pair of distinct processes; aedeagus short, curved, broad at base, distally pointed (lateral view).

**Female genitalia** (Figs. 26–27). – Apophyses anteriores very long; segment VIII simple, without distinct modifications, rather short; ductus bursae short, membranous; corpus bursae well developed, signum large, sub-rhombic.

**Distribution**. – Eastern Mediterranean area (Ukraine, Greece, Cyprus, Syria); possibly also in Iraq and Iran (Sattler 1982).

**Biology**. – The larva has been reported as a pest of *Pistacia vera* L. (Anacardiaceae). It bores into the half-ripe nuts and destroys the kernel (Weber 1957). Pupation takes place after hibernation and moths have been recorded in a single generation from June to early August, whereas the closely related *S. pistaciicola* (Danilevsky 1955) occurs in two to three generations (Sattler 1982).

**Remarks**. – The genus *Schneidereria* shows a close relationship to *Teleiodes*, differing primarily in a few characters of the vinculum/juxta. In the absence of a generic revision it is here retained as a separate genus.

### ***Teleiodes italica* Huemer, 1992: 8**

(Figs. 13–18)

*Teleiodes gallica* Huemer, 1992, figs. 6, 23–26, 33–34. **Syn. n.**

**Diagnosis**. – Adult. See Huemer & Karsholt (1999: 57).

**Male genitalia**. – See Huemer & Karsholt (1999) and Figs. 13–18.

**Female genitalia**. – See Huemer & Karsholt (1999).

**Distribution**. – Widely distributed in the western Mediterranean area, from southern Switzerland and Italy through France and Spain.

**Biology**. – The larva seems to be restricted to various trees and shrubs in the family Rosaceae such as *Crataegus*, *Cydonia* and *Sorbus aucuparia*. Adults occur from late May to late July and are attracted to light.

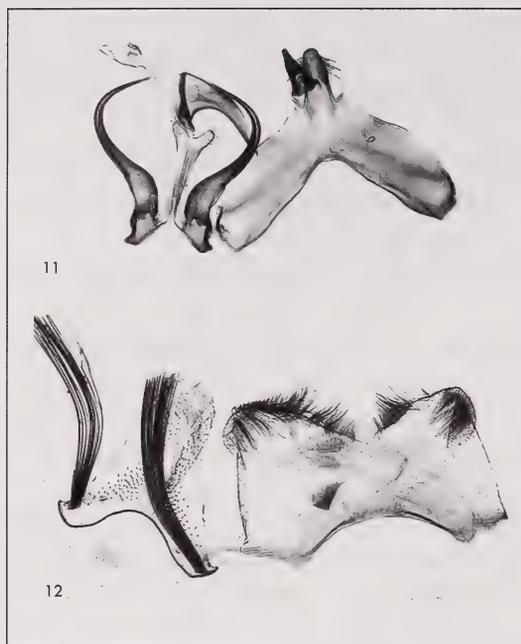
**Remarks**. – The differential diagnosis of *Teleiodes italica* and *T. gallica* was based on alleged differences in the shape of the valva (see Huemer 1992; Huemer & Karsholt 1999). However, an examination of more extensive material from various parts of the Mediterranean area has shown a considerable degree of individual variation with intermediate characters and also a tendency to geographically correlated character complexes (Figs. 13–18). We therefore consider *T. gallica* as a new subjective synonym of *T. italica*.

### ***Teleiodes albiluculella* sp. n.**

(Figs. 3-4, 19-22)

**Material examined**. – Holotype, ♂, Greece, 'GR, Crete W. Omalos, 1200 m. 25.–30.VI.2000 leg. M. Fibiger, P. Svendsen, D. Nilsson, A. Madsen' (ZMUC). Paratypes: 4 ♂, 7 ♀, same data as holotype (genitalia slides H. Hendriksen 2669, 2744; 91/961, 91/963 P. Huemer, GEL 968 P. Huemer)(TLMF, ZMUC); 1 ♂, Crete, Kallergi; Mts., 1450–1550m, 28.–30. vii. 2001, leg. M. Fibiger, A. Madsen, D. Nielsson, P. Svendsson (ZMUC)

**Diagnosis**. – Adult (Figs. 3–4). Wingspan 9–11 mm. Labial palp slender, white; segment 2 mottled with black, especially on outer surface; segment 3 with 2–3 black



rings. Antenna ringed with black and brown. Head cream; thorax white with a few darker scales; tegula white with blackish base. Forewing slender, white, mottled with yellowish and black (especially in apical part), and with distinct black markings: on costa at base, one third and two thirds (costal spot); a distinct, oblique black spot near base in middle of the wing, often reaching dorsum; tornal spot prominent, having width of two thirds of the wing; fringes dark grey. Hindwing dark grey, darkest towards apex.

**Figs. 11–12.** *Schneidereria pistaciella* Weber, male genitalia/abdominal segment VIII. – **Fig. 11.** Ukraine, GU 99/868 P. Huemer (genitalia) (ZMKU). – **Fig. 12.** ditto (segment VIII).

**Variation.** – Some specimens have blackish scales scattered all over the forewing. Occasionally the costal and tornal spots are confluent.

**Similar species.** – *T. albiluculella* **sp. n.** resembles *T. albidorsella* Huemer & Karsholt, 1999, but is even lighter. In *T. albidorsella* the labial palps are black, and it often has an indistinct orange spot in the middle of the forewings. It is also similar to *Altenia mersinella* (Staudinger) (Fig. 5), which is on average larger (11–13 mm), with more white labial palps (especially segment 2) and the forewings mottled with light brown (instead of black) scales. In *A. mersinella* the tornal spot is rather indistinct, but in contrast to *T. albiluculella* **sp. n.** it has a black longitudinal spot that ends between the costal and tornal spots.

**Male genitalia** (Fig. 19). – Sternite VIII broad, trapezoid; tergite VIII long, broadly tongue-shaped with pair of long coremata laterobasally; uncus sub-rectangular with strongly sclerotized apical tooth; gnathos with short, pointed medial process; tegumen slender, strongly projected anteriorly with extremely deep emargination; valva long, almost sickle-shaped, curved, without bulbous base; vinculum strongly reduced; processes of juxta digitate; aedeagus short, slender, more or less fused with ventral wall of tegumen.

**Female genitalia** (Figs. 20–22). – Apophyses posteriores about 3.5 times length of segment VIII; segment VIII simple, without distinct modification, strongly fused with segment VII; apophyses anteriores shorter than segment VIII, bent; ostium bursae/antrum extended caudally, separating a strongly sclerotized tube, which extends beyond the entire length of segment VIII; distal part of tube with flap-like dorsal sclerite, medial part with transverse ribbon-like sclerotizations; base of tube fused with anterior margin of segment VIII; ductus bursae membranous, long; corpus bursae well separated with tiny accessory bursa; signum with pair of serrate-edged lobes.

**Distribution.** – Greece (Crete).

**Biology.** – Host-plant and early stages unknown. The adults have been collected at light in late June in a mountain area.

**Etymology.** – The species name refers to the moderately close relationship with *T. luculella*.

**Remarks.** – *T. albiluculella* **sp. n.** is easily recognized by the male and female genitalia which show some unique characters. At first glance *T. albiluculella* **sp. n.** resembles *Teleia mersinella* Staudinger, 1879. However, the male genitalia of the latter are very different (Fig. 24) and show that *mersinella* belongs in the genus *Altenia* Sattler, 1960 (as *Altenia mersinella* (Staudinger, 1879) **comb. n.**). This species has not been recorded from Europe, but as it is known from adjacent parts of the eastern Mediterranean area (Cyprus, Lebanon, Syria, Turkey), it may also occur in south-eastern Europe. We therefore figure *mersinella* and its genitalia (Figs. 24–25). *A. mersinella* is related to *A. elsneriella* Huemer & Karsholt, 1999, in genitalia characters, with some differences in the shape of the female ostium bursae.

***Teleiodes traugotti* sp. n.**

(Figs. 6, 23, 28)

**Material examined.** – Holotype ♂, Spain, 'Hispania, Andalucia, Sierra de Marbella, El Mirador, 700 m, 10.7.1982, E. Traugott-Olsen' 'GU 99/875 P. Huemer' (ZMUC). Paratypes: 1 ♂, same data as holotype, but 19.viii.1977 (gen. slide 5317 Traugott-Olsen); 1 ♂, 2 ♀, ditto, but 14.vii.1980 (gen. slide 5551 Traugott-Olsen; GU 00/906 P. Huemer); 1 ♂, ditto, but 21.vii.1982 (Gen. prep. Nr. 4985 O. Karsholt) (TLMF, ZMUC).

**Diagnosis.** – Adult (Fig. 6). Wingspan 10 mm. Labial palp blackish with two lighter rings at segment 2 and 3, respectively. Antenna in male slightly serrate and ciliate, black, ringed with grey, in female simple, black, ringed with light grey. Head light grey mottled with black; thorax and tegula concolorous with forewing. Forewing fuscous, mottled with light grey, ochreous and black scales; a blackish, indistinct, angulated band near base; two black patches at costa at one third and two thirds; two black spots surrounded with ochreous scales in middle of wing; three groups of short, raised, ochreous scales in middle of the wing at one, two and three-quarters; a thin, but distinct, black line running from middle of wing into apex; a more distinct such line running along the fold; fringes concolorous with forewing. Hindwing dark grey, lighter towards base, with grey fringes.

**Similar species.** – Very similar to *T. huemeri* Nel, 1998, which is distinctly larger and has broader forewings. Also similar to *T. cisti* (Stainton, 1869), which has more prominent raised scales in the forewings, and to *T. sequax* (Haworth, 1828), which can be recognized by its more brownish forewings.

**Male genitalia** (Fig. 23). – Sternite VIII broadly sub-rectangular; tergite VII tongue-shaped; uncus long, slender, evenly tapered, apex truncate; gnathos about width and length of uncus; tegumen with narrow sinus-shaped emargination anteromedially; pedunculi distinct moderately narrow sclerites; valva evenly curved ventrad, with sharp point; processes of juxta of intermediate length (compared with *T. sequax* and *T. huemeri*); aedeagus curved ventrad, slender.

Female genitalia (Fig. 28). – Apophyses anteriores about three times length of segment VIII; segment VIII with weakly sclerotized laterodorsal parts, medially membranous; ostium bursae near anterior margin of segment VIII with sclerotized band dorsal of antrum; antrum indistinct, funnel-shaped; ductus bursae short, not extending beyond apophyses anteriores; corpus bursae very small; signum reduced.

Distribution. – Only known from Spain (Andalusia).

Biology. – Host-plant and early stages unknown. The few adults known to date have been collected in July and August.

Etymology. – The species is named after its collector, Mr. Ernst Traugott-Olsen (Marbella, Spain).

Remarks. – *T. traugotti* sp. n. is most closely related to *T. huemeri* and *T. sequax*. However, the peculiar ostium/antrum and the reduced signum are characteristic for the new species. It differs from *T. huemeri* in the slightly shorter and more narrow processes of the juxta in the male genitalia and the absence of a ribbon-like sclerotization of the female sternite VIII. *T. sequax* is immediately recognized by the dorsolateral humps of the male tegumen and the ostial sclerotization in the female.

### *Mirificarma minimella* sp. n.

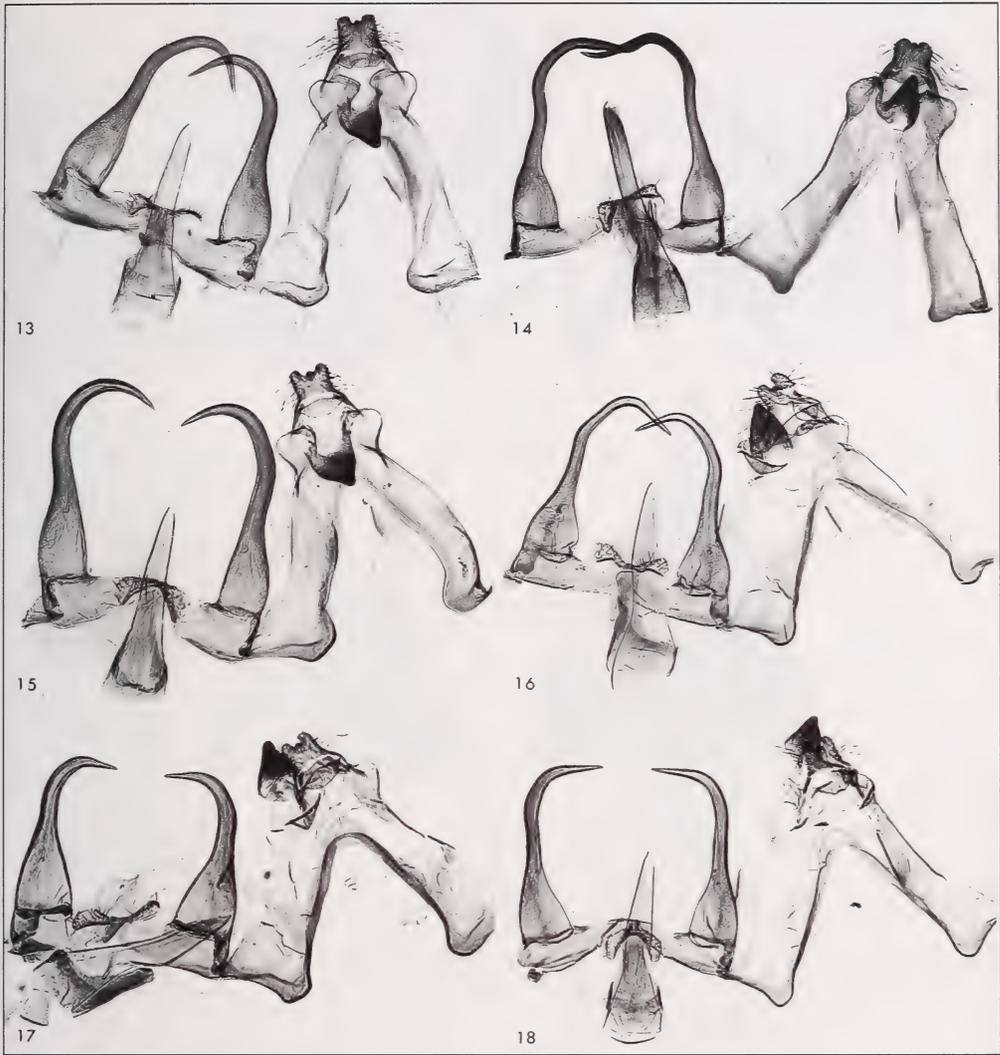
(Figs. 7, 29, 33)

Material examined. – Holotype ♀, 'Hellas, Lakonia, 7 km sw Monemvasia, 13.v.1980, leg. G. Christensen' 'ZOOLOG. MUSEUM, DK COPENHAGEN' 'L.M.P. genitalia slide female No. 16' '*Mirificarma rhodoptera* (Mann) (small form) det. L. M. Pitkin, 1982' '*Mirificarma ?rhodoptera* Mann, det. O. Karsholt'. Paratypes: 1 ♂, 1 ♀, same data as holotype, but 5 km s. Monemvasia, 18.v.1978; 2 ♀, ditto, but 5 km s. Monemvasia, 22.v.1978 (gen. slide No. 2 L.M.P. 1982; Gen. prep. Nr. 4985 O. Karsholt); 1 ♀, ditto, 16.v.1980 (gen. slide No. 7 L.M.P.); 1 ♂, ditto, 18.v.1978 (GU 00/893 P. Huemer); 1 ♀, ditto, 2.vi.1983; 1 ♂, ditto, 16.v.1987; 1 ♂, ditto 15.–17.vi.1982, leg. Skule & Langemark (gen. slide H. Hendriksen 1814) (all ZMUC); 1 ♀, ditto, but 18.v.1978, leg. G. Christensen (BM Genitalia slide No. 22480) (BMNH); 1 ♂, ditto, but 16.v.1980 (BM Genitalia slide No. 22479) (BMNH); 1 ♀, ditto, but Monemvasia, 9.v.1979, leg. Gozmány & Christensen (BM Genitalia slide No. 24491) (BMNH); 1 ♂, Hellas, Lakonia, Mt. Taygetos, 1000 m, 11.vi.1978, leg. Christensen (gen. slide No. 5 L.M.P.) (ZMUC); 2 ♀, Pelopónnisos, Yithion, 14.v.1990, leg. O. Karsholt, Zool. Mus. Copenh. Exp. (ZMUC).

Additional material: 1 ♀, Crete, Iraklion distr., Zaros, 5.–6.vi.1988, leg. R. Johansson (ZMUC); 1 ♀, Crete, Lassithi distr., Kapsa gorge, 15.v.1993, leg. Johansson (ZMUC); 1 ♀, Crete, Lassithi distr., Makrigialos, 15.v.1993, leg. Johansson (ZMUC); 2 ♂, Crete, Agia Pelagia, 20.–26.iv.1995, leg. Fibiger (GU 00/952 and GU 00/958 P. Huemer) (ZMUC); 1 ♀, Crete, Ag. Galini, 20 m, 24.v.1994, leg. Sutter (GU 6115 R. Sutter) (SUTT); 1 ♂, 1 ♀, Crete, south-east, Makrigialos, Aspros Potamos, 20 m, 22. & 25.v.1998, leg. Sutter (GU 6254, 6255 R. Sutter) (SUTT); 1 ♂, Rhodos, Faliraki, 4.v.1991, leg. Klimesch; 3 ♂, ditto, 5.v.1991 (GU 00/953 and GU 00/955 P. Huemer); 1 ♀, ditto, 8.v.1985 (gen. slide H. Hendriksen 2579); 1 ♀, ditto, 11.v.1991; 1 ♀, ditto, 12.v.1991 (GU 00/956 P. Huemer) (all ZSM).

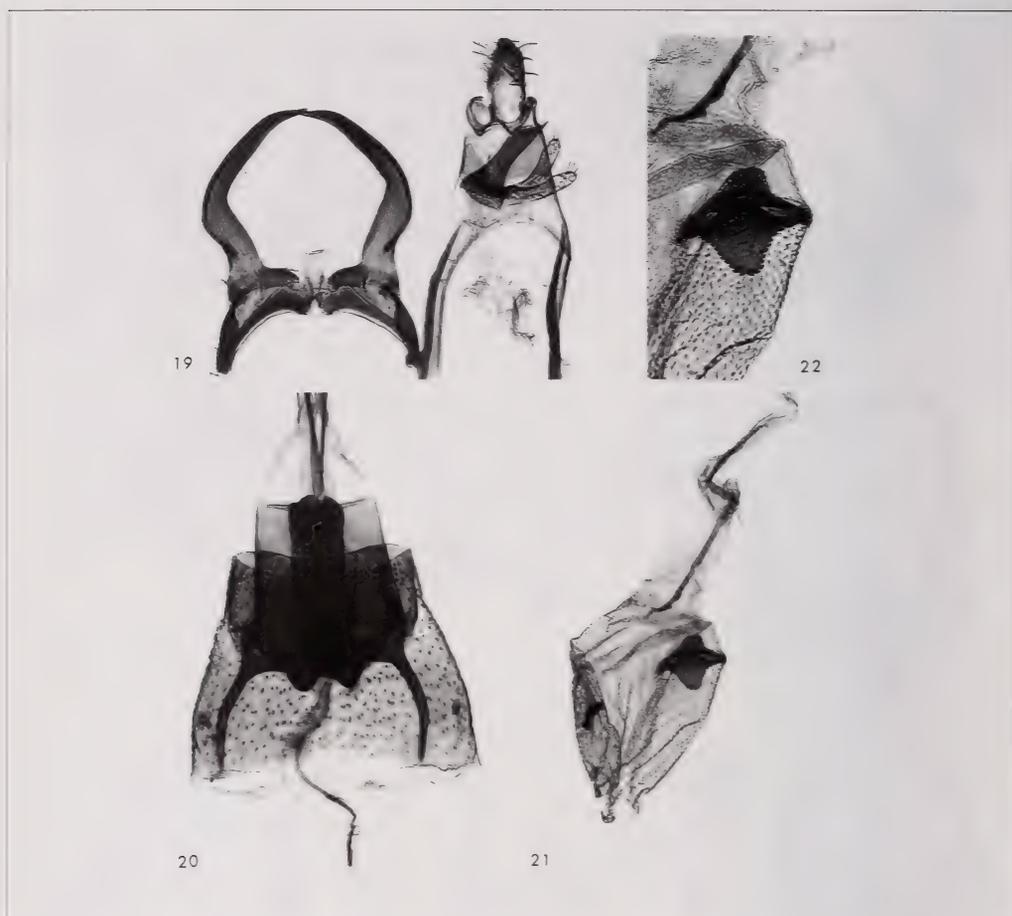
Diagnosis. – Adult (Fig 7). Wingspan 12–13 mm. Labial palp cream, mottled with dark brown, especially on outer surface of segment 2 and on segment 3. Antenna blackish brown, ringed with light brown. Head light brown; thorax and tegula concolorous with forewing. Forewing covered with light brown scales with blackish brown tips; black spots at one third and two thirds surrounded by orange-yellowish; costal and tornal spots yellowish orange, often fused in an angulated fascia; apical area with many blackish scales; cilia greyish, with black cilia line. Hindwing dark grey, with greyish fringes.

Variation. – Specimens from the type locality may have the forewing more or less covered with black scales, and they vary slightly in the distinctness of the black markings. In specimens from Rhodos (Fig. 8) the black spots in the forewings are more



**Figs. 13–18.** *Teleiodes italica* Huemer, male genitalia. – **Fig. 13.** Italy, GEL 267 (*T. italica* holotype) (TLMF). – **Fig. 14.** France, GEL 259 (*T. gallica* holotype) (TLMF). – **Fig. 15.** Italy, GU 91/287 P.Huemer (*T. italica* paratype) (ZMUC). – **Fig. 16.** Spain, 2043 Hendriksen (ZMUC). – **Fig. 17.** Italy, 904 Hendriksen (ZMUC). – **Fig. 18.** Spain, 2040 Hendriksen (ZMUC).

distinct, with the one at one third often forming a transverse streak from the dorsum almost to the costa. From Crete we have examined specimens which are similar to those from the type locality, others which resemble those from Rhodos, and some intermediate forms. However, the specific identity of those insular populations is uncertain (see below). Similar species. – *M. rhodoptera* (Mann) is larger (wingspan 13–16 mm), with more black on the labial palps and the forewings, and with the black, orange-yellowish surrounded black spot in the forewing at one third extending from the dorsum almost to the costa. The strongly marked form occurring in Rhodos and Crete is externally very similar to *rhodoptera*, but is smaller and has genitalia similar to those of *minimella*.



**Figs. 19–22.** *Teleiodes albiluculella* sp. n., paratypes, Greece (Crete). – **Fig. 19.** Male genitalia GEL 968 P. Huemer. – **Figs. 20–22.** Female genitalia GU 01/963 P. Huemer.

**Male genitalia** (Fig. 29). – Uncus trapezoidal; gnathos hook strong; valva long, extending to about middle of uncus; sacculus rather narrow, short; saccus short, slightly pronounced; aedeagus short, weakly swollen at base, with short apical projection.

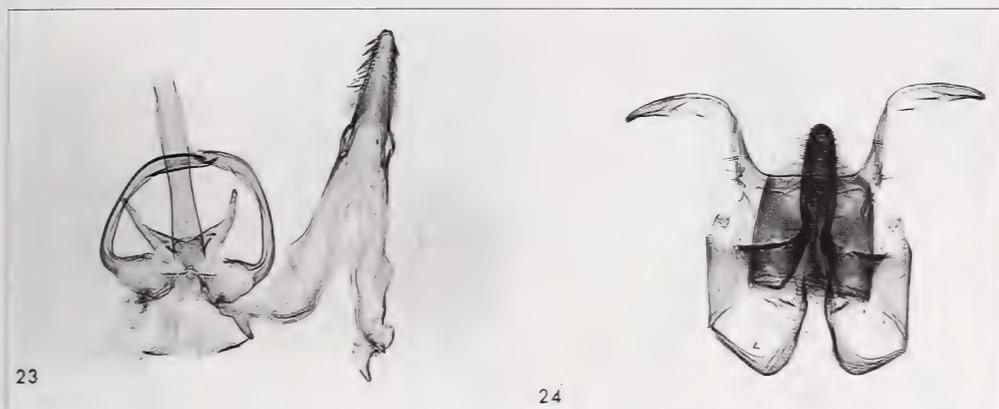
**Female genitalia** (Fig. 33). – Apophyses anteriores short; apophyses posteriores about twice length of anteriores; antrum funnel-shaped, narrow, tapered, almost extending to tip of apophysis anterioris; ductus and corpus bursae well separated; signum small, sub-oval, spiny.

**Distribution.** – Greece (Lakonia).

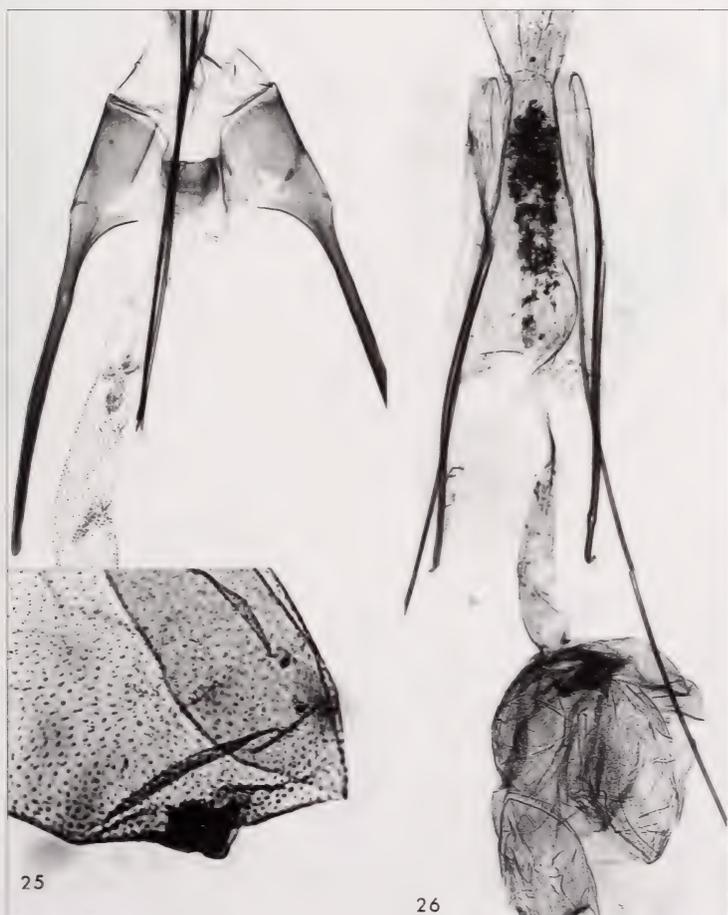
**Biology.** – Host-plant and early stages unknown. The adults have been collected from mid-May to mid-June.

**Etymology.** – The species name refers to the small size of the new species compared with *M. rhodoptera*.

**Remarks.** – *M. minimella* sp. n. is very similar to *M. rhodoptera* (Mann, 1866) in male genitalia (Fig. 30). Minor differences are found in the slightly longer valva, more



Figs. 23–24. Male genitalia. – Fig. 23. *Teleiodes traugotti* sp. n., paratype, 4985 O.Karsholt (ZMUC). – Fig. 24. *Altenia mersinella* (Staudinger), Turkey, GEL 961 P. Huemer (TLMF).



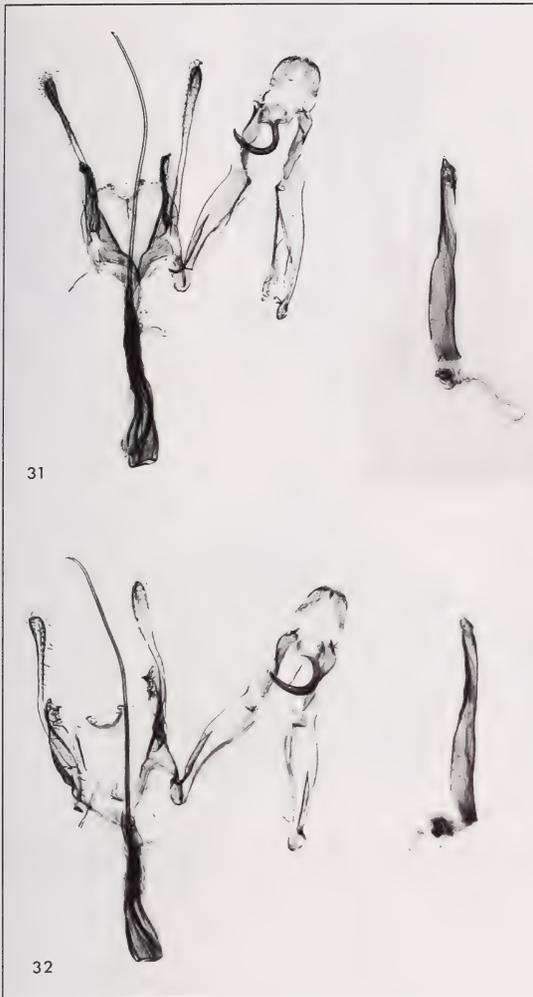
Figs. 25–26. Female genitalia. – Fig. 25. *Altenia mersinella* (Staudinger) (signum enlarged). Cyprus. (GEL 962 P. Huemer) (TLMF). – Fig. 26. *Schneidereria pistaciella* Weber. Ukraine. 1836 Hendriksen (ZMKU).



**Figs. 27–28.** Female genitalia. – **Fig. 27.** *Schneidereria pistaciella* Weber (signum in left upper corner), Greece (Chiros), GU 6385 Sutter (SUTT). – **Fig. 28.** *Teleiodes traugotti* sp. n., holotype, GU 99/875 P. Huemer (ZMUC).



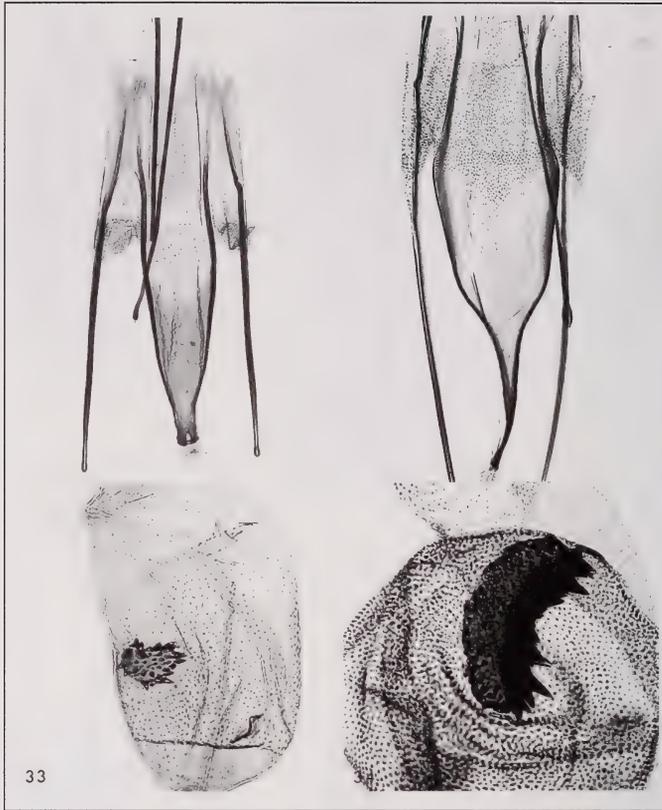
**Figs. 29–30.** *Mirificarma* spp., male genitalia. – **Fig. 29.** *M. minimella* sp. n., paratype, Greece, GU 00/893 P. Huemer (ZMUC). – **Fig. 30.** *M. rhodoptera* (Mann), Greece, GU 99/871 P. Huemer (ZSM).



**Figs. 31–32.** *Mirificarma* sp. (cf. *minimella* sp. n.), male genitalia. – **Fig. 31.** Greece (Rhodos), GU 00/953 P. Huemer (ZSM). – **Fig. 32.** Greece (Crete), GU 00/952 P. Huemer (ZMUC).

pronounced saccus and narrower sacculus of the former. Such comparatively small differences in character states are of specific value in several other groups of Gelechiidae. Furthermore, the female genitalia are clearly differing in the evenly tapered antrum (strongly constricted in *M. rhodoptera*), the shape of the corpus bursae and the small sub-oval signum (large, kidney-shaped in *M. rhodoptera*) (Fig. 34).

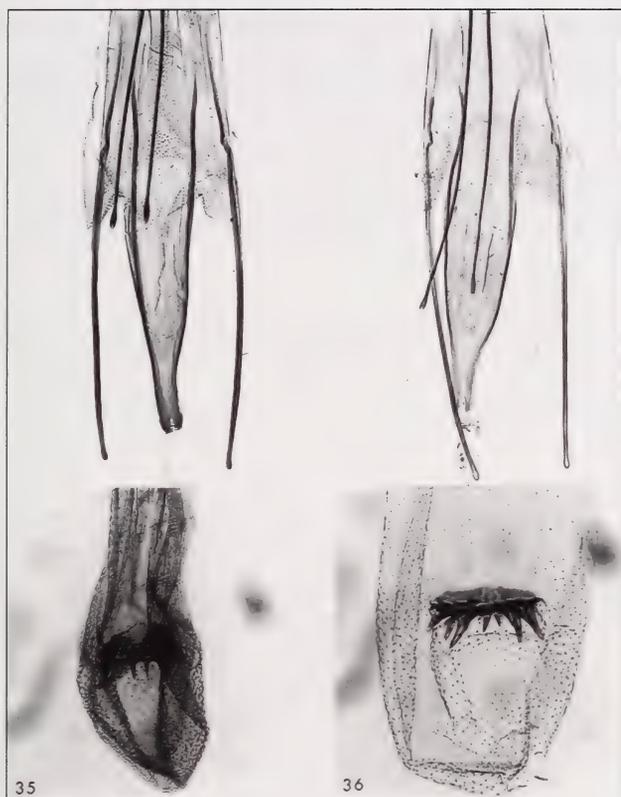
*M. minimella* sp. n. was considered as a small local form of *M. rhodoptera* (Pitkin, 1984: 21). However, genitalia differences in characters of high diagnostic value within the genus point to the existence of two species. This interpretation is also supported by the sympatric occurrence of *M. rhodoptera* and *M. minimella* sp. n. at Monemvasia. Specimens from Rhodos and Crete are very similar to *M. minimella* sp. n. and may represent insular populations of the latter. The male genitalia (Figs. 31–32) are practically indistinguishable from those of *M. minimella* sp. n. However, small differences in the shape of the female signum (Figs. 35–36), which is larger with much longer spines than in specimens from Lakonia, leave some doubts about the identity.



**Figs. 33–34.** *Mirificarma* spp., female genitalia (signa two times enlarged). – **Fig. 33.** *M. minimella* sp. n., holotype, Greece, LMP 16 (ZMUC). – **Fig. 34.** *M. rhodoptera* (Mann), Greece, GU 99/872 P. Huemer (ZSM).

## Conclusions

Gelechiidae are one of the most diverse families of Lepidoptera within the European fauna, including more than 650 species. However, due to the lack of comprehensive identification literature this group was hitherto grossly neglected by lepidopterists. In Teleiodini and Gelechiini, for example, several genera were for the first time reviewed very recently (Huemer & Karsholt 1999) and other tribes will be treated only within the next 10 years when we plan to finish further 3 volumes for ‘Microlepidoptera of Europe’. Therefore the discovery of new species both for the European fauna and for science does not come as a real surprise. Particularly in the Mediterranean area the species inventory is still incomplete and we already know a number of additional taxa mainly from the south-eastern part. Most of them will be described by other specialists in the nearer future. On the contrary only few additional species can be expected in central and northern Europe, an area with a long tradition in lepidopterology. However, strong efforts will be necessary to improve the limited knowledge about biology and distribution of many species even in this part of the continent.



**Figs. 35–36.** *Mirificarma* sp. (cf. *minimella* sp. n.), female genitalia. – **Fig. 35.** Greece (Rhodos), GU 00/956 P. Huemer (ZSM). – **Fig. 36.** Greece (Crete), GU 00/957 P. Huemer (ZMUC).

### Acknowledgements

For the loan and/or donation of material we are most grateful to E. Arenberger (Vienna), Dr. A. Bidzilya (Kiev), Dr. M. Lödl and Dr. S. Gaal (Vienna) and Dr. A. Segerer (Munich), as well as to the Danish lepidopterists M. Fibiger, A. Madsen, D. Nilsson and P. Svendsen. Furthermore we gratefully acknowledge various information and support by R. Sutter (Bitterfeld) and H. Hendriksen (Copenhagen). Dr. K. Sattler (London) kindly commented upon the manuscript. We moreover thank G. Brovad (ZMUC, Copenhagen) for preparing the plate with colour photographs, and R. Sutter for providing the photograph used in Fig. 27. The remaining photographs of genitalia were taken by the first author.

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## Everted vesicae of the *Timandra griseata* group: methodology and differential features (Geometridae, Sterrhinae)

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**Summary.** The internal male genitalia of *Timandra griseata* Petersen, 1902, *T. comai* Schmidt, 1931 and *T. reompta* (Prout, 1930) are illustrated for the first time with the vesica being everted. The vesicae have loosely species-specific, somewhat variable characters that can be interpreted to have anatomical correspondences with the junction of the female corpus bursae and appendix bursae of the bursa copulatrix. Full eversion of these membranous structures is difficult and their interpretation for identification purposes should be performed cautiously. The vesica eversion technique using the lumen of an injection needle is described.

**Zusammenfassung.** Die inneren männlichen Genitalstrukturen von *Timandra griseata* Petersen, 1902, *T. comai* Schmidt, 1931 und *T. reompta* (Prout, 1930) werden erstmalig mit ausgestülpter Vesica abgebildet. Die Vesicae zeigen schwach artspezifische, aber etwas variable Ausprägung, die eine anatomische Korrespondenz zum Übergang des Corpus bursae in den Appendix bursae im weiblichen Genital aufweisen. Die vollständige Ausstülpung der membranösen Strukturen ist schwierig, die Interpretation im Zuge von Artidentifikationen sollte mit Vorsicht erfolgen. Die Technik der Vesicaausstülpung mittels einer Injektionsnadel wird beschrieben.

**Resumé.** L'armure génitale mâle interne de *Timandra griseata* Petersen, 1902, *T. comai* Schmidt, 1931 et de *T. reompta* (Prout, 1930) est illustrée pour la première fois avec les vesicae évaginées. Les vesicae offrent des caractères quelque peu variables et ainsi faiblement diagnostiques au niveau spécifique, pouvant être interprétés comme étant sujets à une correspondance anatomique avec la jonction de la corpus bursae et de l'appendix bursae de la bursa copulatrix chez la femelle. L'évagination complète de ces structures membraneuses est difficile et leur interprétation à des fins d'identification doit être effectuée avec circonspection. La technique d'évagination de la vesica au moyen d'une épingle à seringue est décrite.

**Key words.** Geometridae, *Timandra*, vesica, methodology.

### Introduction

Although the method of vesica eversion has been available for over half a century (Hardwick 1950; redefined and illustrated in Lafontaine & Mikkola 1987), these structures are still rarely illustrated in taxonomical works on Lepidoptera, except for the Noctuidae where this technique has become routine (e.g. Fibiger 1997). The structures of the vesica can enable understanding of mating mechanisms (Callahan & Chapin 1960) and may allow better resolution of particular species-level problems (e.g. Kerppola & Mikkola 1987; Lafontaine *et al.* 1987; Fibiger 1990). Thus far, smaller moths such as geometrids have largely been left unnoticed with regard to the eversion technique (but see e.g. Holloway 1993; Troubridge 1997). Recently Dang (1993) introduced two methods to study these structures in smaller species such as Tortricidae and Nepticulidae.

The *Timandra griseata* group has been revised (Kaila & Albrecht 1994) to include three species: *T. griseata* Petersen, 1902, *T. comai* Schmidt, 1931 and *T. reompta* (Prout, 1930). These species are similar in external appearance, though identifiable. The interspecific differences in both male and female external genitalia are small. This

is the case especially for the male genitalia of *T. griseata* and *T. comai*. Earlier attempts to evert the male vesicae have been unsuccessful and it has therefore been unclear whether they could provide diagnostic features.

Here I will present that in the *Timandra griseata* group the everted male vesicae are loosely species-specific, i.e. with small intraspecific variation, and that they can be useful aids to species identification if carefully used. The male vesicae are shown to have species-specific structures that anatomically correspond with the female genitalia. In addition, I describe a modification of the vesica eversion technique that I have used successfully in many geometrid species.

### Material and method of vesica eversion

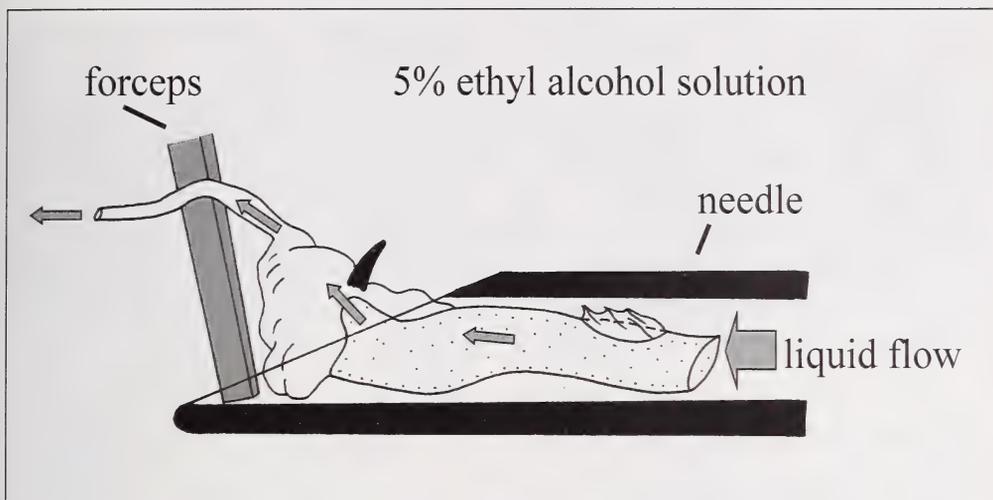
Material examined. – *Timandra griseata*: Finland, Ta: Orivesi, [no date] ♂ (PS594); Al: Lemland, 16.7.1951 ♀; N: Helsinki, 16.7.1958 1♂ (PS596); Ka: Virolahti, 20.–26.8.1990 2♂ (PS597, PS609); Om: Ylivieska, 15.7.1971 ♂ (PS598); Oa: Korsnäs, 25.6.1934 ♂ (PS604); St: Pori, 21.6.1970 ♂ (PS606); St: Reposaari, 21.7.1969 ♀ and Tb: Jyväskylä, 24.6.[19]20 ♂ (PS611). – *Timandra comai*: Finland, N: Helsinki, 27.8.1965 and 5.9.1965 ♂ (PS595, PS599); N: Hanko, 16.8.1985 ♀; Ka: Virolahti, 4.–6.8.1990, ♂ (PS600), 3.–6.9.1990 ♂ (PS607), 1.–3.8.1989 1♀; N: Porvoo, 27.8.1951 1♂ (PS605); Al: Lemland, 19.6.1968 1♂ (PS610); Czech Republic, Bohemia, Teplice, ♂ [no date] (PS601) and Russia, Mari, El, 12.6.1997 ♂ (PS612). – *Timandra recompta* ssp. *ovidius* Bryk, 1942: Russia, Kurils, 11.–18.9.1997 3♂ (PS602, PS603, PS608). – *Timandra recompta* ssp. *recompta* Prout: China, Heilongjiang, Fenglin State Natural Reserve, 48°05'N 128°80'E, 28.6.–10.7.2000 ♂ (PS614). All studied specimens are deposited at the Zoological Museum, University of Helsinki (ZMH).

The genitalia were dissected following the routine techniques described by Hardwick (1950), and terminology is according to Klots (1970). Most of the genitalia are stored in glycerol tubes attached to the specimens. Below I describe a vesica eversion method and it is assumed that the reader is familiar with the techniques for the preparation of the genitalia of Lepidoptera.

For the eversion of male vesica, I have modified the technique described by Dang (1993) so that the aedeagus is placed into the lumen of the needle and the vesica is everted through the incised caecum (fig. 1). This technique has been used earlier by K. B. Bolte (pers. comm.) and K. Mikkola (pers. comm.), so I claim no originality but describe the technique in detail in order to help other colleagues in their work. With this technique it is possible to evert vesicae from aedeagi which measure as little as 0.04 mm in diameter (personal observation).

1. Orientation and removal of the aedeagus. Before removing the aedeagus from the diaphragma, one should study the orientation of the aedeagus carefully. Especially the anterior opening of the aedeagus (the passage through which the ductus ejaculatorius enters the aedeagus) is of importance, since it can be used to orientate the genitalia so that the copulation posture can be reconstructed later. The aedeagus is removed from the diaphragm by gripping it gently with forceps at the caecum and pulling it carefully anteriorly or posteriorly. The aedeagus is placed into a dissecting dish containing 5% aqueous ethanol solution.

2. Removal of the caecum. The aedeagus should be stained (e.g. in Chlorazol Black) to demonstrate the position of the vesica and ductus ejaculatorius within the aedeagus. If such a structure lies within the caecum, it should be moved towards the distal open-



**Fig. 1.** The position of the aedeagus within the needle during the eversion of vesica. The aedeagus is held in place with the help of small forceps.

ing of the aedeagus using a small hair, needle or similar by pushing it gently from the anterior opening of the aedeagus. Once certain that the caecum is empty, it can be cut away using microscissors. The excess of the ductus ejaculatorius, if still outside the aedeagus, should be trimmed as short as possible. A long ductus ejaculatorius may get stuck within the aedeagus and obstruct the jet fluid which everts the vesica.

3. Pushing the vesica posteriorly. Through the opening of the caecum the inverted vesica is pushed to the posterior opening of the aedeagus with the help of a hair or similar tool. The use of sharp or strong tools which may easily puncture the membranous structures should be avoided.

4. Determining the needle size. The diameter of the needle lumen should be slightly wider than the maximum diameter of the aedeagus. Too small a needle may cause structures to break and too large a needle may allow the aedeagus to twist during the eversion and prevent the flow of the liquid. In this study I used a 27G (lumen diameter 0.19 mm) needle for laterally slightly bent aedeagi of approximately 0.14 mm in diameter. I have successfully used a 30G (lumen diameter 0.14 mm) needle for species with an aedeagus diameter of between 0.04–0.08 mm. The tip of the needle should be smoothed with emery paper so that it does not have sharp edges, see Dang (1993).

5. Eversion of the vesica. Fill the syringe with a mild solution of Chlorazol Black or 5% aqueous ethanol solution and fit it with a needle. Press the needle sidewise against the bottom of the dish and pass the aedeagus into the lumen of the needle except for the posterior end. Do not pass the aedeagus too far into the needle, as the walls of the needle may obstruct the full eversion of the vesica. Place the tip of the small forceps at the mouth of the needle to prevent movement of the aedeagus (Figure 1). Then apply moderate pressure to the plunger of the syringe until the vesica is fully everted and then maintain a steady flow until the vesica is adequately stained. Remove the forceps from

the tip of the needle and let the aedeagus fall into the dish. Transfer the aedeagus to a dish that contains 99.5% ethyl alcohol.

6. Fixing the structures. Fill the syringe with 99.5% ethanol or isopropanol and evert the vesica again as described above, to ensure that the membranous structures are fixed at their maximal size. Usually a steady flow of about 30 seconds is adequate. Leave the aedeagus in 99.5% ethanol or in absolute isopropanol for a few hours. It can later be safely transferred to glycerine for detailed study or mounted in euparal.

This technique is applicable to females, too. For instance *Scopula frigidaria* Möschler (Geometridae, Sterrhinae) has a cup-like ostium bursae that can be placed into the lumen of the needle (personal observation).

### Key to the species of *Timandra griseata* group based on vesica structures

The species recognition of *Timandra griseata* and *T. comai* on the basis of this character alone is highly susceptible to incorrect interpretation due to the difficulties in the preparation technique and should therefore be used cautiously.

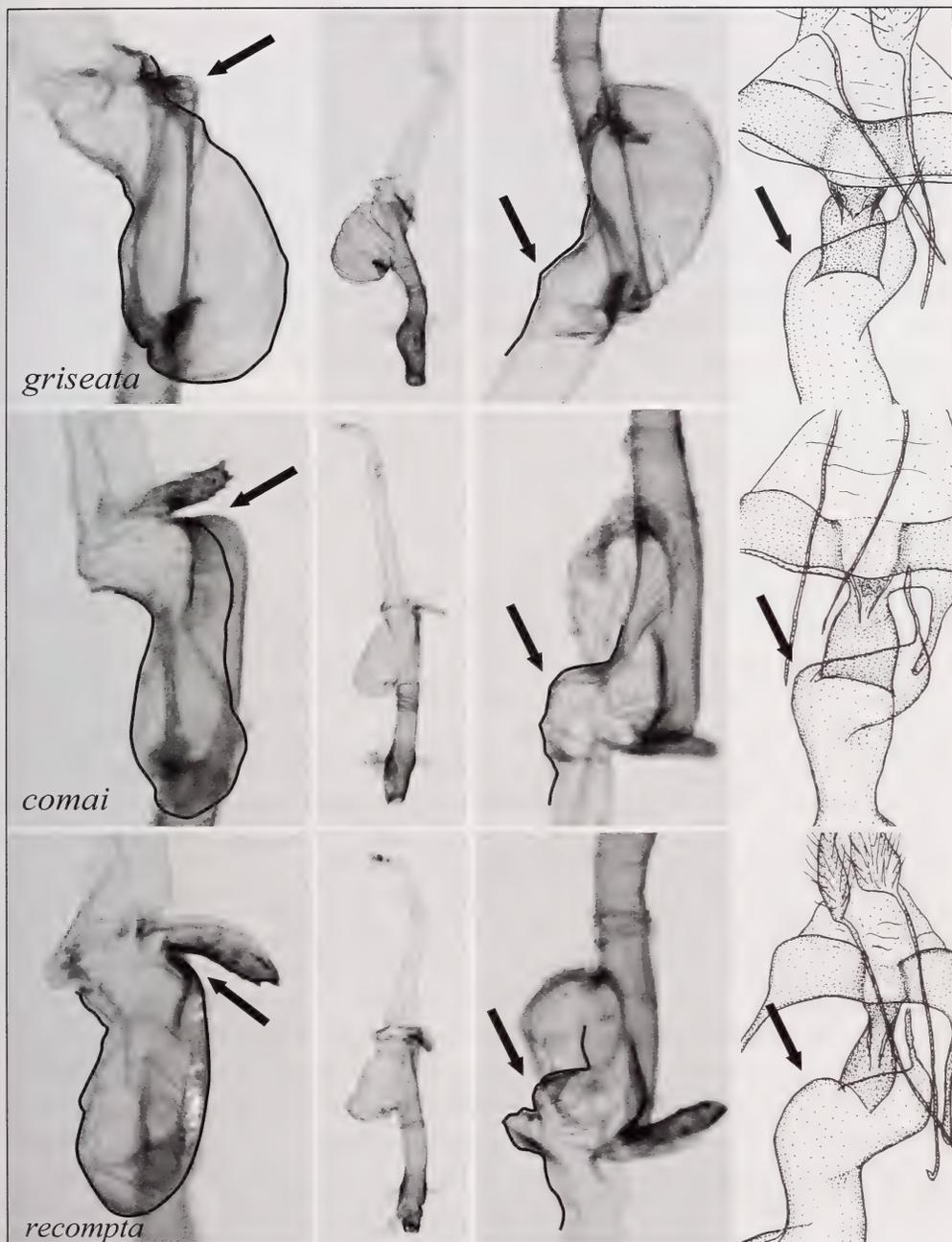
- |    |  |                          |
|----|--|--------------------------|
| 1. | Diverticulum on ventral side covers the apex of the aedeagus         | <i>recompta</i> (Fig. 2) |
| –  | Diverticulum on ventral side does not cover the apex of the aedeagus | 2                        |
| 2. | Edge of the lateral diverticulum forms an angle of about 120°–130°   | <i>griseata</i> (Fig. 2) |
| –  | Edge of the lateral diverticulum forms an angle of about 90°–100°    | <i>comai</i> (Fig. 2)    |

### The vesicae of the *Timandra griseata* group

*Timandra griseata* (Fig. 2). – Aedeagus about 1.7 mm long, 0.14 mm wide, slightly curved laterally, well sclerotized, surface smooth, apex round, slightly expanded dorsally near apex; anterior opening of aedeagus located dorso-laterally at approximately one-fifth of its length from anterior end; caecum slightly curved dorsally. Vesica larger than aedeagus, ventrally directed large diverticulum subapically, about two-fifth of length of aedeagus, oval, not covering apex of aedeagus, near apex laterally two small diverticula on opposite sides, edge of one with an angle of about 120°–130°, other one slightly sclerotized on posterior side on most specimens; near apex one large cornutus with small teeth dorsally, most often directed dorsolaterally; distal end of vesica directed posterolaterally, slightly turned laterally near opening of primary gonopore, narrowing distally, surface with shallow longitudinal grooves basally; primary gonopore opens from distal end of vesica.

*Timandra comai* (Fig. 2). – As in *T. griseata*, with the following small differences: anterior opening of aedeagus located dorsally; edge of one lateral diverticulum forming an angle of about 90°–100° in most specimens; direction of cornutus more variable.

*Timandra recompta* (Fig. 2). – As in *T. griseata*, with the following small differences: anterior opening of aedeagus located dorsally at around one-eighth of its length from anterior end; subapical ventral diverticulum slightly covering apex of aedeagus; one lateral diverticulum large, edge of other one with an angle of about 100°; cornutus often directed ventrally.



**Fig. 2.** The male aedeagus with everted vesica and female ductus bursae of the *Timandra griseata* group. Male *T. griseata* in lateral (from left), ventral and ventrolateral view (slide PS606) and female ductus bursae. Male *T. comai* in lateral (PS607), ventral (PS612) and ventrolateral (PS607) view and female ductus bursae. Male *T. recompta* in lateral, ventral and ventrolateral view (PS608) and female ductus bursae. In ventrolateral view the anterior end of aedeagus is at the top of the figure, in order to show the aedeagus in the copulation posture relative to the female genitalia. The edges of the male membranous structures have been highlighted to show details. Illustrations of female genitalia are taken from Kaila and Albrecht (1994) with permission.

## Discussion

The vesicae of species of the *Timandra griseata* group are very similar and they do not offer taxonomic characters that can be easily used for species identification. Nevertheless, the detailed differences that were found on the lateral diverticulum of the vesica, i.e. shape and angle, appear to be anatomically compatible with the junction of the corpus bursae and appendix bursae of the female genitalia (Fig. 2; Kaila & Albrecht 1994: Fig. 13). The phenomenon of species-specific genitalia is widespread among animals with intromittent genitalia (e.g. Eberhard 1985) as well as species-specific anatomical congruence in internal male and female genitalia (e.g. Callahan & Chapin 1960; Mikkola 1992; Sota & Kubota 1998). Thus the observed species-specific male characters of the *Timandra griseata* group that are anatomically compatible with the female genitalia, should not be considered only as being an artefact of the preparation technique.

According to this study *griseata*, *comai* and *recompta* have loosely species-specific structures in the internal genitalia, thus giving morphological support to the conclusion of Kaila and Albrecht (1994) to treat them as valid species, although some intraspecific variation is present. Due to the membranous nature of these structures in both sexes, their value as diagnostic characters are dependent upon preparation technique and therefore should be used cautiously.

To allow for possible geographical variation, specimens were dissected from Central Finland where *Timandra griseata* occurs alone (i.e. in allopatry to *T. comai*), from southern Finland, where *T. griseata* and *T. comai* occur sympatrically, and from Central Europe, where *T. comai* occurs in allopatry. Minor variation is present in the angle of the diverticulum as well as in other details of the vesica structures. It is possible that some of this variation is a result of the preparation of membranous structures. In a few cases, the identification of a particular specimen to a certain species was difficult if the decision was based on one character only. However, the combination of various vesica characters, i.e. the orientation of vesica, the position of the subapical ventral diverticulum in relation to the apex and the direction of the anterior opening of the aedeagus always resulted in a confident identification.

The difference in the direction of the anterior opening of the aedeagus was found to be constant, dorsolateral in *Timandra griseata* and dorsal in *T. comai* and *T. recompta*. Again, the use of this character is susceptible to incorrect interpretation, as the removal of the genitalia from the abdomen may distort the orientation of the aedeagus and lead to erroneous conclusions. The orientation of the vesica in relation to the rest of the genitalia does not differ between species, despite the difference in the orientation of the anterior opening of aedeagus.

This method for eversion of the vesicae has both advantages and disadvantages. Eversion through the caecum allows a strong and direct flow of liquid into the vesica and it usually effectively everts the diverticula, which may be difficult to evert with other techniques. In the *Timandra griseata* group, the subapical ventral diverticulum lies in close contact with the ventral wall of the aedeagus when the vesica is inverted. I was initially unable to evert the ventral diverticulum through the anterior opening of

the aedeagus, as it lies perpendicularly to the longitudinal axis of the aedeagus and the direction of flow was apparently not strong enough. All attempts through the caecum were successful, however, if the aedeagus was not pushed too far inside the lumen of the needle, allowing it to expand.

The most obvious advantage that comes from placing the aedeagus into the lumen of the needle is that one can evert much smaller vesicae as compared to inserting the needle into the aedeagus. Also, larger needles are easier to keep clean.

An obvious defect of the method is that part of the aedeagus is removed, which may cause other structures, namely the ductus ejaculatorius or vesica, to break. In addition, one needs to be very careful not to loose the caecum during the preparation.

### Acknowledgements

I wish to thank K. Mikkola for teaching me the techniques of vesica eversion. K. Fiedler, A. Hausmann and L. Kaila are thanked for critical comments and discussions on the earlier version of this manuscript. I am grateful to S. Venn for revising my English.

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## Secondary compounds in caterpillars of four moth families (Noctuoidea, Bombycoidea) are partly identical

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**Summary.** Semi-quantitative data on secondary compounds in hemolymph and, where present, in exocrine gland secretions were determined for caterpillars of 17 species of moths from four families. Based on these data, similarities of the chemical bouquets in the larval body fluids were computed using various distance measures. Clustering of larval hemolymph compounds resulted in phenograms which arranged the species corresponding mainly to their taxonomic relationship and permitted to characterize taxa. Phenograms based on the secretion compounds of Saturniidae and Lymantriidae seemed to be influenced also by the potential enemies addressed by the respective secretions. In both cases, basically similar metabolic pathways of secondary compounds in the four families and presumably also in other moths are suggested.

**Zusammenfassung.** Halbquantitative Daten zu Sekundärstoffen in Hämolymphe und, wenn vorhanden, in exokrinen Drüsensekreten wurden für Raupen von 17 Nachtfalterarten aus vier Familien bestimmt. Auf Grundlage dieser Daten wurde die Ähnlichkeit der chemischen Bouquets in den larvalen Körperflüssigkeiten mittels verschiedener Distanzmaße berechnet. Die Gruppenbildung auf Grundlage der larvalen Hämolymphe erzeugte Phänogramme der Arten, welche hauptsächlich ihrer taxonomischen Verwandtschaft entsprachen und auch eine Charakterisierung von Taxa erlaubten. Phänogramme, die auf der Zusammensetzung der Wehrsekrete der Saturniidae und Lymantriidae basierten, schienen auch von ökologischen Aufgaben der jeweiligen Sekrete beeinflusst zu sein. In beiden Fällen ließ sich ein Hinweis auf grundsätzlich ähnliche Stoffwechselwege für Sekundärstoffe bei den vier Familien und vermutlich auch anderen Nachtfaltern erkennen.

**Resumé.** Des données sémi-quantitatives relatives aux composantes secondaires de l'hémolymphe et, quand présentes, dans les sécrétions de glandes exocrines, ont été déterminées pour les chenilles de 17 espèces de papillons nocturnes appartenant à quatre familles. Sur base de ces données, des similarités entre les bouquets chimiques des fluides corporels larvaires ont été calculées au moyen de plusieurs mesures de distance. Le clustering des composantes de l'hémolymphe larvaire a résulté en des phénogrammes qui arrangent les espèces principalement selon leur parenté taxinomique, permettant ainsi de caractériser les taxons. Les phénogrammes basés sur les composantes de sécrétion des Saturniidae et des Lymantriidae paraissaient également être influencés par les ennemis potentiels interpellés par les sécrétions respectives. Dans les deux cas, des trajets métaboliques de composantes secondaires essentiellement similaires au sein des quatre familles, ainsi que vraisemblablement aussi auprès d'autres papillons nocturnes, sont suggérés.

**Key words.** Eupterotidae, exocrine secretions, hemolymph, Lepidoptera, Lymantriidae, Notodontidae, Saturniidae, secondary compounds.

### Introduction

Chemical inventories of secondary compounds have been taken from a wealth of insect species. Such components which are often connected with chemical defence may be of interest for comparative physiological or biochemical purposes, in particular, if they refer to complex metabolic pathways and an according enzyme repertoire needed. However, few comparative efforts using such allomones have been undertaken hitherto in the Lepidoptera. For example, Deml & Dettner (1997) investigated the secondary chemistry of hemolymph and, in part, defensive secretions of several last-instar caterpillars from three moth families: emperor moths (Bombycoidea: Saturniidae), tussock moths (Noctuoidea: Lymantriidae), and prominents (Noctuoidea: Notodontidae). Defensive

secretions, if present, are discharged from specialized integument glands (Saturniidae: scoli; Lymantriidae: osmeteria). Many of the compounds identified by combined gas chromatography/mass spectrometry (phenolics, heterocycles, biogenic amines, aliphatics) were shown to exhibit toxic and/or irritant effects on a series of laboratory test-organisms, including micro-organisms, ants, and birds (summarized in Deml & Dettner 1997).

One particularly interesting finding was the striking similarity of the compound patterns in the three families. This was underlined recently (Deml & Nässig 2001) by the additional detection of several of the afore-mentioned compounds in the hemolymph of monkey moths (*Palirisa* sp.; Eupterotidae) which belong to the Bombycoidea just as the Saturniidae (Minet 1994; Lemaire & Minet 1999). In order to acquire more detailed information about this phenomenon, I determined semiquantitative data for all compounds identified from these larval body fluids (Deml & Dettner 1993, 1997; Deml 2001; Deml & Nässig 2001). Then I performed an analysis of resemblance of the chemical bouquets in order to assess the actual conformity of the caterpillars' chemical composition. Thereby, for the first time, all investigated caterpillar species were considered simultaneously in a multivariate approach, and hemolymph samples (four families) and secretions (Saturniidae/Lymantriidae) were distinguished.

## Materials and methods

*Caterpillar material.* The last-instar caterpillars investigated (and the foodplants of the larvae used) were: (a) Saturniidae: *Saturnia pavonia* (*Crataegus monogyna*, *Prunus spinosa*), *S. pyri* (*C. monogyna*, *P. spinosa*), *Eupackardia calleta* (*Ligustrum vulgare*), *Attacus atlas* (*P. spinosa*); (b) Eupterotidae: *Palirisa* sp. (*L. vulgare*); (c) Lymantriidae: *Lymantria monacha* (*Larix decidua*), *L. dispar* (*Quercus robur*), *L. concolor* (*Rhododendron* sp.), *Euproctis chrysorrhoea* (*P. spinosa*); (d) Notodontidae: *Clostera curtula* (*Populus tremula*), *Notodonta ziczac* (*P. tremula*), *N. dromedarius* (*Betula alba*), *Pheosia tremula* (*P. tremula*), *Pterostoma palpina* (*P. tremula*), *Furcula bifida* (*P. tremula*), *Phalera bucephala* (*P. tremula*), *Stauropus fagi* (*Fagus sylvatica*).

*Data analysis.* Semiquantitative rank scores (intervals corresponding to: major/minor/trace/missing compounds, according to the total ion chromatograms) were determined for the hitherto identified secondary compounds of larval hemolymph (all species) and/or of defensive secretions (Saturniidae and Lymantriidae). Due to the small amounts of sample (of secretion, in particular) per individual caterpillar, in all cases the respective samples had been pooled from several larvae (Saturniidae: 3–5 larvae; Eupterotidae: 4 larvae; Lymantriidae: 4–8 larvae; Notodontidae: 3–5 larvae) before analysis. This resulted in elevated sum peaks of the compounds which could be better and more definitely evaluated. Altogether I detected 37 substances (2-pyrrolidone and GABA could not be chemically distinguished and were treated as one substance), all of which were aromatics, hetero- or alicycles, and aliphatic compounds (Table 1).

Subsequently the data were subjected to various clustering algorithms using the computer program NTSYS-PC 1.50 (Applied Biostatistics Inc.). At first, dissimilarity coefficients ('average taxonomic distances') were computed from a rectangular input

data matrix using the SIMINT program. 'Average taxonomic distances' represent Euclidean distances (shortest distances between two points in an  $n$ -dimensional space) divided by the number of characters ( $n$ ) and are frequently used in numerical taxonomy as a means of measuring overall resemblance, particularly in case of large numbers of characters (Sneath & Sokal 1973: 124) or when values are compared between different studies having different numbers of characters (Abbott et al. 1985: 147). They were computed as follows:

$$d_{jk} = \sqrt{\frac{1}{n} \sum_{i=1}^n (x_{ij} - x_{ik})^2}$$

where  $d_{jk}$  = average taxonomic distance between objects  $j$  and  $k$ ;  $n$  = number of characters;  $x_{ij}/x_{ik}$  = value (score) of the descriptor state that is observed for object  $j/k$  on variable (character)  $i$ . For comparison, average Manhattan distances (city block distances; also called Mean Character Differences, MCD) and average Canberra metrics were also computed. The former measure is also frequently used in numerical taxonomy and is a summation of the absolute differences between the objects on each of the variables taken in turn, divided by the number of characters (Sneath & Sokal 1973: 125; Abbott et al. 1985: 76, 147). The Canberra metric is a property solely of the two individuals/groups being compared in each pairwise comparison, is not affected by the range of the entire characters, and is sensitive to proportional rather than absolute differences (Sneath & Sokal 1973: 125). It is computed as the sum of absolute differences of the objects' values divided by the sum of the corresponding sums of the values. In the present case, distance values were adjusted for the number of characters through division by  $n$ .

Several clustering methods (for definitions see, for example, Sneath & Sokal 1973) were applied to the resulting distance matrices: average-based methods (UPGMA = unweighted pair-group method using arithmetic averages; WPGMA = weighted pair-group method using arithmetic averages; WPGMC = weighted pair-group method using centroid averages), the single-linkage as well as the complete-linkage methods, and the flexible clustering strategy (parameter  $\beta = -0.25$ ). Cophenetic correlation coefficients ( $r_{CS}$ ) were determined through a cophenetic value matrix. In the case of hemolymph samples, resulting multiple trees were combined by computing a consensus tree (strict method). For these, the corresponding consensus fork index ( $CI_c$ ) was calculated.

## Results

In most cases, the phenograms based on caterpillar hemolymph or gland secretions, which were obtained after applying the various dissimilarity coefficients and clustering methods, represented the corresponding distance matrices fairly satisfactorily. Distortion was low, as expressed by high cophenetic correlation coefficients (most  $r_{CS} \geq 0.8$ ; Sneath & Sokal 1973) (Table 2). Also, the consensus trees computed from multiple trees in case of hemolymph were characterized by elevated consensus fork index ( $CI_c$ ) values (Table 2), indicating a good representation of the original, single trees.



**Table 2.** Cophenetic correlation coefficients ( $r_{CS}$ ) and consensus fork indices ( $CI_c$ , plus corresponding numbers of trees; strict method) of the phenograms of larval gland secretions (S) or hemolymph (H), obtained after applying various dissimilarity coefficients and clustering methods.

Clustering method	Dissimilarity coefficient	Average taxonomic distance		Manhattan distance		Canberra metrics	
		$r_{CS}$	$CI_c$ (trees)	$r_{CS}$	$CI_c$ (trees)	$r_{CS}$	$CI_c$ (trees)
UPGMA	H	0.80	0.87 (3)	0.84	0.87 (4)	0.95	0.87 (6)
	S	0.96	–	0.96	–	0.95	–
WPGMA	H	0.80	0.80 (3)	0.84	0.87 (4)	0.94	0.87 (6)
	S	0.96	–	0.96	–	0.94	–
WPGMC	H	0.80	0.87 (3)	0.83	0.87 (4)	0.94	0.87 (12)
	S	0.96	–	0.96	–	0.94	–
Single linkage	H	0.72	0.87 (6)	0.83	0.87 (6)	0.91	0.87 (6)
	S	0.95	–	0.95	–	0.93	–
Complete linkage	H	0.78	0.53 (7)	0.83	0.80 (8)	0.86	0.87 (9)
	S	0.95	–	0.96	–	0.94	–
Flexible clustering	H	0.64	0.53 (2)	0.61	0.73 (2)	0.84	0.93 (2)
	S	0.91	–	0.92	–	0.89	–

Most clustering methods using average taxonomic distances or Manhattan distances produced phenograms of the different hemolymph samples (Table 1) whose arrangements of the families were basically identical with the one illustrated in Fig. 1a. Here three groups were formed. The saturniids, *S. pavonia* and *S. pyri*, branch off first from the other species which in turn separate into one cluster of Notodontidae, and another one comprising Lymantriidae, Eupterotidae and the remaining Saturniidae. Distinguished from this, in the case of average taxonomic distances and single linkage (Fig. 1b), the four Saturniidae species branch off one by one, followed by the eupterotid species, then *L. dispar*, leaving one cluster each for the remaining Lymantriidae and the Notodontidae, respectively. Complete linkage as well as flexible clustering in combination with average taxonomic distances did not provide sufficient separation (one common origin of the clusters). In contrast, flexible clustering with Manhattan distances yielded a phenogram similar to UPGMA, but connected the eupterotid with the *S. pavonia*/*S. pyri* cluster. Since the  $r_{CS}$  and  $CI_c$  values, respectively, of these three pairings were rather low, these combinations are not considered as being convincing. Phenograms obtained with the Canberra metric (for example, Fig. 1c) differed from the corresponding ones obtained with average taxonomic distances mainly in that the notodontid spe-

**Table 1.** Occurrence of secondary compounds hitherto identified by GC-MS in hemolymph (H) and glandular secretions (S) from last-instar caterpillars of Saturniidae (4 spp.), Lymantriidae (4 spp.), Eupterotidae (1 sp.) and Notodontidae (8 spp.).

Above aromatics, center hetero- and alicyclic compounds, below aliphatic compounds. +++, main compound; ++, minor compound; +, trace; -, not detectable; ?, trace compounds with corresponding retention times but only incomplete EI mass spectra as compared with authentic chemicals; blank fields, analyses not performed. Prior to analysis, the respective samples had been pooled from 3–5 larvae (Saturniidae), 4 larvae (Eupterotidae), 4–8 larvae (Lymantriidae), or 3–5 larvae (Notodontidae).

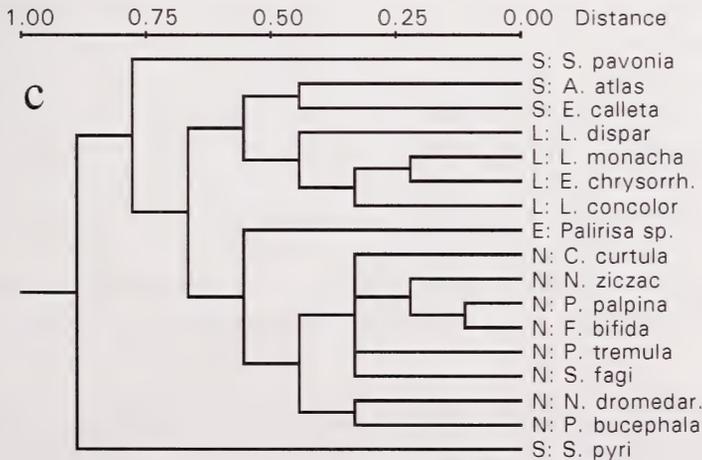
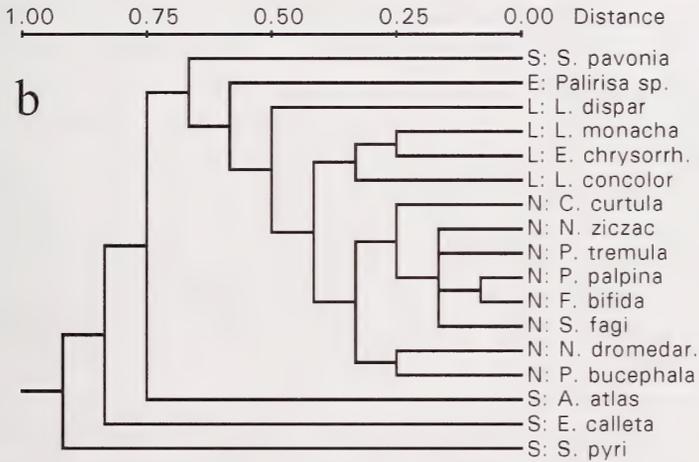
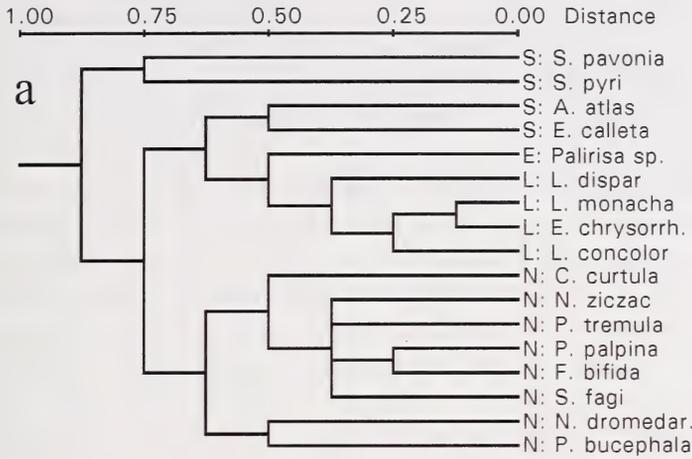
cies were arranged in a somewhat different order and the eupterotid species was regularly placed with the Notodontidae or, in case of flexible clustering, was grouped with *S. pavonia*/*S. pyri*. Thus, the main differences between the more relevant arrangements are the differing subdivision of the Saturniidae (one or two groups), on the one hand, and the position of the Eupterotidae, i.e., whether they are more closely combined with the Notodontidae, Lymantriidae, or Saturniidae, on the other hand.

Altogether three differing arrangements were also obtained after clustering the gland secretions of Lymantriidae and Saturniidae (Table 1, Fig. 2). Most clustering methods with average taxonomic distances as well as flexible clustering using the two other dissimilarity measures separated *S. pavonia* and *S. pyri* from *A. atlas* and *E. calleta*, yet in the reverse order as compared with the hemolymph. The Lymantriidae were positioned between these groups (Fig. 2a). Single linkage (Fig. 2b) and WPGMA, both using average taxonomic distances, resulted in a chain where *A. atlas* and *E. calleta* were separated as a cluster first, then *S. pyri*, *L. dispar*, *S. pavonia*, followed by the remaining lymantriids. In contrast, apart from flexible clustering, all clustering methods using Manhattan distances or Canberra metrics joined the Saturniidae together in an unbroken order (i.e., no lymantriid was intervening), either as a chain of single species (single linkage) or with *A. atlas* and *E. calleta* forming a pair (complete linkage, average-based methods; for example, Fig. 2c).

## Discussion

The phenograms of the larval hemolymph samples revealed that the chemical patterns of the Lymantriidae and Notodontidae, respectively, yielded closed groupings of these families. This means that the bouquets of the hitherto identified chemical compounds in hemolymph are potentially suitable for characterizing families (and the species therein). However, the Saturniidae (the investigated species belong to the subfamily Saturniinae; Michener 1952) were split into two groups with most combinations of dissimilarity coefficients and clustering methods; the two groups corresponded to two tribes within the Saturniinae (Saturniini: *S. pavonia*/*S. pyri*; Attacini: *A. atlas*/*E. calleta*). The Saturniidae were located in a close arrangement only in case of average taxonomic distances and single linkage. The phenogram of this combination also showed a relative conformity of the taxonomic distribution of the substances with the currently supposed relationship of the four families. Lymantriidae and Notodontidae are placed in the superfamily Noctuoidea (Kitching & Rawlins 1999), whereas Saturniidae and Eupterotidae belong to the only distantly related superfamily Bombycoidea (Minet 1994; Lemaire & Minet 1999). However, the  $r_{CS}$  value obtained by this clustering combination was relatively low, indicating a comparably low correspondence of the dissimilarity matrix and the phenogram. The elongate growth of the single-linkage clusters ('chain-

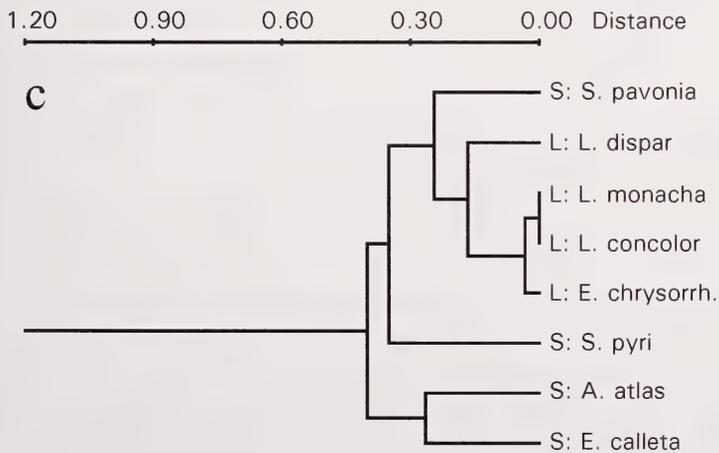
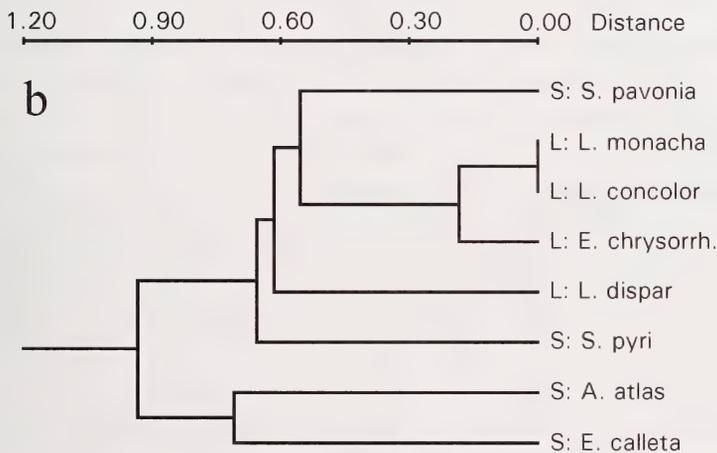
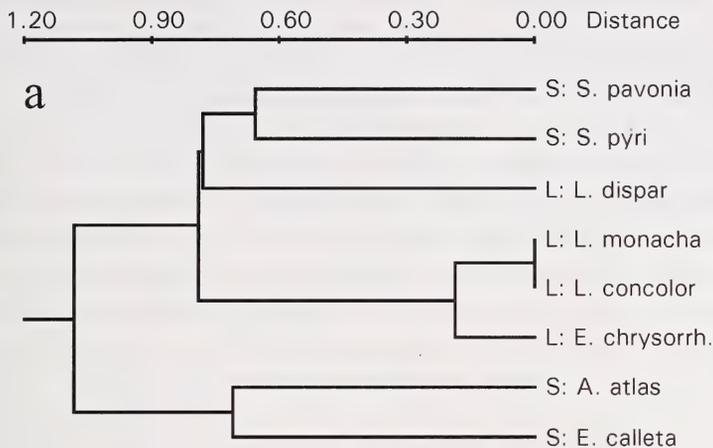
**Fig. 1.** Phenograms (strict consensus trees) of hemolymph from last-instar caterpillars of Saturniidae (S), Lymantriidae (L), Eupterotidae (E), and Notodontidae (N). Dissimilarity coefficients of the consensus trees were computed from an interval data matrix of amounts of 37 secondary compounds. a) average taxonomic distances, clustering by UPGMA, three resulting trees; b) average taxonomic distances, single linkage, six trees; c) Canberra metrics, UPGMA, six trees.



ing') which occurs particularly when there are a number of equidistant or near-equidistant points (Sneath & Sokal 1973), also indicates that this 'nearest neighbour' method might not be optimal for the present analysis. The phenograms generated by average-based methods (such as UPGMA) using average taxonomic distances or Manhattan distances as well as the one resulting from the 'farthest neighbour' method (complete linkage) using Manhattan distances were basically identical (the same was found with the corresponding clusterings with the Canberra metrics). One may therefore conclude that the absolute differences of the original data-matrix values are relatively small. The range of almost all distance values per species in the distance matrix was  $<0.3$  (most differences even  $<0.2$ ; corresponding distance values between 0.0 and 0.9) with average taxonomic distances,  $<0.2$  with Manhattan distances (corresponding distance values: 0.0–0.65), and  $<0.55$  with Canberra metrics (corresponding distance values: 0.0–0.6). There were many identical distance values in each matrix. Therefore the phenograms using Canberra metrics, although having the highest cophenetic correlation coefficients, might rather reflect an overemphasis of proportional differences between the original values by this dissimilarity coefficient. This might be the reason for the altered structure of the Notodontidae and their 'wrong' grouping with the species of Eupterotidae, in comparison with most unique phenograms made by means of the two other dissimilarity coefficients. However, for the moment it cannot be excluded that any observed conformity of resemblance of hemolymph chemistry, on the one hand, and taxonomy, on the other hand, is conditional on mere accident. Results from such phenetic analyses *per se* need not have any connection with phylogenetic relations between families or species, as long as no hemolymph compounds have been explained as synapomorphies. One should keep in mind that all the 37 compounds used in this study were scored for multivariate analysis in an identical manner, irrespective of their structural complexity and state of derivation.

It appears more difficult to interpret the results from the cluster analyses of the exocrine secretions of Lymantriidae and Saturniidae. The cophenetic correlation coefficients for all phenograms obtained are very high. The three arrangements shown in Fig. 2 particularly differ in the position of *S. pavonia* and *S. pyri*. While in Fig. 2a these species form a group which is very distant from the other saturniids, *A. atlas* and *E. calleta* ('beyond' the Lymantriidae), in Fig. 2b *S. pyri* has changed sides, and in Fig. 2c *S. pavonia* has done so, too. The phenogram in Fig. 2c (most methods using Canberra metrics or Manhattan distances) shows a considerably larger resemblance of the secretions than in the two other phenograms which indicates that not only the sums of the objects' values (scores) are small but also their differences. The distances in Fig. 2b are generally only somewhat smaller than in Fig. 2a which is probably simply caused by the 'space dilating' effect of average-linkage clustering methods (UPGMA etc.; Fig. 2a) and the corresponding 'space contracting' properties of single-linkage, respectively,

**Fig. 2.** Phenograms of gland secretions from last-instar caterpillars of Saturniidae (S) and Lymantriidae (L). Dissimilarity coefficients of the trees were computed from an interval data matrix of amounts of 37 secondary compounds. a) average taxonomic distances, clustering by UPGMA; b) average taxonomic distances, single linkage; c) Canberra metrics, UPGMA.



where no average distance-values of clusters but only the nearest neighbours are considered. Considering such shortcomings of the single-linkage method, the 'intermediate' phenogram obtained by this method as well as by WPGMA using average taxonomic distances (Fig. 2b) seems to be the least trustworthy. However, Abbott et al. (1985) recommend to use just the single-linkage method, at least above the species level, because the corresponding diagrams would reveal the full diversity of clusters, chains, and outliers, whereas group-average methods (UPGMA, WPGMA) only reveal a quick look at a variation pattern, but at the expense of precision and loss of information. Furthermore, only single linkage always places an item in the same cluster as its nearest neighbour in the geometric model, whereas in methods such as UPGMA the nearest neighbours may be led into separate clusters due to space dilation.

The other two, extreme phenograms of the gland secretions suggest two ideas, but it cannot be decided at present which one is 'correct', or whether none or even both are 'correct'. First, the phenograms obtained by 10 clustering-method combinations using Canberra metrics or Manhattan distances (Fig. 2c) separate the two families in so far as the concerned species per family are arranged in an order – though not in two separate clusters – reflecting their taxonomic affiliations (no intervening member of the other family, in each case). Secondly, although these secretions are discharged by morphologically very different glands (Deml & Dettner 1997), the position of *L. dispar* and the other Lymantriidae in between the saturniids in the phenograms produced by six method combinations (most clusterings using average taxonomic distances as well as flexible clustering using the other two dissimilarity coefficients; Fig. 2a) could point at different adjustments of the ecological function of the secretions of the two families which is assumed to be chemical defence against enemies. For example, the secretions of *S. pavonia*, *S. pyri*, and the Lymantriidae as well as several compounds therein are effectively deterring ants (Deml & Dettner 1993, 1997; Aldrich et al. 1997). In contrast, *E. calleta* and *A. atlas* (both species are not Palearctic) additionally discharge large amounts of biogenic amines (e.g.: histamine, acetylcholine) which are assumed to be effective against vertebrates (Deml & Dettner 1997). Combinations of high titres of especially ant-detering substances (benzaldehyde, phenylacetaldehyde, 2-pyrrolidone/GABA, 1-methyl-2-pyrrolidone, nicotine; Table 1) in the scoli secretions of *S. pavonia* and *S. pyri* and in the osmeterial secretion of the Lymantriidae, in particular of *L. dispar*, explain the close arrangement of these species in the phenograms, while the weighting of the cyclic compounds (second section in Table 1) obviously particularly influences the species' relative order in Figs. 2a and 2b.

The three phenograms of the larval secretions, in particular, distinctly illustrate that it can be very informative to compare various combinations of selected distance measures and clustering algorithms. As could be shown, alternative but equally plausible conclusions may be drawn from identical data material when subjected to different methods of data analysis. A mistake when formulating one-sided hypotheses relying on only a single, arbitrary method can be avoided by such comparisons. However, one must be aware that such data analyses provoking new thoughts do not represent the final point of an investigation, but only an intermediate step which may guide the further procedure into a completely different direction.

Finally, a high relative similarity of the chemical bouquets of most secretions is obvious. In most species of Saturniidae and Lymantriidae studied thus far, the patterns of hemolymph compounds are also quite similar to those of the secretions (Deml & Dettner 1997). Superficially, this might be explained as uniformity caused by equal larval food (leaves from few species of deciduous trees and shrubs used in rearing). However, as stated earlier (Deml & Dettner 1993, 1997), most of the substances found in Lymantriidae and Saturniidae are probably biosynthesized by the caterpillars. Analyses of various foodplant samples and comparisons to the larval components revealed only single, occasional cases of correspondence (e.g., benzaldehyde, nicotinic acid). Furthermore, chemicals such as acetylcholine, histamine, or benzonitrile, whose synthesis requires many metabolic steps, are unlikely to represent merely detoxication or degradation products of toxic plant substances. It is possible, yet has not been tested, that the substances are produced through identical metabolic pathways. If this were the case, biosynthetic parallels in these moth families could point at certain basic and common metabolic processes within them and possibly also within a larger part of the Macrolepidoptera. However, more data on the origin of the compounds (sequestration from food or biosynthesis by larvae) and analyses of additional relevant species and moth families are required to address this question conclusively.

#### Acknowledgements

This work was supported in part by a grant from the Deutsche Forschungsgemeinschaft (Bonn) (De 568/1-1). I thank Dr. W. A. Nässig (Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt a. M.) who gave me living specimens of *Palirisa* sp., and Mr. U. Bauer (Bayreuth) who performed chemical analyses of notodontid hemolymph. Furthermore, I am greatly obliged to Prof. Dr. K. Fiedler (Universität Bayreuth), Prof. Dr. K. Dettner (Universität Bayreuth), and an anonymous reviewer for helpful advice and remarks on various drafts of the manuscript.

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## Spatio-temporal dynamics in a population of the copper butterfly *Lycaena hippothoe* (Lycaenidae)

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**Summary.** A mark-recapture analysis showed a strong decline in *Lycaena hippothoe* numbers (and changes in the spatial distribution) between 1995 and 1999 within a western German population. Neither land-use practices nor adult mortality could be accounted for this development. Based on a close correlation between *L. hippothoe* numbers and the mean daily cloud cover during previous flight period, the hypothesis is advanced that the observed decline basically reflects a series of flight periods with adverse weather conditions. These should constrain the time available for feeding and oviposition. Given a strong reliance of the reproductive output in *L. hippothoe* on adult-derived nectar resources, reduced fecundity is regarded as the proximate reason for the population decline. These findings may have implications for conservation, as reduced availability of nectar sources, be it caused by adverse weather conditions or by modern agricultural techniques, may contribute to regional declines.

**Zusammenfassung.** Eine Fang-Wiederfang-Studie zeigte einen kontinuierlichen Rückgang von *Lycaena hippothoe* sowie Änderungen des räumlichen Verteilungsmusters zwischen 1995 und 1999 in einer westdeutschen Population. Weder Habitatveränderungen noch eine erhöhte Imaginalmortalität können für diese Entwicklung verantwortlich gemacht werden. Basierend auf einem engen Zusammenhang zwischen Falterzahl und Tagesmittel der Bewölkung während der vorhergehenden Flugsaison wird die Hypothese entwickelt, daß der beobachtete Rückgang Ausdruck einer Folge von Flugperioden mit ungünstigen Witterungsbedingungen ist, wodurch die für Nahrungsaufnahme und Oviposition verfügbare Zeit reduziert wird. Da die Eiproduktion von *L. hippothoe* in hohem Maße vom Zugang zu Kohlenhydraten abhängt, wird eine reduzierte Fekundität als proximaler Mechanismus angesehen. Die Befunde könnten für den Schutz nektarsaugender Falter in Zusammenhang mit einer großflächigen Reduzierung des Nektarangebotes infolge moderner landwirtschaftlicher Bewirtschaftungsmethoden (oder aber ungünstiger Witterungsbedingungen) Bedeutung erlangen.

**Resumé.** Une analyse de marquage-recapture a révélé un importante déclin numérique au sein d'une population ouest-allemande de *Lycaena hippothoe* (Linné, 1761) (ainsi qu'une modification de la distribution spatiale) pour la période de 1995 à 1999. Cette tendance ne peut être imputée ni à des changements au niveau de l'habitat, ni à une augmentation de la mortalité adulte. Sur base d'une étroite corrélation entre les nombres de *L. hippothoe* et la durée moyenne journalière de couverture nuageuse pendant la période de vol précédente, l'hypothèse est avancée que le déclin observé reflète une série de périodes de vol successives à conditions météorologiques adverses. Celles-ci devraient limiter le temps disponible à la nutrition et à l'oviposition. Vu la forte dépendance de la capacité de reproduction de *L. hippothoe* d'hydrates de carbone dérivés du nectar obtenu au stade adulte, la fécondité réduite est considérée comme étant la raison proximale du déclin de la population. Ces résultats pourraient avoir des implications pour la conservation, étant donné que la disponibilité limitée de sources nectarifères, qu'elle soit due à des conditions météorologiques adverses ou à des techniques modernes d'agriculture, peut contribuer à des déclin régionaux.

**Key words.** *Lycaena hippothoe*, population dynamics, weather, imaginal resources, realised fecundity.

### Introduction

Many animal populations, in particular those of insects, undergo pronounced dynamics in space and time (e.g. Ehrlich 1984; Thomas & Harrison 1992; Dempster *et al.* 1995; Zwölfer 1999). Although this has been known for a long time, dynamic processes were largely neglected in conservation biology, being dominated by static approaches

(Reich & Grimm 1996). Only recently, the rebirth of metapopulation concepts (e.g. Hanski & Gilpin 1997; Hanski 1999; Mousson *et al.* 1999; Gutiérrez *et al.* 2000; Thomas 2000) brought dynamic aspects into the focus of conservation research. In spite of a concomitant increase in publications on metapopulation topics, most of which basically deal with the incidence of species on a landscape level (e.g. Thomas *et al.* 1992; Hanski 1994; Hanski *et al.* 1996; Settele 1998), there is a lack of studies concerned with spatio-temporal dynamics on a local scale (but e.g. Murphy *et al.* 1986; Pollard & Yates 1993), providing quantitative data on the size of specific populations over a range of years.

Against this background we report here on the dynamics within a population of the butterfly *Lycaena hippothoe* between 1995 and 1999, using mark-recapture techniques. Such data are crucial to gain a better understanding of the underlying proximate factors and thus the exact mechanisms causing changes in population size, which are still largely unknown (Dempster & Pollard 1981; Kingsolver 1989; Zwölfer 1999; but see Roy *et al.* 2001). Based on our results we suggest a causal relationship between adverse weather conditions and *L. hippothoe* numbers in subsequent generations.

## Material and Methods

**Study organism.** – *L. hippothoe* (Linnaeus, 1761) is a widespread temperate zone butterfly, ranging from northern Spain in the west throughout much of the northern Palaearctic region eastwards to the easternmost parts of Siberia and China (Ebert & Rennwald 1991; Tuzov 2000). In central Europe, adults fly in one generation from about early June through late July (Ebert & Rennwald 1991; Fischer 1998). The species inhabits different kinds of wetland as well as unimproved grassland. The principal larval host-plant is *Rumex acetosa* L. (Polygonaceae), a common and widespread perennial herb.

**Field methods.** – Field work was carried out at two adjacent sites (study sites A and B, situated only a few kilometres apart from each other) in the Westerwald area (Rhineland-Palatinate, western Germany; cf. Fischer 1998). Both sites were formerly used as rough cattle pastures, which have been abandoned decades ago (last turning out to pasture 1962 and about 1965) and are now sporadically grazed by sheep or wild game only. During the complete flight seasons 1995 (site A only), 1997, 1998, and 1999 both *L. hippothoe* populations were sampled on every favourable day. All individuals encountered for the first time were captured using an insect net, individually marked (by writing a number with a permanent ink, felt-tip pen on the hindwing undersides), and afterwards immediately released at the point of capture. As evidenced by the observation of single individuals over extended periods of time in the same territories, the capture and marking procedure did not evoke adverse handling effects (Fischer & Fiedler 2001b).

**Data analysis.** – For this paper we analysed recapture rate (percentage of butterflies recaptured at least once), distance moved between capture and subsequent recapture event, minimum number alive, and total number of brood. For the latter three different methods were used (all based on Jolly-Seber estimates; see Southwood & Henderson

2000) as described by Watt *et al.* (1977), Matsumoto (1984) and Kockelke *et al.* (1994). The minimum number alive comprises the sum of individuals seen on a specific day plus those which were previously marked and recaptured at a later date, but not seen that specific day (see Blower *et al.* 1981). To investigate a possible relationship between butterfly numbers and weather conditions during the previous flight period (site A only), we used the mean daily cloud cover during June and July in 1994, 1996, 1997, and 1998. Data on cloud cover were obtained from Deutscher Wetterdienst (1997–2000), measured at a nearby (ca. 8 km) meteorological station (Bad Marienberg).

## Results

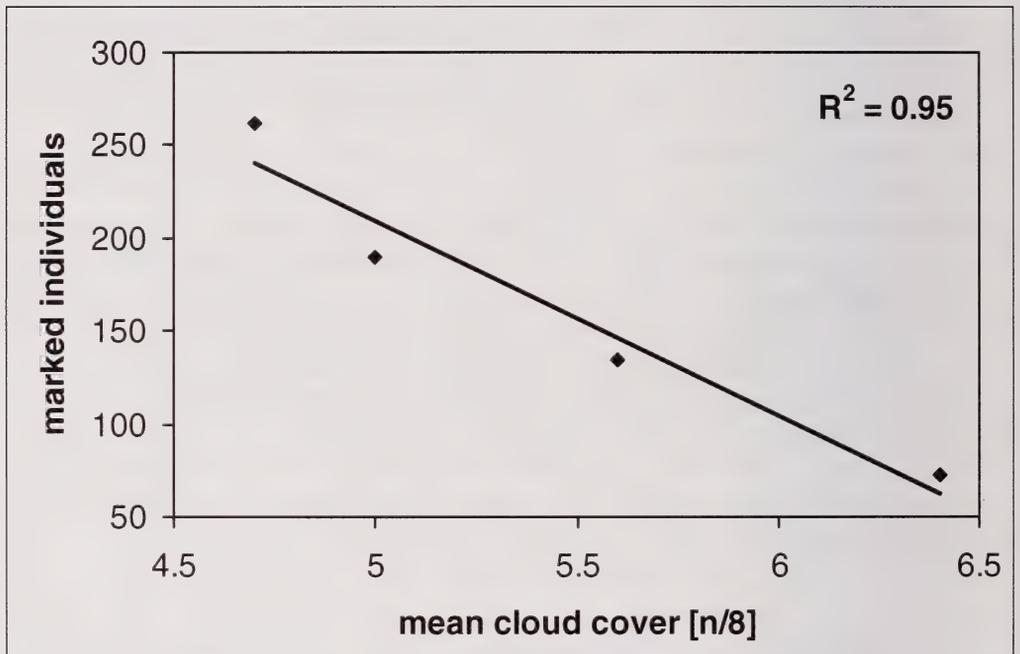
Across the emergence periods, the number of individually marked butterflies (Tab. 1) decreased in site A between 1995 and 1999 from 262 to 72. For the period 1997–1999, a comparable decline in butterflies was found for both sites (Tab. 1). The same pattern emerged if statistical estimates of total brood sizes, rather than the numbers of marked individuals, were considered (Tab. 1). A close correlation occurred between butterfly number observed in a given year and the mean daily cloud cover during the previous flight period, i.e. population size decreases as cloud cover increases (Fig. 1). Nevertheless, the minimum number alive showed no indication of direct effects of weather conditions within an emergence period on adult longevity (see examples in Fig. 2). Even after spells of unfavourable (rainy) weather that precluded flight activity for up to four days, no reduction in population abundance could be noticed. In addition to the decline in numbers over the years, changes in the spatial distribution were observed in site A (Fig. 3). Prominent examples with large deviations between subsequent years include grid cells C5, C6, D5, E4, E5, F4, and G4. For instance, cell E4 contained only 6.2 % of all observations in 1997, but 25.7 % in the following year. Regarding sexual differences, males exhibited higher recapture rates than females throughout (Tab. 1). Moreover, males were generally more stationary than females, confirmed by lower distances between capture and subsequent recapture event (Tab. 2).

**Tab. 1.** Number of *L. hippothoe* individuals marked, population size (total number of brood, given as mean of three methods; see above), and recapture rates [%] for two study sites in different years. Sex-specific differences in recapture rates were analysed using pairwise Bonferroni-corrected  $\chi^2$ -tests (significance threshold:  $p < 0.007$ ; null hypothesis: equal recapture probability in both sexes; ♂: males, ♀: females). Significant p-values are printed in bold.

Site	Year	Marked individuals			Population size ♂ + ♀	Recapture rates			
		♂	♀	♂ + ♀		♂	♀	$\chi^2_{1df}$	p
A	1995	158	104	262	570	58.3	30.6	28.0	<b>&lt;0.0001</b>
A	1997	95	95	190	259	49.5	29.5	7.8	<b>0.0048</b>
A	1998	73	61	134	173	64.4	36.1	10.7	<b>0.0011</b>
A	1999	27	45	72	95	63.0	28.9	8.1	<b>0.0045</b>
B	1997	110	76	186	204	79.1	51.3	15.9	<b>0.0001</b>
B	1998	68	67	135	164	77.9	46.3	14.4	<b>0.0001</b>
B	1999	44	50	94	103	81.8	74.0	0.8	0.36

**Tab. 2.** Distances [m] between capture and subsequent recapture event for male and female *L. hippothoe* for two study sites in different years. Sex-specific differences were analysed using Mann-Whitney's U-test (Bonferroni-corrected threshold for significance:  $p < 0.007$ ). Significant p-values are printed in bold.

Site	Year	Males		Females		Z	p
		Mean $\pm$ s.d.	n	Mean $\pm$ s.d.	n		
A	1995	46.9 $\pm$ 54.4	325	80.9 $\pm$ 69.0	66	4.07	<b>&lt;0.0001</b>
A	1997	43.4 $\pm$ 54.1	136	84.7 $\pm$ 65.1	47	4.11	<b>&lt;0.0001</b>
A	1998	46.2 $\pm$ 49.2	134	68.0 $\pm$ 61.5	36	2.03	0.04
A	1999	33.7 $\pm$ 63.0	82	39.2 $\pm$ 49.1	25	1.26	0.21
B	1997	30.1 $\pm$ 41.6	271	52.1 $\pm$ 49.0	88	4.29	<b>&lt;0.0001</b>
B	1998	33.3 $\pm$ 40.7	152	65.2 $\pm$ 58.8	59	4.33	<b>&lt;0.0001</b>
B	1999	18.3 $\pm$ 37.9	158	43.5 $\pm$ 40.9	91	6.18	<b>&lt;0.0001</b>



**Fig. 1.** Total number of marked *L. hippothoe* butterflies in site A during flight seasons 1995, 1997, 1998, 1999 in relation to mean daily cloud cover [n/8 of sky] during previous flight period.

## Discussion

For study site A, our data show a steady decline in butterfly numbers between 1995 and 1999 as well as changes in the spatial distribution within this site. The decline in numbers was apparent from both, the number of individuals marked as well as the estimated total number of brood. This is not surprising since the relatively high recapture rates indicate that a large proportion of the population has actually been marked during each flight period. Interestingly, the decline in site A was paralleled by a very similar one in site B (Tab. 1), which is only a few kilometres away. Habitat changes due to

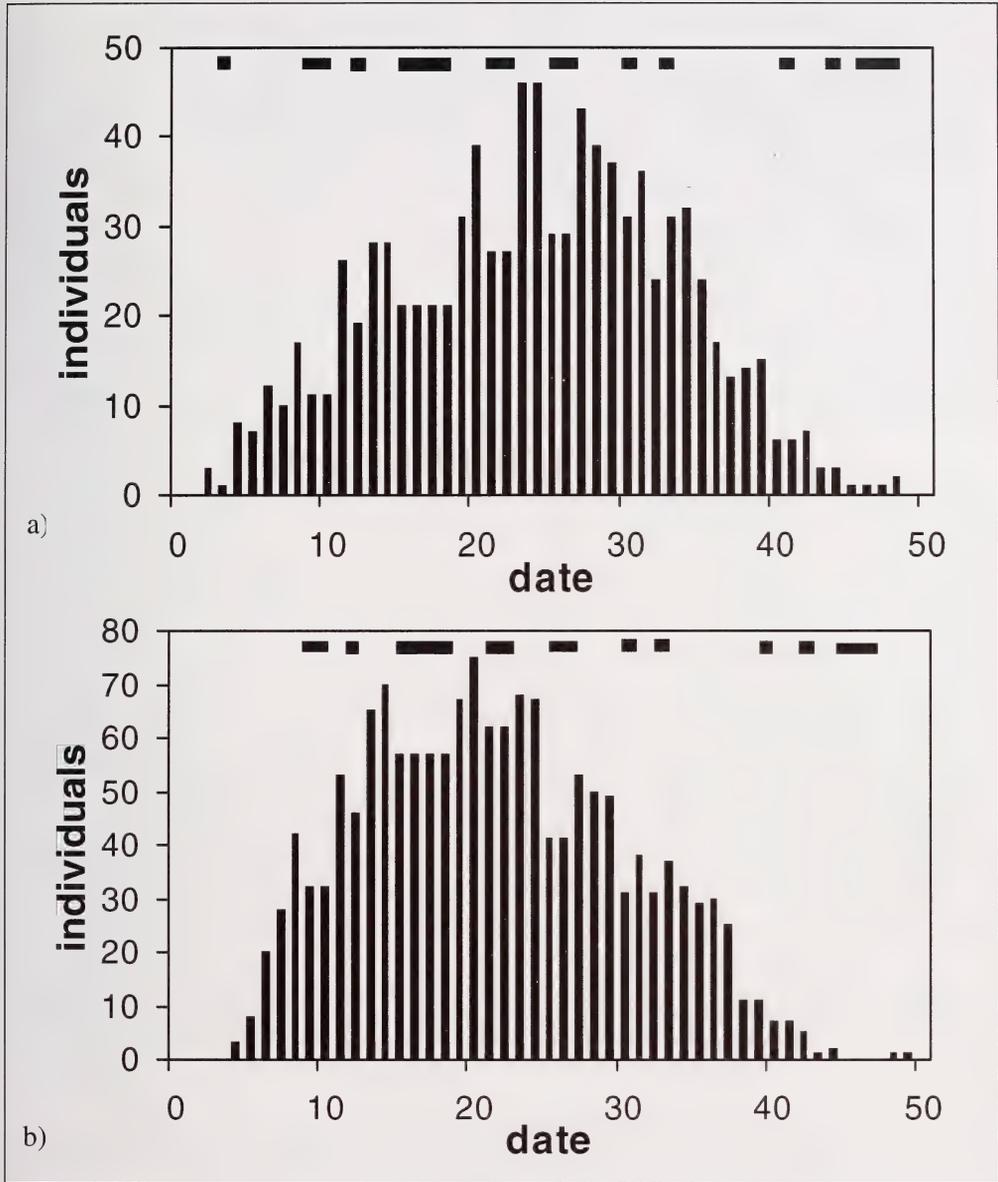
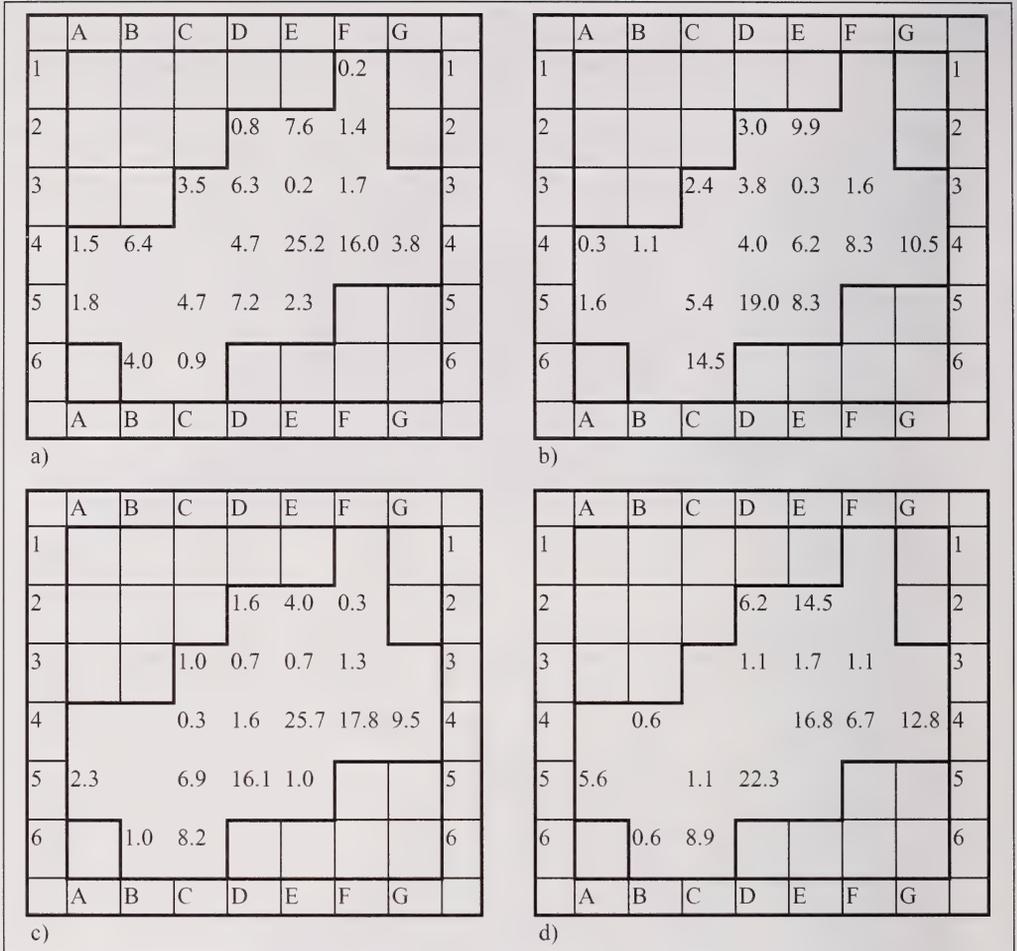


Fig. 2. Daily minimum number alive for *L. hippothoe* in study sites A (a) and B (b) 1997 (date 1: 07.06). Dates with adverse weather conditions are indicated by bars at the top of the graphs.

altered land-use practices can be ruled out in causing these declines, as both sites are lying fallow for decades. Likewise, no changes attributable to secondary succession and concomitant changes in vegetation could be observed during the study period, although this was not examined in detail. The comparable decline of *L. hippothoe* in both study sites, however, may favour a common explanation rather than site-specific reasons. Perhaps the most important and wide-spread factor affecting local butterfly



**Fig. 3.** Schematic map of study site A. Figures within grid cells give the proportion of *L. hippothoe* observations per grid, expressed as percentage of all observations made during the whole flight period in different years (a: 1995, n (total number of observations) = 656; b: 1997, n = 373; c: 1998, n = 304; d: 1999, n = 179). Internal lines indicate the boundaries of the study site. One grid cell = 2500 m<sup>2</sup>.

populations equally, and thus causing synchrony of population fluctuations on regional scales, is weather (e.g. Pollard & Lakhani 1985; Pollard 1988, 1991; Roy *et al.* 2001). The close relationship between *L. hippothoe* numbers and cloud cover (and other indicators of favourableness of weather conditions for butterflies such as amount of precipitation or mean maximum temperature; results not shown) during the previous flight period suggests that weather conditions may have been important during this study as well, although the finding rests on a small sample size of four years and two study sites only. In a number of univoltine butterfly species which hibernate as small larvae, Roy *et al.* (2001) likewise observed that weather conditions during the preceding flight period explain abundance data better than do temperature and rainfall in the year of emergence. Thus, we assume that the observed decline in *L. hippothoe* was probably caused by adverse weather conditions during a sequence of flight periods.

As our results show no reduction in adult numbers within one flight season following cold and rainy weather (cf. Fig. 2), the decline is unlikely to be due to increased adult mortality. However, we do not have any data on larval mortality. A few studies confirmed a higher mortality of butterfly larvae during droughts due to desiccation of larval food plants (e.g. Ehrlich *et al.* 1980; Endo *et al.* 1986; Pollard *et al.* 1997). Adverse effects of particularly cold or wet conditions are apparently largely unknown, except for mortality under rather extreme conditions (i.e. flooding; see Webb & Pullin 1996, 1998). However, correlational evidence does suggest that low temperatures or high levels of rainfall during early stages of a life cycle may play a role in abundance fluctuations of various butterflies (Roy *et al.* 2001). Overall, predation and parasitoid attacks appear to be the main mortality factors during larval development in insects (Moore 1989; Cornell & Hawkins 1995; Rosenheim 1998), which may, however, in itself be related to weather conditions (Warren 1992).

Regarding the adult life stage, carbohydrate ingestion (i.e. nectar) can profoundly affect longevity and fecundity in many temperate-zone nectar-feeding butterflies (e.g. Murphy *et al.* 1983; Karlsson & Wickman 1990; Boggs & Ross 1993; Rusterholz & Ehrhardt 2000). Fecundity in *L. hippothoe* butterflies, showing a seven-fold increase when fed concentrated sucrose solution as compared to water only, depends far more on adult-derived resources than in any other nectar-feeding butterflies for which comparable data exist (Fischer & Fiedler 2001a). The crucial role of nectar sources for the reproductive output in *L. hippothoe* is highlighted by field data on its behavioural ecology (Fischer & Fiedler 2001b). Males exhibit aggressive territorial behaviour by defending areas rich in flowering nectar plants (resource-based territoriality). The concomitant site tenacity is indicated by the higher recapture rates and shorter distances moved between capture events in males than in females, resulting in sex-related differences in these traits in the present study (Tables 1 and 2). Given the strong dependence of the reproductive output on adult resources, the monopolisation of nectar sources is a straightforward strategy in spite of the males' high investments.

From these findings we draw the conclusion that the most likely mechanism through which weather influences *L. hippothoe* abundance may be a reduction in realised fecundity (cf. Courtney & Duggan 1983; Dempster 1983; Kingsolver 1989; Warren 1992). In nature, female *L. hippothoe* were found to exhibit residence times of about 8 days (Fischer & Fiedler 2001c). Under semi-natural conditions, within such a period of time about 160 eggs per female were laid, comprising 32% of the species' mean potential fecundity (Fischer & Fiedler 2001a). However, under optimal (laboratory) conditions females may have reached a value close to their maximal fecundity after 8 days only (Fischer & Fiedler 2001a). Thus, given a rather short life span similar to the residence times found, a series of rainy days may strongly reduce realised fecundity.

Moreover, a high incidence of rainy or overcast days would constrain not only the time available for egg-laying, but also for feeding. The resulting lack of nourishment, causing a reduced egg production (Porter 1992), should impede compensation of time limitations through an increase in oviposition rate. In particularly bad seasons, females may be able to lay those about 60 eggs only which are already well developed at emergence (Fischer & Fiedler 2001a). In contrast to species in which reproduction

relies less strongly on adult feeding, population dynamics of *L. hippothoe* should be far more affected if access to adult nutrient resources is limited. These findings may also be important for the conservation of this and other species, as a reduced availability of nectar sources caused by modern agricultural techniques (e.g. due to high mowing frequencies and recurrent applications of fertilizer; e.g. Barabasz 1994; Ellenberg 1996; Erhardt 1995) may well play an important role for regional declines.

### Acknowledgements

We would like to thank J. Settele and an unknown reviewer for valuable comments on this manuscript, and the Koblenz district government for granting permission to pursue this study. The work was partially supported by grants from the Friedrich-Ébert-Foundation to K. Fischer.

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## Continuous long-term monitoring of daily foraging patterns in three species of lappet moth caterpillars (Lasiocampidae)

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**Summary.** Activity patterns of caterpillars of three species of Lasiocampidae were long-time monitored by electronic data acquisition. We used these data to test the hypothesis that the coloration of a caterpillar corresponds to its activity patterns. Caterpillars with warning colours (usually supposed to be chemically or physically well-defended) should forage conspicuously throughout the day whereas cryptic caterpillars (supposed to be 'palatable') should have behavioural mechanisms for reducing exposure to natural enemies (hiding, nocturnal feeding). In terms of predator avoidance and thermoregulation social caterpillars should be strongly synchronized when foraging. Social caterpillars of *Eriogaster lanestris* (Linnaeus, 1758) were strongly synchronized and fed day and night, but synchronicity was low during moulting time and at the end of the last instar. Caterpillars of *Macrothylacia rubi* (Linnaeus, 1758) despite their aposematic colour and urticating hairs proved to be strictly nocturnal while larvae of *Gastropacha populifolia* ([Denis & Schiffermüller], 1775), which are cryptically coloured, were active by day and night. Comparisons with other Lasiocampidae further corroborate the suggestion that there is no correspondence between colour and activity patterns. As a priori judgements of aposematism are doubtful, if not tested explicitly, abiotic factors and life history traits seem to be of greater importance in shaping activity patterns of these caterpillars.

**Zusammenfassung.** Die Aktivitätsmuster von Raupen dreier Lasiocampiden-Arten wurden mittels elektronischer Datenerfassung langfristig überwacht. Mit den so gewonnenen Daten wurde die Hypothese überprüft, daß die Färbung der Raupe mit ihrem Aktivitätsmuster in Zusammenhang steht. Raupen mit Warntracht, von denen in der Regel angenommen wird, daß sie chemisch oder physikalisch wehrhaft sind, sollten tagsüber wie nachts auffällig sein und fressen. Kryptisch gefärbte Raupen dagegen, von denen vermutet werden kann, daß sie 'freßbar' sind, sollten Verhaltensmechanismen besitzen, die ihren Kontakt zu natürlichen Feinden vermindern sollten (Verstecken, nächtliche Futtaufnahme). Soziale Raupen wiederum sollten ihre Aktivität streng synchronisieren, um ihre Auffälligkeit gegenüber Prädatoren so gering wie möglich zu halten und thermoregulatorische Vorteile des Sozialverhaltens zu maximieren. Die sozialen Raupen von *Eriogaster lanestris* (Linnaeus, 1758) erwiesen sich hinsichtlich ihres Fouragierverhaltens als stark synchronisiert und fraßen tagsüber und nachts. Während der Häutungsphasen war die Synchronität allerdings wenig ausgeprägt und schwächte sich zum Ende des letzten Larvenstadiums immer mehr ab. Trotz ihrer Warntracht und ihrer Brennhaare erwiesen sich die Raupen von *Macrothylacia rubi* (Linnaeus, 1758) als strikt nachtaktiv, während Raupen von *Gastropacha populifolia* ([Denis & Schiffermüller], 1775), die kryptisch gefärbt sind, bei Tag und Nacht aktiv waren. Der Vergleich mit anderen Lasiocampidenarten unterstützt die Vermutung, daß es keinen zwingenden Zusammenhang zwischen der Färbung und dem Aktivitätsmuster gibt. Da die Beurteilung von Aposematismus a priori stets zweifelhaft ist, sofern dies nicht explizit geprüft wurde, scheinen abiotische wie biotische Faktoren (z.B. Life-history-Eigenschaften) einen größeren Einfluß auf das Aktivitätsmuster von Lasiocampiden-Raupen zu haben.

**Résumé.** Les modèles d'activité des chenilles de trois espèces de Lasiocampidae ont été recensés sur une longue période au moyen d'acquisition de données électronique. Nous avons utilisé de ces données afin de tester l'hypothèse selon laquelle la coloration d'une chenille correspond à ses modèles d'activité. Des chenilles à couleurs alarmantes (généralement supposées comme bénéficiant d'une bonne protection chimique ou physique) devraient se nourrir la journée entière tout en étant bien visibles, tandis que les chenilles cryptiques (supposées "commestibles") devraient montrer des mécanismes de comportement de nature à réduire leur exposition à des ennemis naturels (mœurs cachées, nutrition exclusivement nocturne). En termes d'évitement de prédateurs et de thermorégulation, des chenilles sociales devraient être fortement synchronisées quant à leurs périodes de nutrition. Les chenilles sociales de l'espèce *Eriogaster lanestris* (Linnaeus, 1758) étaient fortement synchronisées et se nourrissaient de jour comme de nuit, mais la synchronisation était faible lors des mues et à la fin du dernier état larvaire. Les chenilles de *Macrothylacia rubi* (Linnaeus, 1758), malgré leur coloration aposématique et leurs poils urticants, se sont avérées strictement nocturnes, alors que les chenilles de *Gastropacha populifolia* ([Denis & Schiffermüller], 1775), qui sont cryptiques, étaient actives tant de nuit que de jour. Des comparaisons avec d'autres Lasiocampidae corroborent également la suggestion comme quoi il n'y a pas de

correspondence entre la couleur et les modèles d'activité. Les jugements a priori quant à l'aposématisme étant douteux quand ils ne sont pas testés explicitement, il semble que des facteurs abiotiques et des traits biologiques soient de plus grande importance lors de la détermination des modèles d'activité de ces chenilles.

Key words. Lepidoptera, Lasiocampidae, caterpillars, automated monitoring, activity patterns, coloration, *Eriogaster*, *Macrothylacia*, *Gastropacha*.

## Introduction

The major task of lepidopteran larvae is to feed and accumulate resources that will become the main and sometimes even the sole supply of energy for activity and reproduction in later life. Frequently the amount of assimilated food which is directly reflected in body mass of the imago correlates with fitness (Honěk 1993). Accordingly one would predict that caterpillars should feed both day and night, if only limited by abiotic conditions, especially temperature which determines physiology of ingestion and digestion of food. However, caterpillars are slowly moving insects which are the target of a huge number of predators and parasitoids. Caterpillars are therefore forced to evolve mechanisms to minimize exposure to natural enemies while optimizing food intake. This trade-off affects foraging behaviour and activity patterns, preventing caterpillars from unlimited foraging (see Stamp & Casey 1993 and references therein).

Heinrich (1979, 1993) suggested that activity patterns of caterpillars are influenced by their colour and morphological defensive structures. Aposematic caterpillars with spines and chemical defence are supposed to be unpalatable allowing those species to feed in an exposed position in the vegetation by day and night. In contrast, cryptically coloured caterpillars which are expected to lack a chemical or morphological defence and are therefore supposed to be palatable should hide and evolve a foraging schedule that minimizes their encounters with visually hunting predators.

The biology of caterpillars is comparatively poorly studied because they are not as apparent as the imagoes. Hence, apart from a number of pest species, there is only little information on most behavioural patterns. Most information on activity patterns of caterpillars so far available is based on intermittent visual observation and only provides an incomplete picture.

Monitoring caterpillars with customary techniques (e.g. videotaping) is expensive and time-consuming but discloses lots of behavioural details. However, caterpillars do not show very diverse behavioural patterns: they mainly switch between phases of rest and foraging, only interrupted during moults when resting time is prolonged. If one is primarily interested in the activity patterns simple and inexpensive techniques are far more suitable for monitoring activities.

We here introduce an inexpensive, yet precise method of recording caterpillar activity by continuous electronic long-time monitoring of the foraging schedule of three different Lepidopteran species under laboratory conditions. Data are directly recorded by a computer which makes exact counting possible and which is advantageous over techniques like event recorders or data logger (e.g. Fitzgerald *et al.* 1988; Lance *et al.* 1986; Fitzgerald 1980) previously used to measure activity patterns.

The three species under consideration all belong to the moth family Lasiocampidae, one species with social caterpillars (*Eriogaster lanestris* (Linnaeus, 1758)) and two solitary species which differ in coloration (aposematic: *Macrothylacia rubi* (Linnaeus, 1758) and plant-mimetic: *Gastropacha populifolia* ([Denis & Schiffermüller], 1775).

According to Heinrich's hypothesis that activity patterns can be predicted from the caterpillar's external appearance we expected that the solitary aposematic species should be active by day and night, while the solitary cryptic species should hide at the bark and restrict foraging to the night. In the case of social caterpillars one would further predict high within-colony synchronicity of individuals to minimize time of consciousness to predators, at least for activity during the day. Moreover, collective thermoregulation also requires well synchronized activities.

## Methods

**Animals.** – Whole colonies of *E. lanestris* were collected in the field (near Würzburg, Germany) and transferred to an environmental cabinet with a 14:10 L:D light regime. Temperature changed between 15°C at night and 22°C during the days. For one colony temperature was changed manually and varied from 18°C (night) and 25°C (day). Caterpillars live communally in a silken tent which is used as a home base and does not include food resources (Ebert 1994). Therefore caterpillars are forced to leave the tent for every foraging bout (so called 'central place foraging', Fitzgerald & Peterson 1988). Caterpillars are totally black during the first three instars, whereas they develop tufts of flaming red hair in the fourth and fifth instar which are urticating (Pro Natura 2000).

Caterpillars of the solitary species *Macrothylacia rubi* (from Bayreuth, Germany) and *Gastropacha populifolia* (from Gmunden at the Traunsee, Austria) were reared ex ovo by collecting a gravid female or were obtained by a breeder respectively. Both species were held in an environmental cabinet with a 18:6 h (L:D) light regime and 25/18°C temperature (day/night). Temperature was decreased one hour before dusk, and increased with the onset of dawn. This was aimed at experimentally decoupling the potential stimuli that trigger nocturnal activity (drop in temperature, or light intensity).

Caterpillars of *Macrothylacia rubi* are black or dark brown with bright yellow intersegmental membranes during the first four instars. In the last instar they are covered with dense long and short urticating hair (Pro Natura 2000).

Caterpillars of *Gastropacha populifolia* are greyish brown. Dorsal hair is reduced and the shape of the larva is dissolved by lateral lappets which are pressed to the bark (twig mimic). There are two transversal bands of black lancet shaped setae with a tinge of blue in the second and third thoracic segment which are invaginated while at rest and can be everted when the caterpillar is disturbed.

**Measuring activity patterns.** – Quantifying activity patterns was realized by using infrared light barriers with IR diodes (type LD 271) as emitters and IR photo transistors with daylight filter (type SFH 309 F) as receptors. Signals of the light barriers were taken up by a AD/DA card (Decision Computer International Taiwan). Signals were smoothed by an expressly written software which was also used to set a

trigger threshold to eliminate interference and to set a dead time. The counter was read once every minute and the count as well as the time of day were written into a file. Temperature in the environmental cabinet was also measured electronically once a minute with the help of thermal sensors (thermistors type SEMI 833 ET) which were calibrated by an additional software.

Light barriers were co-ordinated differently according to the requirements of the three species investigated (see below).

*Eriogaster lanestris*: Central-place foraging social caterpillars can be monitored easily by forcing the caterpillars of a colony to pass a wooden rod linking their tent with a bunch of blackthorn twigs, *Prunus spinosa*, kept in water. Light barriers were attached beside this rod thus counting all caterpillars passing by during their way to their host plant and back (Fig. 1A). Direct observation showed that caterpillars always walk on the upper side of the rods unless too many caterpillars pass by during the same time. Although single caterpillars were not counted correctly there was no significant difference between direct observational counts and computer based counts ( $t(18df, N=20) = 0.97, p > 0.05$ ).

Seven colonies were monitored over a period of several weeks starting during their 3<sup>rd</sup> instar.

To assess synchronicity of caterpillars of *E. lanestris* an index was calculated by dividing the cumulated number of signals of a whole day by the cumulated number of minutes with at least one signal being recorded. Thus the index is a measurement for the density of occurring signals. High signal density indicates strong group cohesion and high synchronicity.

*Macrothylacia rubi*: Observations revealed that caterpillars always left their host plant after feeding and tried to hide in the rearing box. To monitor activity patterns we prepared a plastic box as represented in Fig. 1B: A watered twig of raspberry (*Rubus*

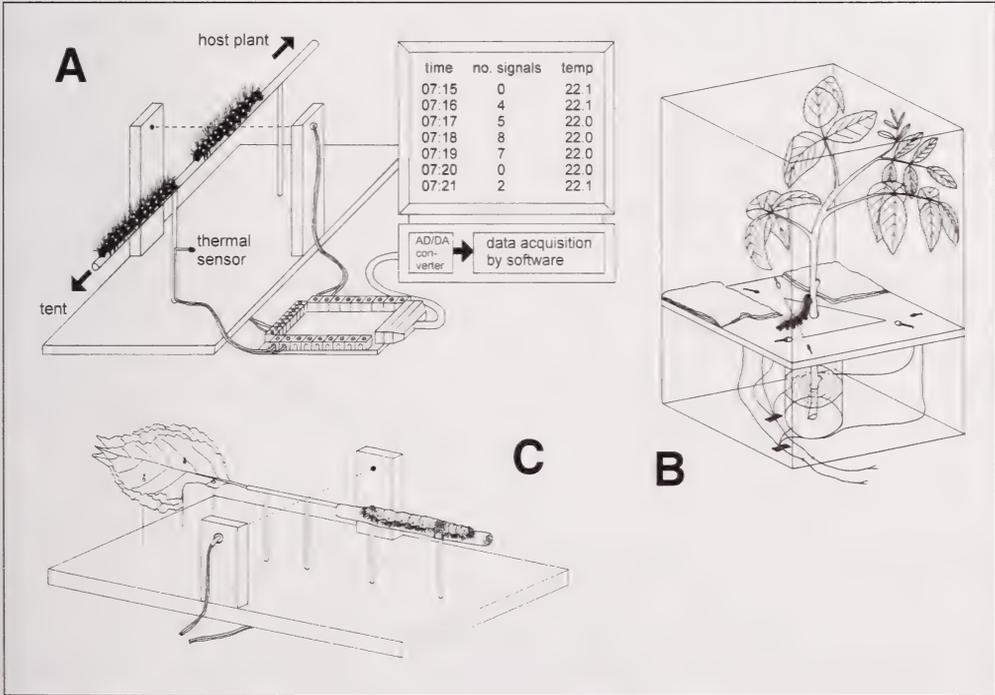
**Tab. 1.** Comparison of activity patterns of different caterpillars within the Lasiocampidae. Colours are judged as aposematic or cryptic from a human perspective. \*: species multivoltine under laboratory conditions (C. Ruf, pers. obs.).

Species	Color	Defense	Voltinism under field conditions	Activity pattern	Place of observation	Reference
<b>Social caterpillars</b>						
<i>Eriogaster lanestris</i> (Linnaeus, 1758)	aposematic	strongly urticating hairs	strictly univoltine (early spring caterp.)	day and night	laboratory, field	this study
<i>Malacosoma americanum</i> (Fabricius, 1793)	aposematic	(weakly) urticating hairs	strictly univoltine (early spring caterp.)	day and night	laboratory, field	Fitzgerald <i>et al.</i> , 1988
<i>Gloveria</i> sp. Packard, 1872	aposematic	urticating hairs	univoltine	nocturnal	laboratory, field	Fitzgerald & Underwood, 1998
<i>Eutachyptera psidii</i> (Sallé, 1857)	aposematic	urticating hairs	univoltine (?)	nocturnal	field	Comstock, 1957
<b>Solitary caterpillars</b>						
<i>Macrothylacia rubi</i> (Linnaeus, 1758)	aposematic	strongly urticating hairs	strictly univoltine	nocturnal	laboratory	this study
<i>Euthrix potatoria</i> (Linnaeus, 1758)	aposematic	urticating hairs	univoltine	nocturnal	field	Pro Natura, 2000
<i>Cosmotriche lobulina</i> ([Denis & Schiffermüller], 1775)	aposematic	?	univoltine *	day and night	laboratory	C. Ruf, pers. obs.
<i>Poecilocampa populi</i> (Linnaeus, 1758)	cryptic	none	univoltine	nocturnal	field	Pro Natura, 2000
<i>Dendrolimus pini</i> (Linnaeus, 1758)	cryptic	hairs in transversal bands?	univoltine / bivoltine *	nocturnal	laboratory, field	Herrebout <i>et al.</i> , 1963. C. Ruf, pers. obs.
<i>Strebote panda</i> Hübner, 1820	cryptic	hairs in transversal bands?	multivoltine	nocturnal	laboratory	Gómez de Aizpúrua, 1988. C. Ruf, pers. obs.
<i>Gastropacha populifolia</i> ([Denis & Schiffermüller], 1775)	cryptic	hairs in transversal bands?	bivoltine *	day and night	laboratory	this study

*idaeus*) was surrounded by a triangle of light barriers. In the corner of the box folded tissue paper was offered to the caterpillar as shelter. Every time a caterpillar wanted to feed or leave the plant it had to pass the light barriers. Four individual caterpillars were monitored in this way for more than a month each.

*Gastropacha populifolia*: Observations showed that caterpillars rest on thick twigs not far away from their feeding sites. Monitoring was realized by offering a natural poplar twig for resting which was joined with some fresh poplar leaves (*Populus* spp.) by a small wooden rod (Fig. 1B). The light barriers were fixed left and right of the small rod. After feeding caterpillars turned round and walked up to the end of the twig, where they rested until the onset of the next feeding period. During numerous hours of observation caterpillars never chose the underside of the twig neither to walk nor to rest. Thus we can almost rule out the possibility that foraging periods were overlooked when caterpillars avoided the light barriers. The whole construction was placed in a big plastic box lined with wet tissue paper to maintain high humidity. This was necessary to prevent the poplar leaves from quick withering. Ten individual caterpillars were monitored for 2 to 4 weeks each. Caterpillars were kept isolated until eclosion of the moths to determine the sex of the animal.

Obtained data were analyzed statistically using standard procedures with the software package STATISTICA '99.



**Fig. 1.** Methods for monitoring activity patterns of three species of lepidopteran larvae. – **A.** *Eriogaster lanestris*. – **B.** *Macrothylacia rubi* (size of plastic box: 30 × 20 × 20cm). – **C.** *Gastropacha populifolia* (size of PVC board: 20 × 12cm). Data processing was the same for all experimental designs as shown in Figure A.

## Results

*Eriogaster lanestris*. – Monitoring data of all colonies were uniform. During the course of a day there was a sequence of strongly synchronized foraging bouts, as opposed to communal resting times when only few single caterpillars were active (Fig. 2A).

At the onset of an activity period caterpillars started walking around the tent and showed marked spinning behaviour (at least in the first four instars). Caterpillars then suddenly started leaving the tent *en masse*. After feeding caterpillars directly returned to the tent and stayed inactive until the onset of the next activity period. With the exception of the early morning when caterpillars ‘basked’ on the tent before their first daytime foraging bout, they always entered the tent after foraging periods.

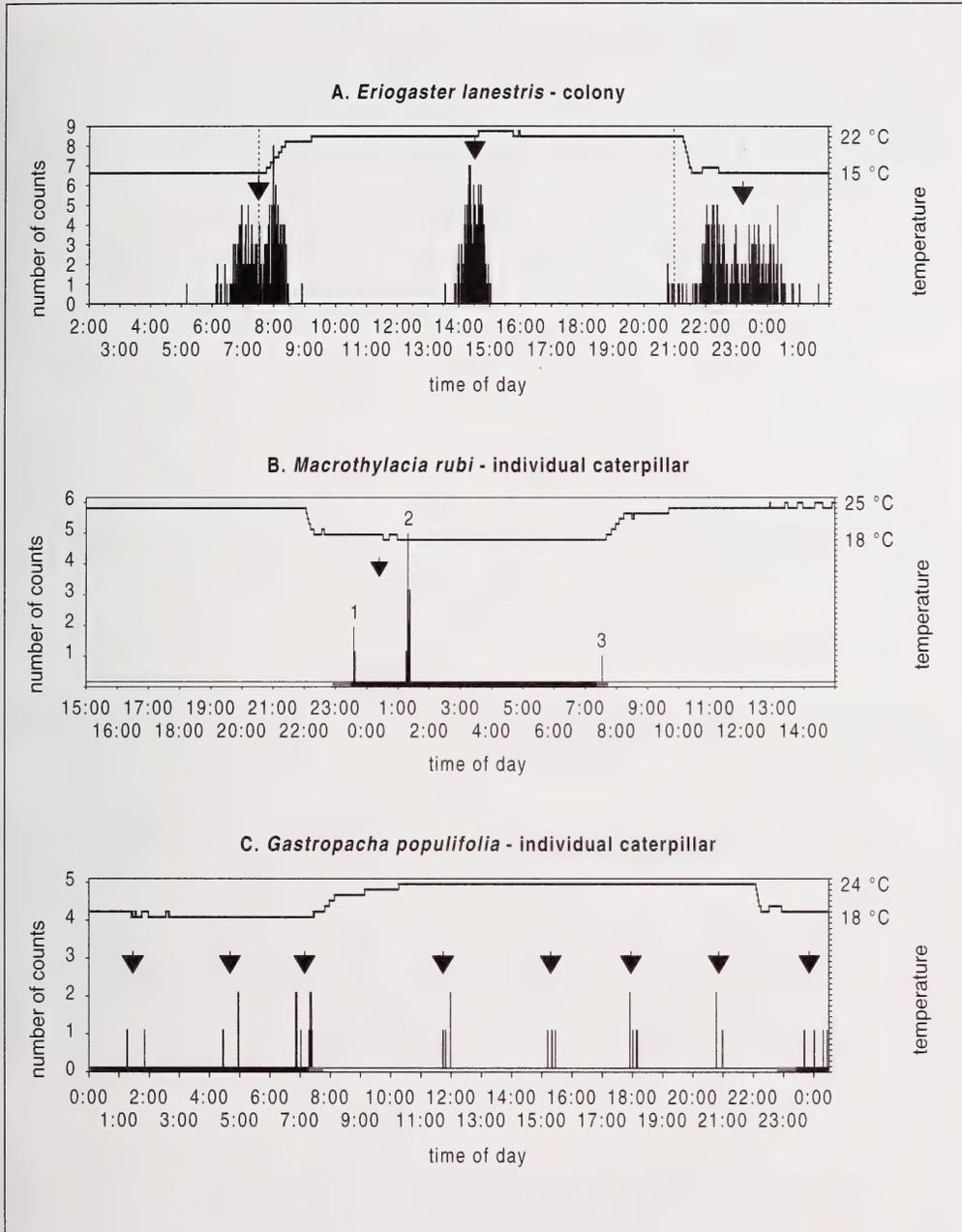
Foraging bouts took place by day and night. When temperature changed between 15°C (night) and 22°C (day) colonies usually undertook three foraging periods per day but sometimes one or two additional foraging bouts occurred. The colony kept at higher temperatures left the tent 4 to 6 times a day, indicating that foraging is opportunistic and does not follow a fixed pattern. This assumption is corroborated when comparing intervals between foraging bouts. These intervals coincide with the time for digestion and depended on predominant temperatures, being shorter when temperatures were higher (Kruskal Wallis ANOVA:  $H(2df, N=30) = 13.74, p < 0.01$ ). Digestion periods at high temperatures (25°C) differed significantly from those at cold temperatures (15°C) and those at transient temperature. Duration of foraging periods itself also proved to be temperature dependent (Comparison of 25°C / 18°C: Mann-Whitney U-test:  $Z(N=31) = -4.7, p < 0.0001$ ).

Synchronicity was not constant over time. In all colonies synchronicity broke down during the moulting periods and was less pronounced in the last instar (Fig. 3). When the first caterpillars start leaving the tent for pupation the colony breaks up into subgroups, which results in only indistinctly separable activity and resting periods.

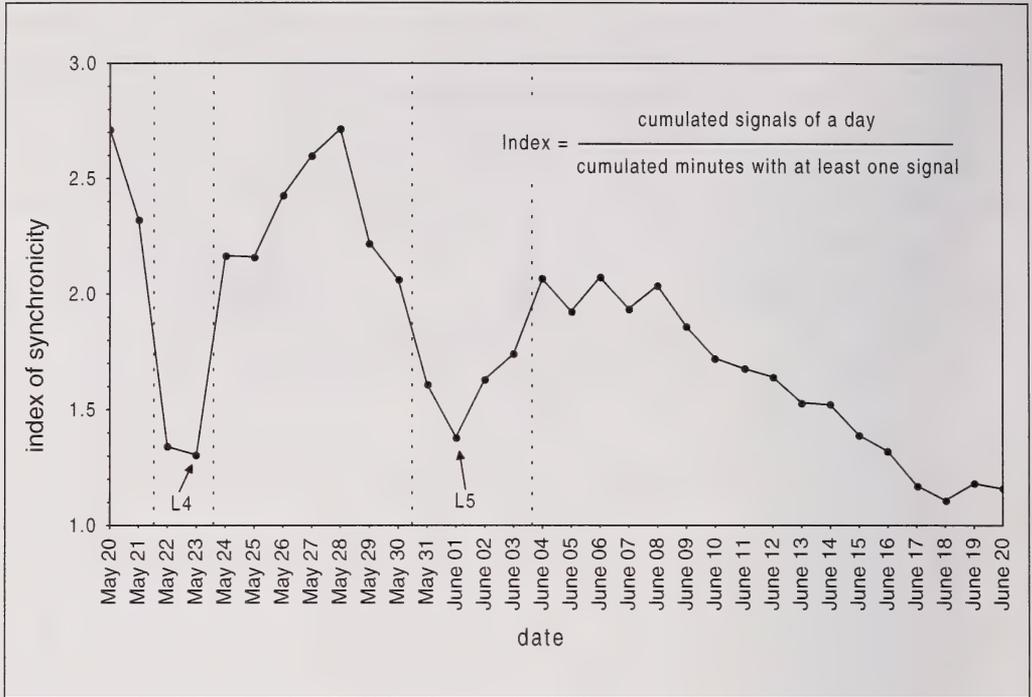
*Macrothylacia rubi*. – Activity of caterpillars of *M. rubi* was completely restricted to nocturnal foraging. Caterpillars first left their hiding place with the onset of total darkness (Fig. 2B, 1) and fed for about two hours ( $114 \pm 42$  min (mean  $\pm$  SD),  $N = 89$  activity periods, pooled data of all caterpillars). Caterpillars then left the plant (Fig. 2B, 2), sometimes by dropping off, thus getting round the light barrier without passing through the beam. No later than at onset of dusk caterpillars looked for a hiding place where they rested during the whole day (Fig. 2B, 3).

Although high temperatures in the laboratory are favourable to ecdysis, moulting time proved to be extremely long in *M. rubi*. Caterpillars stayed in their hiding place for four days before moulting and again one day afterwards (Fig. 4).

*Gastropacha populifolia*. – Caterpillars of *G. populifolia* proved to be highly active by day and night, showing a steady sequence of feeding and resting irrespective of temperature or light regime (Fig. 2C). The number of foraging periods varied between individuals and larval instars, ranging from 3 to 10 per day, but no consistent pattern could be detected. Temperature did not influence the duration of intervals between the foraging periods (time for digestion) significantly (one-way ANOVA design with repeated measurements ( $N=9$  for all categories,  $F_{1,8} = 1.70, p=0.23$ ).



**Fig. 2.** Comparison of daily activity patterns in caterpillars of three different lasiocampid species. Arrows indicate one foraging period. Changes of light regime are indicated by dashed vertical lines (A) or a black and white baseline (B, C). – **A.** *Eriogaster lanestris*: social, active by day and night. – **B.** *Macrothylacia rubi*, solitary, 'aposematic', strictly nocturnal. – **C.** *Gastropacha populifolia*: solitary, active by day and night, 'cryptic'. Note that time axes are different in all graphs for better visibility of all activity periods.



**Fig. 3.** Change of synchronicity in a colony of *E. lanestris* from the late 3rd instar until the members of the colony disperse before pupation. Areas between vertical lines indicate mouling periods, arrows show the date when the first caterpillar of the next instar was detected.

Duration of foraging period depended on temperature, being twice as long during the night (daytime:  $22 \pm 12$ min (N=283; T=25°C); night:  $40 \pm 19$ min (N=274; T=18°C), means  $\pm$  SD, pooled data). Activity periods of male caterpillars tended to be shorter on average than those of females. Nevertheless, only the effect of temperature was statistically significant (two-way ANOVA design with repeated measurements (N=15 for all categories, effect of temperature:  $F_{1,14} = 28.5$ ,  $p < 0.001$ , Effect of sex:  $F_{1,14} = 3.1$ ,  $p = 0.10$ ). Mouling time is characterized by an interruption of feeding for about 2.5 days.

## Discussion

The method presented here differs from those published elsewhere (Fitzgerald *et al.* 1988; Lance *et al.* 1986; Fitzgerald 1980) with respect to comfortable data management. Data are already analyzed in part because the software does not only provide records of the darkening of the light barrier but real counting events. By saving data in a common file format, they can be processed quickly. However, the method implies that caterpillars always leave their feeding place and do not rest directly in the vegetation after feeding. Thus it is, for example, inapplicable to species living and feeding on herbaceous plants.

Continuous long-term monitoring of caterpillar activity by electronic means has at least three great advantages. First, it allows to study cyclic activity patterns over substantial periods of time, which would be impossible through direct observation. Second, disturbance of animals through the observer can be minimized, since only once a day the animals need to be disturbed (when exchanging food). Third, 'rare' behaviours which occur during short periods, such as foraging movements in *M. rubi*, are reliably recorded, but could easily be missed under direct observation.

Our results indicate different strategies in foraging behaviour between species which do not fit the predictions made: Despite its 'aposematic' colour and defence through urticating hairs *M. rubi* surprisingly restricts foraging to the night whereas *G. populifolia* is active throughout the day and feeds whenever digestion has been completed.

At least for *G. populifolia* these results are inconsistent with qualitative observations made in rearing containers where caterpillars were reported to be 'mainly active by night' (Pro Natura 2000). Caterpillars of *M. rubi* can often be observed in late summer during sunny days (e.g. Ebert 1994). However this behaviour most likely serves thermoregulation (sun-basking) rather than the intake of new food. Since in our experimental conditions radiation from artificial light sources was too low to allow for basking behaviour, it is not surprising that no such behaviour was recorded.

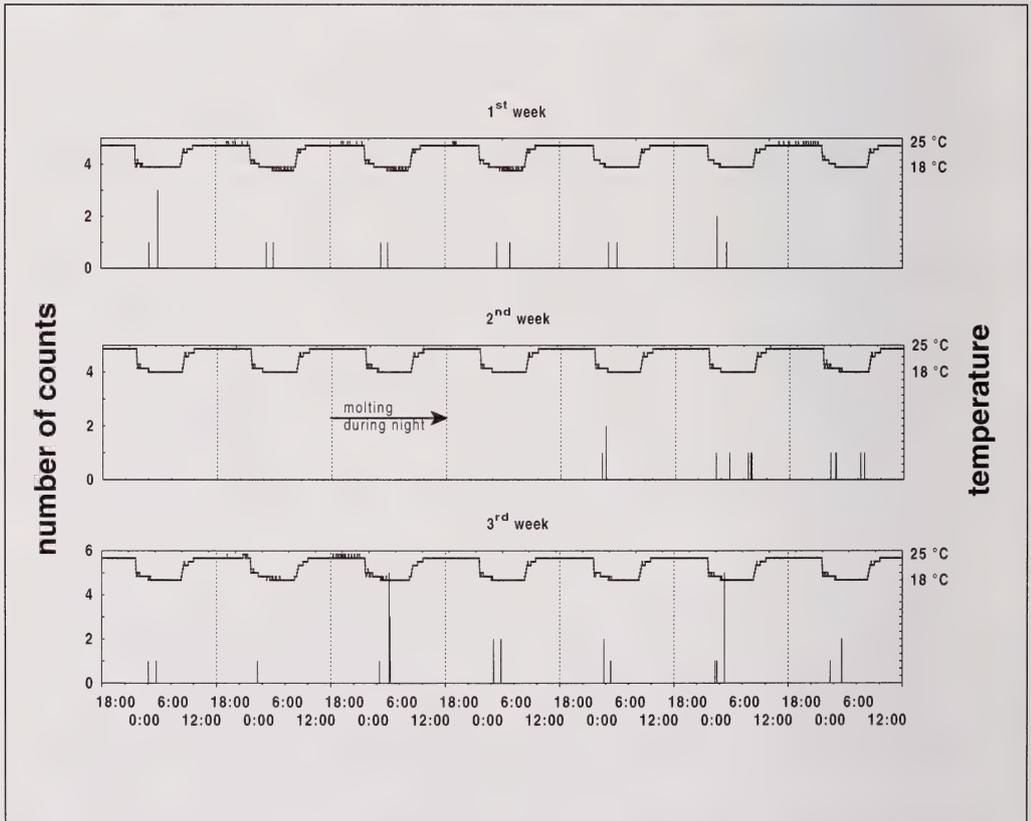
Social larvae of *E. lanestris* foraged in a highly synchronized manner as could be expected in terms of predator avoidance. In our laboratory studies caterpillars were active by day and night. Again, these results are not fully consistent with qualitative observations because published reports on activity patterns in this species vary a lot, ranging from 'active by day and night' (Balfour-Browne 1933) to 'only active by day' or 'only active by night' (Carlberg 1980 and references therein). These inconsistencies in published literature again point to the promising opportunities offered by automatic supervision of caterpillar activity patterns. Evidently, conclusions drawn from intermittent observations and not accounting for environmental conditions may be misleading.

Since our studies took place under standardized laboratory conditions with caterpillars reared in the laboratory which never had experienced any contact to natural enemies, one should expect these larvae to exhibit behaviours which are not modified by biotic or extreme abiotic factors. Obviously selective pressures other than those to enhance food intake or to hide from predators must have played a significant role in shaping feeding behaviour, resulting in the strong interspecific (and probably genetically determined) differences. Abiotic factors may affect foraging behaviour of caterpillars in several ways. High temperatures during daylight may restrict foraging to the night in desert species (Casey 1976), whereas deep temperatures in the night restrict foraging to warm days in arctic caterpillars (Kukal 1993). Anyhow, most caterpillars feed day and night when temperatures in the laboratory are moderate (Casey 1976), indicating that strictly nocturnal or diurnal activity as displayed under natural conditions may often not be fixed genetically.

In our study temperature was always moderate and would have allowed, for physiological reasons, for uninterrupted food intake and processing. Since food was definitely digested in a few hours after feeding caterpillars should therefore not give up

many hours of potential feeding and growing time in daylight, to feed only at lower temperatures in the night. Basically, feeding only at night is costly in terms of time, particularly in north-temperate regions where night-time is short. Nevertheless, caterpillars of *M. rubi* exhibit a strictly nocturnal foraging pattern. Thus, the pattern of foraging only once a day appears as an innate and presumably adaptive behaviour rather than a temporary, environmentally constrained behaviour imposed on a caterpillar by the climatic conditions.

The most common explanation for nocturnal activity is related to the avoidance of visually hunting predators, such as birds. It is generally assumed that most mortality in caterpillars is caused by avian predators (Heinrich & Collins 1983), which is supported by the fact that caterpillars are frequently the main diet for young birds (Nour *et al.* 1998; Seki & Takano 1998). Additionally many caterpillars seem to be perfectly camouflaged by colour or by dissolving the shape of its body which is only useful against predators with a highly evolved visual performance.



**Fig. 4.** Activity pattern of one individual caterpillar of *Macrothylacia rubi* over the course of three weeks. Molting time is extremely long in this species and caterpillars may abandon feeding for five consecutive days. The space between two vertical dashed lines refers to a period of 24 hours.

However, studies on the effectiveness of cryptic coloration of caterpillars in evading predators are incomplete. Nonetheless, there is considerable indirect evidence that cryptic coloration and behaviour reflect the need to avoid predators and thus play an important part in the foraging pattern of insect herbivores (Stamp & Wilkens 1993).

The main problem in judging a caterpillar either to be aposematic or cryptically coloured is caused by the human observer. Scoring a prey as 'cryptic' or 'apparent' depends on the distance between predator and prey and on the discriminatory abilities of the predator (and not that of a human observer) (Endler 1978, 1990). This means that only the predator's perception is relevant for the quality of a caterpillar's crypsis. Studies which include the ultraviolet spectrum indicate that most of the 'cryptically coloured' species investigated were really cryptic to UV sensitive birds but some did not match the background and must be clearly visible to birds (Church *et al.* 1997). Similar qualifications apply if the aposematic nature of a colour pattern is inferred solely on the basis of human perception.

Hairy caterpillars can cause severe contact dermatitis in humans (also called erucism) (Kawamoto & Kumada 1984; Weidner 1936). Nevertheless, the assumption that caterpillars with irritative hairs will also be distasteful for birds often proves wrong. Specialized birds like cuckoos may even prey on pine processionaries and *M. rubi* caterpillars (Pro Natura 2000).

Coloration and defence proved to be poor predictors for larval activity patterns in lappet moths. This not only applied for the three species investigated in this study, but also in other confamilial species (cf. Table 1). Life-history traits may be much more informative, because comparing the species reveals marked differences in life-history.

Daily food intake in *M. rubi* is restricted to a small temporal window and caterpillars are therefore forced to compensate for this cost by a prolonged developmental time. This is possible because caterpillars are strictly univoltine, polyphagous, hibernant as full grown caterpillar, and may feed up to late autumn (Ebert 1994).

In contrast, *G. populifolia* is facultatively bivoltine and under laboratory conditions even polyvoltine. Fast development through frequent foraging may be the best strategy despite the risk of a reduced probability of survival in the field. Activity patterns of *G. populifolia* may therefore be influenced by a trade-off between being apparent during foraging to enhance development and being invisible during digestion to enhance survival. Furthermore, the thoracic eversible setae of *G. populifolia* may be used for defence in case of a bird's attack. Effectiveness of these setae as anti-predator defence has not yet been shown but seems likely as their morphology strongly resembles that of the confamilial species of the genus *Dendrolimus*, where these hairs were found to contain toxic substances (Kawamoto & Kumada 1984).

Life-history traits can also explain activity patterns in social caterpillars. Caterpillars of *E. lanestris* and *Malacosoma* spp. are strictly univoltine and develop very fast in early spring (Fitzgerald 1995; Ebert 1994). In contrast, caterpillars of an undetermined species of the genus *Gloveria* observed by Fitzgerald & Underwood (1998) feed on coniferous trees and have a long developmental time. Activity in this species is again restricted to nocturnal feeding although larvae are very hairy and aposematically coloured.

However, there is no consistent pattern of activity patterns and life history traits (cf. Table 1), indicating that several factors in combination influence feeding and resting behaviour of caterpillars and that generalizations are not appropriate.

Synchronicity of activity is a key factor for social species because it serves many purposes. Strongly synchronized foraging periods minimize conspicuousness to natural enemies. Furthermore synchronicity of all behaviours enhances thermoregulation (Ruf & Fiedler 2000; Casey *et al.* 1988), tent building (Fitzgerald & Willer 1983) and group defence displays (Costa & Pierce 1997).

It is obvious that the daily patterns of activity and rest exhibited by caterpillars under standardized conditions in the laboratory are unlikely to be fully realized under field conditions, where thermal constraints as well as encounters with predators and parasitoids may modify behaviour (Stamp & Bowers 1988). Nevertheless, only laboratory studies which exclude biotic and abiotic constraints on the caterpillars, give insights into genetically determined feeding patterns. Clearly, improved methods of continuously recording caterpillar activity patterns provide a convenient and powerful tool for gathering such knowledge which is crucial to understand the evolutionary ecology of caterpillar foraging more deeply.

### Acknowledgements

This work was in part supported by a grant from the Bayerische Graduiertenförderung to CR. We thank an anonymous reviewer for comments that helped to improve presentation of this paper.

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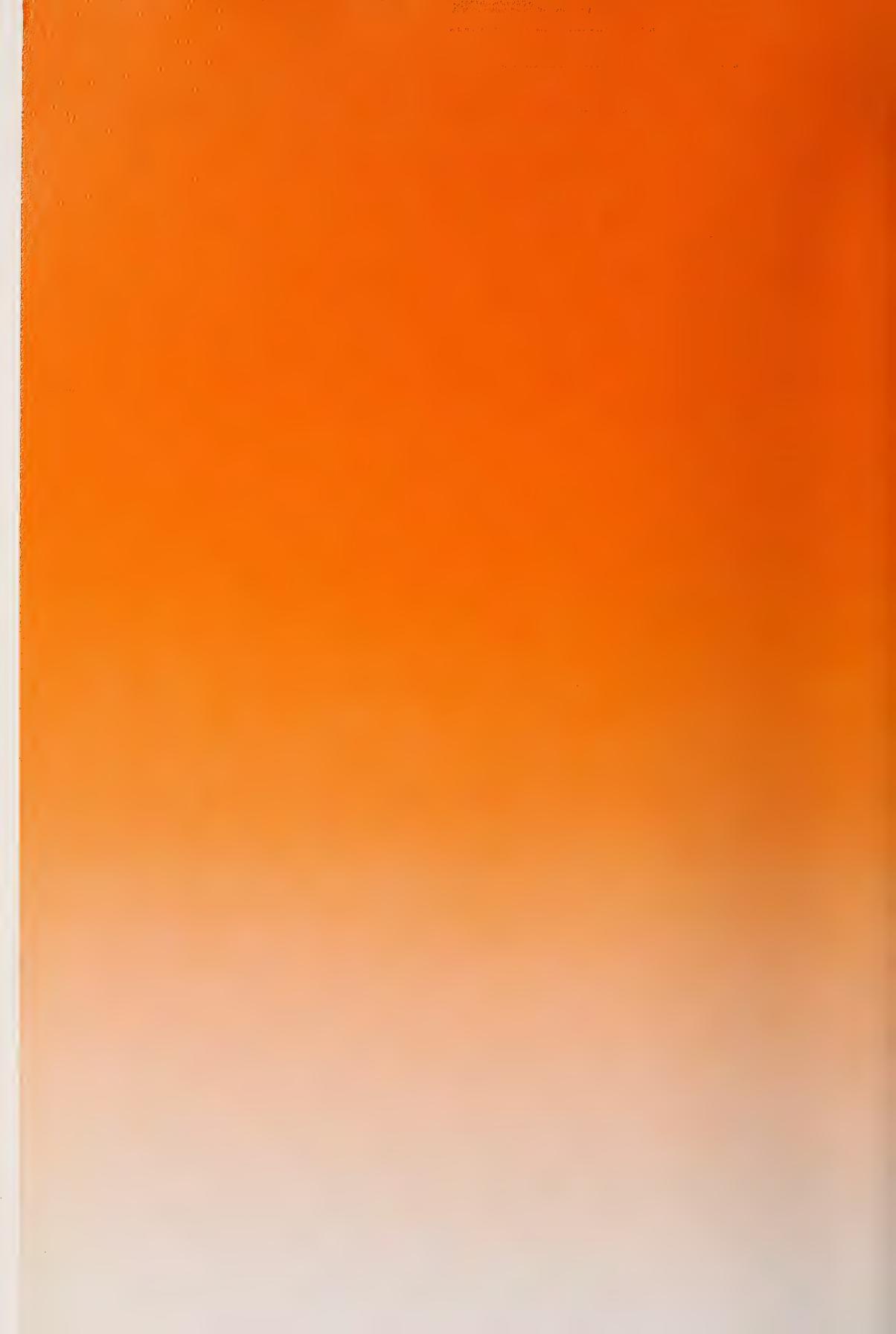
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Halle / Saale, 01. 03. 2002

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The quality of any scientific publication critically depends on the screening of incoming manuscripts. For this goal, experts outside the Editorial Board of *Nota lepidopterologica* are frequently asked to provide constructive criticism. We herewith express our sincere gratitude to all those who have devoted a share of their precious time to serve SEL in this way.

The following colleagues (in alphabetical order) assisted with manuscript reviews for completing volume 24 of *Nota lepidopterologica*:

Martin Corley, Gerfried Deschka, Sven-Ingo Erlacher, Helen Ghiradella, Cees Gielis, Philippe Goffart, Hermann Hacker, Axel Hausmann, Hans-Joachim Hannemann, John B. Heppner, Ronald W. Hodges, Lauri Kaila, Axel Kallies, Niels P. Kristensen, Gerardo Lamas, Miguel L. Munguira, Wolfgang A. Nässig, Gabriel Nève, Janusz Nowacki, Elisenda Olivella, Linda Pitkin, Willi Sauter, Klaus G. Schurian, Andreas Segerer, Joseph Settele, Michael Shaffer, Peder Skou, Chris D. Thomas, Pasquale Trematerra, Paolo Triberti, Robert Trusch, Niklas Wahlberg, Martin S. Warren, Irma Wynhoff, Alberto Zilli.

# The identity of *Tinea megerlella* Hübner, [1810] – a long-lasting confusion between *Elachista* (Elachistidae) and *Adela* (Adelidae)

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**Summary.** Examination of Hübner's [1810] figure (p. 44, fig. 307) demonstrated that the current use of the name *Tinea megerlella* Hübner, [1810] for a species in the genus *Elachista* (Gelechioidea, Elachistidae) is incorrect. We provide evidence that Hübner may have figured a female of the species currently known as *Adela associatella* (Zeller, 1839) (Incurvarioidea, Adelidae). As this newly discovered senior subjective synonym, *Adela megerlella* (Hübner, [1810]), has not been used for the species of *Adela* for more than 100 years, whereas the junior synonym, *A. associatella*, is commonly accepted (at least 26 references, all by different authors, during the past 50 years), our discovery has no effect on the nomenclature of fairy moths (Adelidae): the junior synonym is protected in accordance with ICZN Article 23.9.1. However, the name *Elachista obliquella* Stainton, 1854, should be used for the species currently known as *Elachista megerlella* auct., because the latter name (misidentification) is invalid according to ICZN Article 49. Neotypes designated for both *Tinea megerlella* Hübner and *Elachista obliquella* Stainton are deposited in the Natural History Museum (London).

**Zusammenfassung.** Das Studium von Hübners [1810] Abbildung (p. 44, fig. 307) zeigte, daß die gegenwärtige Nutzung des Namens *Tinea megerlella* Hübner, [1810] für eine Art der Gattung *Elachista* (Gelechioidea, Elachistidae) nicht korrekt ist. Wir erbringen Beweise, daß Hübner vielleicht ein Weibchen der Art, welche gegenwärtig als *Adela associatella* (Zeller, 1839) (Incurvarioidea, Adelidae) bekannt ist, abgebildet hat. Da dieses neu entdeckte, ältere Synonym *Adela megerlella* (Hübner, [1810]) seit über 100 Jahren nicht für eine Art der Gattung *Adela* benutzt wurde, während das jüngere Synonym, *Adela associatella*, häufig Verwendung findet (in mindestens 26 Publikation, alle von verschiedenen Autoren innerhalb der letzten 50 Jahre), hat unsere Entdeckung keine nomenklatorischen Auswirkungen auf Langfühlermotten (Adelidae): das jüngere Synonym behält in Übereinstimmung mit den ICZN Artikel 23.9.1 seine Gültigkeit. Allerdings sollte der Name *Elachista obliquella* Stainton, 1854 für die Art, welche gegenwärtig als *Elachista megerlella* auct. bekannt ist, benutzt werden, da der letztgenannte Name in Übereinstimmung mit ICZN Artikel 49 ungültig ist. Neotypen wurden für *Tinea megerlella* Hübner und *Elachista obliquella* Stainton designiert; ihr Aufbewahrungsort ist das Natural History Museum (London).

**Résumé.** L'étude de la figure d'Hübner [1810] (p. 44, fig. 307) a permis d'établir que l'usage actuel du nom *Tinea megerlella* Hübner, [1810] pour une espèce appartenant au genre *Elachista* (Gelechioidea, Elachistidae) est incorrect. Nous apportons les éléments permettant d'affirmer que Hübner pourrait bien avoir figuré une femelle appartenant à l'espèce connue actuellement sous le nom de *Adela associatella* (Zeller, 1839) (Incurvarioidea, Adelidae). En vue du fait que ce synonyme subjectif plus ancien, *Adela megerlella* (Hübner, [1810]), n'a été employé pour aucune espèce d'*Adela* pendant plus de 100 ans, tandis que le synonyme plus récent *A. associatella*, est généralement accepté (au moins 26 références, toutes d'auteurs différents, durant les 50 dernières années), notre découverte n'a aucune incidence quant à la nomenclature des Adelidae: le synonyme plus récent étant valide conformément au Code (4<sup>e</sup> éd., article 23.9.1). Néanmoins, le nom *Elachista obliquella* Stainton, 1854 devrait en fait être employé pour l'espèce actuellement connue comme *Elachista megerlella* auct., ce dernier nom étant non valide (erreur d'identification) d'après le Code (4<sup>e</sup> éd., article 49). Des Néotypes, déposés au Natural History Museum (London), sont désignés aussi bien pour *Tinea megerlella* Hübner que pour *Elachista obliquella* Stainton.

**Key words.** Lepidoptera, Elachistidae, Adelidae, identity, type-material, nomenclature.

## Introduction

The early history of many names of European Microlepidoptera appears rather confusing. In the course of revisionary work on fairy moths (Adelidae) one of us (MK) discovered two old references to *Tinea megerlella* Hübner as a member of the family

Adelidae (Incurvarioidea). However, this name has more recently been used, as *Elachista megerlella*, for a moth of the family Elachistidae (Gelechioidea). As Adelidae and Elachistidae are externally very different, we attempted to clarify the identity of *T. megerlella* Hübner and consider the nomenclatural implications for both families.

### The identity of *Tinea megerlella* Hübner, [1810]

Hübner [1825] included *T. megerlella* in the genus *Antispila*, along with species currently placed in the families Micropterigidae, Nepticulidae, Tineidae, Oecophoridae and Elachistidae, whereas the species of Adelidae were placed in other genera. Stephens (1829: 226) listed *megerlella* without a generic name; later on, he published (Stephens 1834: 355) the very first, although short, description of this species (as *Amaurosetia megerlella*, with reference to Hübner's plate), mentioning in particular narrow ('slender') hindwings. We found no indication that Stephens doubted whether his species was the same as that illustrated in Hübner's work. Treitschke (1833) did not mention *T. megerlella*. Herrich-Schäffer (1835) included *T. megerlella* (as '- Megerl 307. 3') in his 'Nomenclator' (p. 32). He did not possess any specimen of this species, as shown by the minus sign in front of the species' name. However, he did not consider the species rare or very difficult to obtain, as indicated by a modest exchange value (3) ascribed to *T. megerlella*: the highest value among the *Tinea* (sensu lato) included in his list was 6. Douglas (1854) and Stainton (1854) redescribed '*megerlella*', using the combination *Elachista megerlella*, with reference to both Hübner (with a question mark in Douglas' work) and Stephens; examination of historical collections (Bradley 1963) demonstrated that both these authors possessed specimens of the species currently known as *Elachista megerlella* auct.

Herrich-Schäffer [1855] was probably the first to discover the mismatch between the figure by Hübner and the later use of Hübner's name: he attributed *Poeciloptilia megerlella* to Stainton (Herrich-Schäffer, [1855]: 303) and mentioned '? *megerlella* Hb.' as a synonym of *Adela associatella* Zeller, 1839 [Herrich-Schäffer, 1855: Index, p. 5]. However, a majority of subsequent researchers have used the specific name (attributed to Hübner) for the *Elachista* species, although occasionally (Curó & Turati 1882: 15) it was listed as a synonym of *A. associatella*. To the best of our knowledge, this name has not been associated with any other European moth, and therefore we have chosen to compare (Table 1) the characters of *Tinea megerlella* Hübner (Fig. 1), *Elachista obliquella* Stainton (= *megerlella* auct.) (Fig. 2) and *Adela associatella* Zeller (female, Fig. 3).

Although only a few characters can be seen in Hübner's figure, there is no doubt that *Tinea megerlella* has a wide hindwing with relatively short cilia (Fig. 1), whereas all *Elachista* species possess a narrow hindwing with long cilia (Fig. 2). Another important difference concerns the size of the moth, as measured from the original figure. Hübner appeared to be extremely precise in providing an 'average' size of the moths: for the remaining six species from the same plate (Tineae 1, Vol. 8) the correlation between the wing expanse measured from the figure and the median wing expanse published in recent revisions is extremely high (Fig. 4). *Tinea megerlella* Hübner is larger than *E. obliquella* but perfectly fits the size of *A. associatella* (Fig. 4). Two other

**Tab. 1.** Comparison between *Tinea megerlella* Hübner, *Elachista obliquella* Stainton (= *megerlella* auct.) and *Adela associatella* Zeller (female).

Character	<i>Tinea megerlella</i>	<i>Elachista obliquella</i>	<i>Adela associatella</i>
Wing expanse (mm)	11.2	8–10	10–12
Antenna/forewing ratio	0.8	0.65–0.70	0.85–0.95
Forewing colour	yellowish brown <sup>1</sup>	gray	yellowish brown
Forewing cilia at apex	unicolours	with white spot	unicolours
Shape of hindwing	wide	narrow	wide
Cilia of hindwing	short	long	short

characters, the relative length of the antenna and the colour of the forewing cilia, are less reliable; however in these points Hübner's figure also differs from *E. obliquella* but is similar to *A. associatella*.

The most problematic character of *T. megerlella* is the forewing colour, which is coppery brown in the printed (and hand-painted) copies of the Hübner's book. This character is clearly different from both *E. obliquella* (forewing grey) and *A. associatella* (forewing brown, with scattered pale yellow scales and bronze iridescence). However, on the original watercolour figure (Hübner [1785]: [71]) the forewing colour is brown, suffused with minor yellow spots; also the yellow band of the fascia is bordered by dark (coppery?) brown bands. We therefore conclude that *Tinea megerlella* Hübner is not a member of Elachistidae, but most likely the species currently known as *Adela associatella* (Zeller, 1839). Since the collection of Hübner is lost, and the figure of the holotype may not be sufficient to unequivocally reveal the species' identity, we have selected a female neotype of *Tinea megerlella* to assure further stability in the use of this specific name. However, to assure stability of the nomenclature we consider this newly discovered senior subjective synonym of *A. associatella* as *nomen oblitum*.

### *Adela megerlella* (Hübner, [1810]) sp. rev.

*Tinea megerlella*: Hübner [1810], pl. 44 fig. 307.

*Antispila megerlella*: Hübner [1825]: 419.

*Adela megerlella*: Herrich-Schäffer [1855], index: 5; Curó & Turati 1882: 15 (both as a synonym of *A. associatella* Z.)

Neotype ♀ (here designated): Switzerland, Zürich; labelled: 8 mm circle with red border, print 'Neotype'; 4 × 12 mm, in black ink 'Zurich'; 6 × 11 mm, print 'Frey Coll. | Brit. Mus. | 1890-62'; 10 × 18 mm, print 'NEOTYPE ♀ | Tinea megerlella | Hübner [1810], Fig. 307 | design. M. Kozlov, 2001' (BMNH).

**Diagnosis.** For the differences from *Elachista obliquella*, see Table 1. For the differences from other species of the genus *Adela* Latr. consult the diagnostic traits of *A. associatella* (Wojtusiak 1972; Razowski 1978; Zaguljaev 1978; Küppers 1980).

**Note.** The exact type locality of *T. megerlella*, as of many other species described by Hübner, remains unknown. The only geographical information which can be extracted

<sup>1</sup> As on the original water-colour (brown to coppery brown in printed and hand-painted copies)



Fig. 1. *Tinea megerlella* Hübner (after Hübner, [1810], pl. 33, fig. 307). Fig. 2. Neotype of *Elachista obliquella* Stainton.



Fig. 3. *Adela associatella* (Zeller), female.

from Hübner [1825] is that this species was not recorded in Augsburg (because *T. megerlella* is not marked with an asterisk in the referred publication).

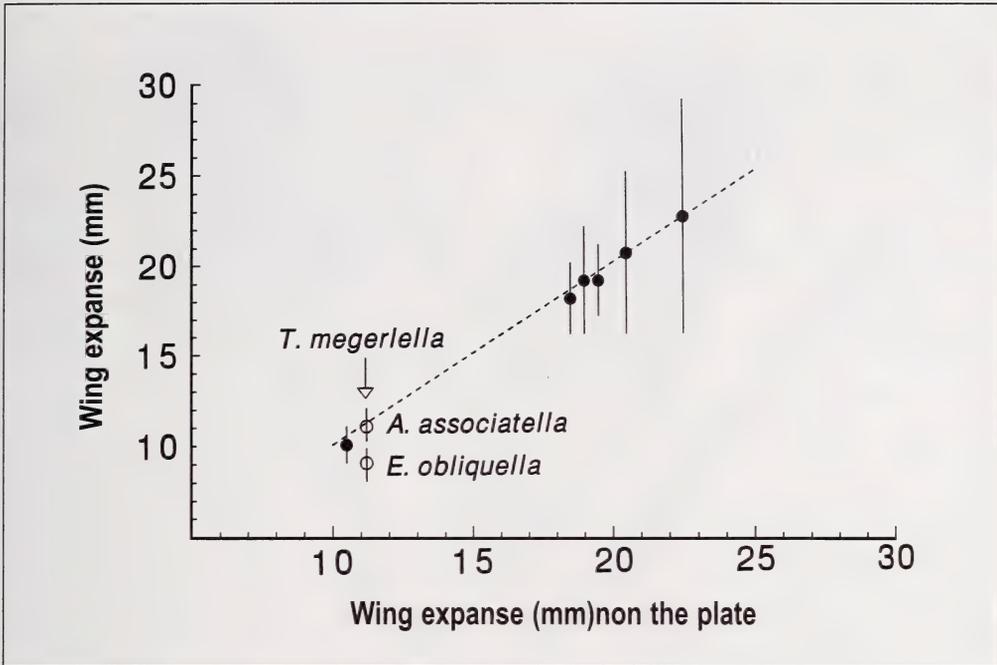
### *Adela associatella* (Zeller, 1839), nomen protectum

*Tinea megerlella* Hübner, [1810], nomen oblitum

To the best of our knowledge, the newly discovered senior synonym had never been used as such for the species in question, and only twice (Herrich-Schäffer [1855]; Curó & Turati 1882) was listed as a possible synonym of *A. associatella*. Although the specific name *megerlella* had been repeatedly used for a species of the family Elachistidae, this use is invalid as based on misidentification (ICZN Article 49). Therefore we conclude that the conditions of ICZN Article 23.9.1.1 are met. We are aware of the fact that the latter conclusion can be contested<sup>2</sup>; however, we believe that our interpretation of the Article 23.9.1, aimed at maintenance of nomenclatural stability, is in line with the basic principles of ICZN.

The more or less comprehensive bibliography (to be published in the forthcoming revision of the genus *Adela* by MK) includes about 100 references to *A. associatella* (preferentially in combination with the generic name *Nemophora*), among which 26

<sup>2</sup> In particular, Dr. I. M. Kerzhner did not accept this conclusion and advised us to apply to the International Commission of Zoological Nomenclature in order to suppress the principle of priority in this specific case.



**Fig. 4.** Correspondence between the wing expansion of moth specimens figured on the plate 'Tineae 1' by Hübner [1810] (horizontal axis) and the wing expansion published in recent major revisions (vertical axis). Recent data are shown as the interval between minimum and maximum values; circles indicate median values; regression is calculated for the median values of all species except *Tinea megerlella* (filled circles):  $y = 1.04 * x$  (H: intercept  $\neq 0$  rejected,  $P = 0.12$ ),  $R^2 = 0.99$ ,  $P < 0.0001$ .

sources, all by different authors, were published in 1951–2000. Thus, the conditions of ICZN Article 23.9.1.2, which requires that the junior synonym is used as the valid name in at least 25 publications during the last 50 years, are also met. Furthermore, all major revisions (Razowski 1978; Küppers 1980), keys (Wojtusiak 1972; Zaguljaev 1978) and checklists (Wojtusiak 1996; Leraut 1997) have consistently applied this name, which can be considered as sufficient proof of its universal usage. Therefore, in accordance with the procedure described in ICZN Article 23.9.2), the application of the principle of priority is moderated, and the prevailing usage of the junior subjective synonym, *Adela associatella* (Zeller, 1839), is maintained.

#### *Elachista obliquella* Stainton, 1854

*Amaurosetia megerlella* auctorum, non Hübner [1810]: Stephens 1834: 355.

*Elachista megerlella* auctorum, non Hübner [1810]: Stainton 1854: 258–259; Douglas 1854: 211, pl. 18 fig. 2; Stainton 1858: 74–83, pl. 2 fig. 2; Bradley 1963: 153–155; Traugott-Olsen & Nielsen 1977: 119–120, figs. 108, 109, 208, 353, 354, 471, 472; Biesenbaum 1996: 84, pl. 7 fig. 41; Parenti 1996: 71.

Neotype ♀ (here designated): Great Britain, London; labelled: 8 mm circle with red border, print 'Neotype'; 10 × 15 mm, in black ink 'E. megerlella | Pope's lane | Ealing | 26.5.[19]08'; 4 × 16 mm, print 'S. N. A. Jacobs Coll. | B. M. 1977-420'; 10 × 18 mm, print 'NEOTYPE ♀ | *Elachista obliquella* | Stainton, 1854 | L. Kaila design. 2001'; B.M. genitalia slide 29825 (BMNH).



Fig. 5. Neotype of *Elachista obliquella* Stainton. Male genitalia (B.M. genitalia slide 29825).

**D i a g n o s i s .** External appearance (Fig. 2) and male genitalia characteristics (Fig. 5) allow reliable identification of the species. For more information, consult description of *E. megerlella* (auct.) by Traugott-Olsen & Nielsen (1977).

The original syntypes of *E. obliquella* (two specimens from London), according to the original description, were kept in the Edelstain collection; their whereabouts are unknown (presumably lost). Therefore we have selected a neotype to assure the stability of the further use of this specific name. The type locality for the selected neotype is now within the city of London; this fits perfectly to Stainton's note (1854: 258) that the syntypes were collected around London.

We see no such particular significance in the past application of the name *megerlella* to *E. obliquella* that it would justify an application to the International Commission of Zoological Nomenclature, asking for some actions required to conserve the recent use of *E. megerlella* auctorum. The species in question has no economic importance, and the total number of publications on the family Elachistidae is relatively small. The stability in the nomenclature of Elachistidae can anyway be questioned due to very frequent misconcepts of nominal taxa. All these facts justify the simple solution of the problem – replacement of an incorrectly used specific name by a valid name, which had long been considered a junior subjective synonym of *E. megerlella* auctorum. The name *E. obliquella* is also known to lepidopterists, and the identity of it can easily be revealed, because the major revisions (Traugott-Olsen & Nielsen 1977; Kaila 1999) list both names.

## Acknowledgements

M. Kozlov thanks SYS-Resource (EC Programme *Access to Research Infrastructures*) for the financial support of the study visit to the Natural History Museum in London. We are very much indebted to G. S. Robinson and K. R. Tuck for useful discussions, and to K. Sattler, O. Karsholt and one anonymous referee for critical comments to the manuscript.

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## *Luffia palmensis* sp. n., eine neue Psychide von den Kanarischen Inseln (Psychidae)

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**Summary.** Larval cases of a *Luffia* species were found on the Canary Island La Palma in February 2000. In April 2000, three males and five females emerged from these cases. Investigation of these specimens showed that they belong to a new species, here described as *Luffia palmensis* sp. n. This new species is distinguished from the related species *Luffia rebeli* Walsingham, 1908 occurring on Tenerife and *L. gomerensis* Henderickx, 1996 occurring on La Gomera by its habitat, phenology, wing index and wing pattern of the males. The breeding of a F1-generation succeeded and is described. Larvae fed on lichen provided on pieces of bark, development in captivity took about one year.

**Zusammenfassung.** Im Februar 2000 wurden auf der Kanareninsel La Palma Raupensäcke einer *Luffia*-Art gefunden. Die Aufzucht ergab im April 2000 drei Männchen und fünf Weibchen einer neuen Art, die als *Luffia palmensis* sp. n. beschrieben wird. Diese neue Art unterscheidet sich deutlich von den auf den Nachbarinseln Teneriffa und La Gomera vorkommenden *Luffia rebeli* Walsingham, 1908 und *L. gomerensis* Henderickx, 1996 durch Ökologie, Flügelindex und Flügelzeichnung der Männchen. Es gelang die Zucht einer F1-Generation, deren Verlauf beschrieben wird. Die Larven wurden mit Flechten gefüttert, welche auf Rindenstücken gereicht wurden. Die Entwicklung unter künstlichen Bedingungen dauerte ein Jahr.

**Résumé.** En février 2000, des fourreaux d'une espèce de *Luffia* ont été trouvées dans l'île de La Palma (Îles Canaries), dont trois mâles et cinq femelles ont éclost en avril 2000. Une étude de ces spécimens a révélé qu'ils appartiennent à une nouvelle espèce, décrite ici comme *Luffia palmensis* sp. n. Cette espèce nouvelle diffère de ses proches parents *Luffia rebeli* Walsingham, 1908 de Tenerife et *L. gomerensis* Henderickx, 1996 de Gomera par son habitat, sa phénologie, son indice alaire et les dessins alaires du mâle. L'élevage d'une génération F1 a réussi et est décrit. Les chenilles se nourrissaient de lichen obtenu de morceaux d'écorce et le développement en captivité prit environ un an.

**Key words.** Lepidoptera, Psychidae, *Luffia palmensis* sp. n., La Palma.

### Einleitung

Die nach bisherigem Kenntnisstand auf die Westpaläarktis beschränkte Gattung *Luffia* Tutt, 1899 umfaßt nach Sauter & Hättenschwiler (1991, 1999) drei bekannte, äußerlich sehr ähnliche Arten. *Luffia lapidella* (Goeze, 1783) ist atlanto-mediterran verbreitet. Neben der Nominatform sind zwei weitere Formen beschrieben: f. *ferchautella* (Stephens, 1850), die sich ausschließlich parthenogenetisch fortpflanzt, und f. *magierella* (Chapman, 1901) mit einem Männchenanteil von ein bis fünf Prozent. Zwei weitere Arten sind auf den Kanarischen Inseln endemisch: *Luffia rebeli* Walsingham, 1908 auf Teneriffa und *L. gomerensis* Henderickx, 1996 auf La Gomera.

Die Weibchen der Gattung *Luffia* sind – wie bei den meisten Arten der Psychidae – flügellos, womit die Ausbreitungsmöglichkeiten eingeschränkt sind und sich im wesentlichen auf das Raupenstadium reduzieren.

Während einer Reise Ende Februar 2000 nach La Palma, die speziell dem Studium von Psychiden galt, wurden außer der bekannten *Amicta cabrerai* (Rebel, 1894), die an einer Vielzahl von Lokalitäten vorkommt, auf der Ost- und Nordostseite der Insel Säcke einer *Luffia*-Art an mehreren Stellen festgestellt, deren Artzugehörigkeit vorerst nicht geklärt werden konnte. Der Vergleich der Imagines mit den bekannten Arten

führte zu der Erkenntnis, daß es sich bei der gefundenen Psychide um eine bisher unbekannte Art handelt, die im Folgenden beschrieben wird.

### *Luffia palmensis* sp. n.

**Untersuchtes Material.** – Holotypus ♂ (inkl. Sack und Exuvie) La Palma, Los Tilos, 23.iv.2000 (e. l.), Museum für Tierkunde Dresden. Paratypen: Gleiche Daten, aber ♀ 12.iii.2000 (e. l.), ♀ 12.iv.2000, ♀ 14.iv.2000, ♂ 17.iv.2000, ♀ 19.iv.2000, ♂ 24.iv.2000, ♀ 24.iv.2000, ♀ 26.iv.2000; 10♂, 10♀ (e. o.) (F1-Zucht) 6.iv.–29.iv.2001 (alle Paratypen inkl. Sack und Exuvie), coll. Hättenschwiler, Henderickx, Sobczyk et Museum für Tierkunde Dresden.

**Männchen** (Abb. 1, 3–4). – Flügelspanne 9,7–10,0 mm; Länge der Vorderflügel (inkl. Fransen) 4,8–5,0 mm (n = 11).

**Kopf.** – Fühler bräunlich, doppelt kammzählig; 21–23 Glieder (ein untersuchtes Exemplar mit nur 19 Fühlergliedern), länger als die halbe Vorderflügelänge (Verhältnis Fühlerlänge zu Vorderflügelänge = 0,57–0,60); Fühlerglieder beschuppt; Kammzähne bewimpert, etwa auf dem 8. Glied die maximale Länge erreichend (Verhältnis Fühlerglied zu Kammzahn = 1,0); Augen oval, kleinster Augenabstand entspricht der Augenhöhe; Labialpalpen reduziert; Kopf grau behaart.

**Thorax.** – Dicht grau behaart; von gleicher Farbe wie Beine und Abdomen.

**Beine.** Vorderbein mit Epiphyse, Mittelbein mit einem, Hinterbein mit zwei Spornpaaren an der Tibia; anliegend grau behaart.

**Abdomen.** – Hinterleibssegmente schwach sklerotisiert; dicht grau behaart.

**Vorderflügel.** – Länge der Vorderflügel (inkl. Fransen) 4,8–5,0 mm, Breite 1,9–2,2 mm; breitflügelig; Flügelindex (Verhältnis der Vorderflügelbreite auf der Hälfte der Vorderflügelänge zur Vorderflügelänge) >0,40; neun Adern aus der Mittelzelle, mit Anhangzelle, Adern m<sub>3</sub> und cul ungestielt; Grundfarbe der Vorderflügel grau mit auffallend kontrastreichen weißen Flecken; Zeichnung neigt im Bereich des Außenrandes zum Zusammenfließen, bildet ein schmales fleckiges Band; größerer, weißlich beschuppter Bereich am Hinterrand der Vorderflügel im basalen Flügeldrittel ausgeprägt; Beschuppung dicht, Deckschuppen breit (Klasse 5–6 nach Sauter 1956), vielzackig; Fransen weißlich und grau gemischt.

**Hinterflügel.** – Hinterflügel grau, Fransen weißlich und grau gemischt; Schuppen meist zweizackig; Apex leicht gerundet.

♂ **Genital** (Abb. 4). – Saccus länger als breit, gedrunken; Sacculus gekrümmt, am Ende mit einigen kurzen stumpfen Dornen; Tegumen gerundet, Tegumendach eingekerbt; Aedeagus wenig gebogen, etwa zwei Drittel der Genitallänge erreichend.

Die Untersuchung der Genitalstrukturen (n = 4) ergab keine offenkundigen Unterschiede zu den bekannten Arten der Gattung *Luffia*, auch die übrigen Arten dieser Gattung sind voneinander anhand der Genitalstrukturen nicht unterscheidbar.

**Weibchen** (Abb. 2, 5). – Flügellos; Grundfarbe gelblichgrau (n = 12).

**Kopf.** – Die Antennen zurückgebildet; aus 7–9 kurzen Gliedern bestehend, unbeschuppt; Augen klein; Verhältnis größter Augendurchmesser zu kleinstem Augenabstand 2,3–2,5.

**Thorax.** – Thorax mit stärker sklerotisierten, braun gefärbten Bereichen, die lateral schmaler werden; ventral keine ausgeprägte Sklerotisierung.



Abb. 1. *Luffia palmensis* sp. n. ♂ Holotypus.



Abb. 2. *Luffia palmensis* sp. n. ♀ Paratypus.

**Abdomen.** – Locker dunkelgrau beschuppt, überwiegend Schuppenklasse 4–6 nach Sauter (1956); Legeröhre sehr lang, im ausgestreckten Zustand (beim Locken oder der Eiablage) etwa der Körperlänge entsprechend; Afterwolle gelblich-weißlich, als Kranz auf dem 7. Hinterleibssegment ausgebildet.

**Beine.** – Voll entwickelt; meist 3, selten 4 Tarsenglieder; erstes Tarsenglied der Vorderbeine bei 10 der 12 untersuchten Weibchen doppelt so lang wie zweites Tarsenglied; Hinterbeine kürzer als Mittel- und Vorderbeine.

**♀ Genital.** – Ovipositor lang gestreckt, Postvaginalplatte unbedornt. Ostium bursae halbrund ausgeformt.

**Säcke.** – Länge (n = 45) 6 mm, sich zur Spitze stark verjüngend; Durchmesser 2 mm, Querschnitt rund; kein auffälliger Geschlechtsdimorphismus; meist mit Flechtenteilchen, die dem Sack eine graugrüne Farbe geben, belegt (gelegentlich auch kleine mineralische Teilchen oder Pflanzenstückchen); innen mit feinen Gespinstfäden ausgekleidet.

**Diagnose.** – *L. palmensis* sp. n. ist sowohl geographisch als auch durch die Flugzeit der Falter von den verwandten Arten *L. lapidella*, *L. rebeli* und *L. gomerensis* isoliert. Während die bisher bekannten Arten vor allem trockenwarme Habitate (Felsen, besonnte Stämme) besiedeln, liegt der Typenfundort von *L. palmensis* sp. n. im Bereich der Lorbeerwälder an geschützten, schattigen Stellen mit sehr hoher Luftfeuchte und ausgeglichenen Temperaturverhältnissen. Von den verwandten Arten unterscheidet sich *Luffia palmensis* sp. n. strukturell vor allem durch den hohen Flügelindex. Weiterhin weist keine der bisher bekannten Arten eine derart kontrastreiche, helle Zeichnung auf. Im Saumbereich ist ein aus weißen Schuppen bestehendes durchgehendes Band ausgeprägt, das bei den anderen Arten fehlt oder in kleine Flecken aufgelöst ist (Tab. 1).

**Vorkommen.** – Die Nachweise beschränken sich auf die Felsen im Osten und Nordosten der Insel La Palma. Säcke fanden sich in Los Cancajos, San Isidro und Los Tilos. Das Mikroklima an den einzelnen Fundorten ist sehr unterschiedlich. Die Säcke aus Los Cancajos (ca. 15) wurden an Felsen etwa 50 m vom Strand entfernt gefunden. Diese wiesen auch tagsüber eine gewisse Feuchte auf. Flechten waren kaum sichtbar. Leider waren die Larven ausnahmslos durch Hymenopteren parasitiert. Am Fundort San Isidro befanden sich leere Säcke (ca. 15) an einer Trockenmauer, die zum Teil voll besonnt und aufgeheizt war. In Los Tilos schließlich befanden sich etwa 40 Säcke an dicht mit Flechten überzogenen, nassen Felsen bis in eine Höhe von 900 m. Es ist zu vermuten, daß bei intensiver Suche in den Barancos im Nordosten der Insel weitere Nachweise gelingen.

**Lebensweise.** – Die Säcke von Los Tilos enthielten zum Zeitpunkt der Aufsammlung (13.ii.2000) fast erwachsene Raupen. Die Falter schlüpfen im April. Beim Schlupf des Männchens schiebt sich die Puppe bis zur Hälfte aus dem Sack, die weibliche Exuvie hingegen verbleibt im Sack. Unter Zuchtbedingungen verließen die Falter zwischen 18:20 Uhr und 20:10 Uhr (MESZ) die Puppen. Als Schlupfzeit der Weibchen wurde der Zeitraum von 14:10–17:10 Uhr (MESZ) registriert. Die männlichen Falter erreichen innerhalb von 10 Minuten nach dem Schlupf Flugfähigkeit und fliegen sofort zu paarungsbereiten Weibchen (einzige vollständig beobachtete Kopulations-

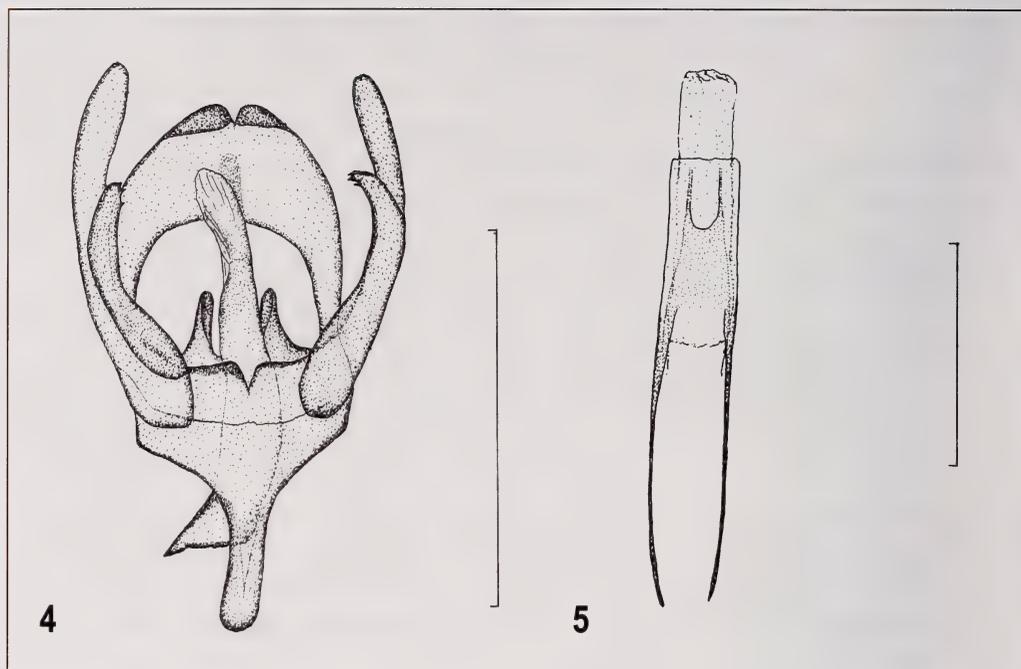
**Tab. 1.** Vergleich von Merkmalen der Gattung *Luffia* (Männchen). Die Angaben zu *Luffia rebeli* und *L. gomerensis* beinhalten neben eigenen Untersuchungen Daten aus Henderickx (1996).

	<i>L. lapidella</i>	<i>L. rebeli</i>	<i>L. gomerensis</i>	<i>L. palmensis</i> sp. n.
Fühlerglieder	20–24 (n = 15)	23, 24 (n = 2)	23, 24 (n = 2)	(19) 21–23 (n = 5)
Vorderflügelänge	3,7–4,9 mm	3,8–5,0 mm	3,6–4,1 mm	4,8–5,0 mm
Vorderflügelbreite	1,6–1,9	1,5–1,8 mm	1,2–1,5 mm	1,9– 2,2 mm
Vorderflügelindex	0,30–0,40	0,30–0,40 (0,44)	0,36–0,38	0,41–0,46
Zeichnung	grau, verwaschen, schwach gegittert, ohne deutliche Zeichnungselemente	grau, verwaschen schwach gegittert, ohne deutliche Zeichnungselemente	grau, weißliche Zeichnung – insbesondere Fleck im ersten Drittel der Vorderflügel, im Saumbereich einzelne helle Flecken	grau, kontrastreich weißliche Zeichnung überwiegt, im Saumbereich flächig zusammenfließend, im durchgehendes Band bildend
Flugzeit	Juli/ August	Mai/Juni	Februar	April
Verbreitung	West-, Mittel- und Südeuropa	Teneriffa	La Gomera	La Palma

**Abb. 3.** *Luffia palmensis* sp. n. ♂: Fühler. Mikropräparat Sobczyk 210-2000 (Scale 0,5 mm).

dauer: 140 Sekunden). Die flügellosen Weibchen beginnen anschließend sofort mit der Eiablage in den Sack. Nach etwa einem Monat schlüpfen die Eiräupchen (etwa 50 je Weibchen). Diese F1-Generation wurde im Verlaufe eines Jahres unter Zimmerbedingungen bis zum Falter gezogen. Es wird angenommen, daß auch unter Freilandbedingungen die Entwicklung einjährig ist. Die Säcke wurden in Blumentöpfen mit Rindenstücken, die mit Flechten bewachsen waren, gehalten und täglich mit Wasser besprüht. Die Raupen sind vor allem abends aktiv, weiden die Flechten ab und wechseln die Fraßstellen nur bei Nahrungsmangel oder Austrocknung.

Das Geschlechterverhältnis in der vorliegenden Stichprobe beträgt 13 ♂ zu 16 ♀. Insbesondere weisen der Männchenanteil bei der F1-Zucht von 50% sowie fünf beobachtete Paarungen darauf hin, daß *L.*



**Abb. 4.** *Luffia palmensis* sp. n. ♂: Genital, ungequetscht, Valven leicht gebreitet. Mikropräparat Sobczyk 211-2000. **Abb. 5.** *Luffia palmensis* sp. n. ♀: Genital, Postvaginalplatte mit Ostium bursae (Ovipositor angedeutet). Mikropräparat Sobczyk 22-2001 (Scales 0,5 mm).

*palmensis* sich regulär bisexuell und nicht parthenogenetisch fortpflanzt (vgl. Chapman 1901).

**Derivatio nominis.** – Die Benennung von *L. palmensis* sp. n. erfolgt nach der Insel La Palma, wo diese Art entdeckt wurde und vermutlich endemisch ist.

#### Danksagung

Ich danke den Herren P. Hättenschwiler (Uster, Schweiz) und H. Henderickx (Mol, Belgien) für die vielfältige Unterstützung, Herrn H. Henderickx insbesondere für die Überlassung von Vergleichsmaterial von *L. gomerensis* und *L. rebeli*. Weiterhin danke ich Herrn Dr. M. Nuß (Dresden) für die kritische Durchsicht des Manuskripts.

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## *Phyllonorycter irmella*: a junior synonym of the common *P. lautella* (Gracillariidae)

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**Summary.** *Phyllonorycter irmella* (Palm, 1947) is synonymised with *Ph. lautella* (Zeller, 1846) after study of the holotype from Sweden and the single other specimen, from the Netherlands. Both specimens are worn and therefore show a reduced colour pattern. Since the typelocality of *Ph. irmella* is out of the range of its host *Quercus*, we assume that the specimen either was introduced with plants, a casual vagrant, or that the record is due to mislabelling.

**Zusammenfassung.** *Phyllonorycter irmella* (Palm, 1947) wird mit *Ph. lautella* (Zeller, 1846) synonymisiert, nachdem der Holotypus (aus Schweden) und das einzig andere Stück (aus den Niederlanden) untersucht wurden. Beide Tiere sind abgeflogen und zeigen daher ein reduziertes Fleckenmuster. Da die Typenlokalität von *Ph. irmella* vom nächstliegenden Vorkommen der Futterpflanze *Quercus* weit entfernt ist, nehmen wir an, dass es sich beim Holotypus um ein eingeschlepptes oder eingewandertes Tier handelt, oder dass es falsch etikettiert ist.

**Résumé.** Après l'étude de l'holotype, provenant de la Suède, et le seul autre exemplaire, provenant des Pays-Bas, la synonymie de *Phyllonorycter irmella* (Palm, 1947) avec *Ph. lautella* (Zeller, 1846) est établi. Les deux exemplaires étaient en mauvais état, et en conséquence montrent un dessin réduit. Parce que le localité typique étant éloigné de l'aréal du plant-hôte *Quercus*, nous considérons qu'il s'agit d'un exemplaire introduit, ou occasionnellement migratrice; un explication alternative étant un erreur d'étiquetage.

**Key words.** *Phyllonorycter*, Synonymy, *Quercus*, colour pattern.

### Introduction

The Microlepidoptera fauna of Northwest Europe is the best known in the world: discovery of undescribed species has become a very rare event in the last decades. Many of the specific names which have been newly described in the last 50 years or so, have since been synonymized. A few examples are: *Eratophyes aleatrix* Diakonoff, 1975 (Oecophoridae), described from a single specimen, but found in numerous examples before it was later synonymized with the Turkish *E. amasiella* (Herrich-Schäffer, 1854) (Diakonoff & van Nieukerken 1987) and *Crambus hertwigae* Rasmussen, 1964 (Pyralidae: Crambinae), described from one male from Denmark, which turned out to be a synonym of *Agriphila tristella* (Denis & Schiffermüller, 1775) (Bleszynski 1965). Species based on unique specimens are often synonymized, only in some cases these species have been shown to be good species and were found again, especially in very difficult groups. Species described on the basis of unique specimens which have never been found again should be regarded with due suspicion and preferably such types should be re-examined.

*Phyllonorycter irmella* (Palm, 1947) is a species named on the basis of one specimen, which for a long time was the only one known, until recently an old specimen from the Netherlands was also identified as *irmella* (Kuchlein & Langohr 1998). The

third of us already expressed his doubts about a separate identity for this species (Karsholt in Buszko 1996: 303, note 1260). We will show that his doubts were justified.

The genus *Phyllonorycter* is a large genus of small micro-moths with leaf mining larvae, occurring almost world-wide but especially in the Holarctic region. In Europe about 125 species are listed (Buszko 1996), but a revision of this genus has never been undertaken. The most complete treatments are those of the British fauna (Emmet *et al.* 1985) and the key to the species of the European part of the USSR (Kuznetsov 1990). Further there are keys to the French and British species (Bradley *et al.* 1969) and the Czech and Slovak species (Gregor 1952). Deschka described in several papers many new species, especially from southern Europe and nearby regions (e. g. Deschka 1974, 1976). Although many of the species are common and well known, a critical revision of type material is badly needed, in particular for southern European species.

***Phyllonorycter lautella* (Zeller, 1846)**

*Lithocolletis lautella* Zeller, 1846: 194. Syntypes: Austria, Wien, Mann & Germany, Frankfurt am Main, v–vii, from Quercus, von Heyden (not found in BMNH, possibly lost) [not examined].

*Lithocolletis irradiella* Scott, 1854: 9, pl. I, fig. 1. Holotype, Great Britain, Renfrew, vii., J. Scott (probably lost) [not examined].

*Lithocolletis irradiella* Stainton, 1854: 269. Holotype, Great Britain, Renfrew, vii., J. Scott (probably lost) [not examined].

*Lithocolletis irmella* N. Palm, 1947: 41. Holotype male: Sweden, Medelpad, Sundsvall, North Town Hill, 26.vii.1946, N. Palm (Lund), genitalia slide (Museum of Zoology, Lund University). [examined].

**Syn.n.**

*Lithocolletis irmella* Kumata, 1963: 66 (comparison with *L. maculata* Kumata); Kuznetsov, 1981: 236, 240 (fig. 224); 1990: 310, 317.

*Phyllonorycter irmella* Buszko, 1996: 52; Kuchlein & Langohr, 1998: 50 (record Netherlands).

Material examined. – Netherlands: ♂ (published as *Ph. irmella*), Bloemendaal, 22.v.1910, W. H. J. van Beek (Zoological Museum Amsterdam). – Sweden: Holotype of *irmella*.

Long series from Denmark, Great Britain, Netherlands and Poland (Museum collections in Amsterdam, Copenhagen, Leiden and London, coll. Koster).

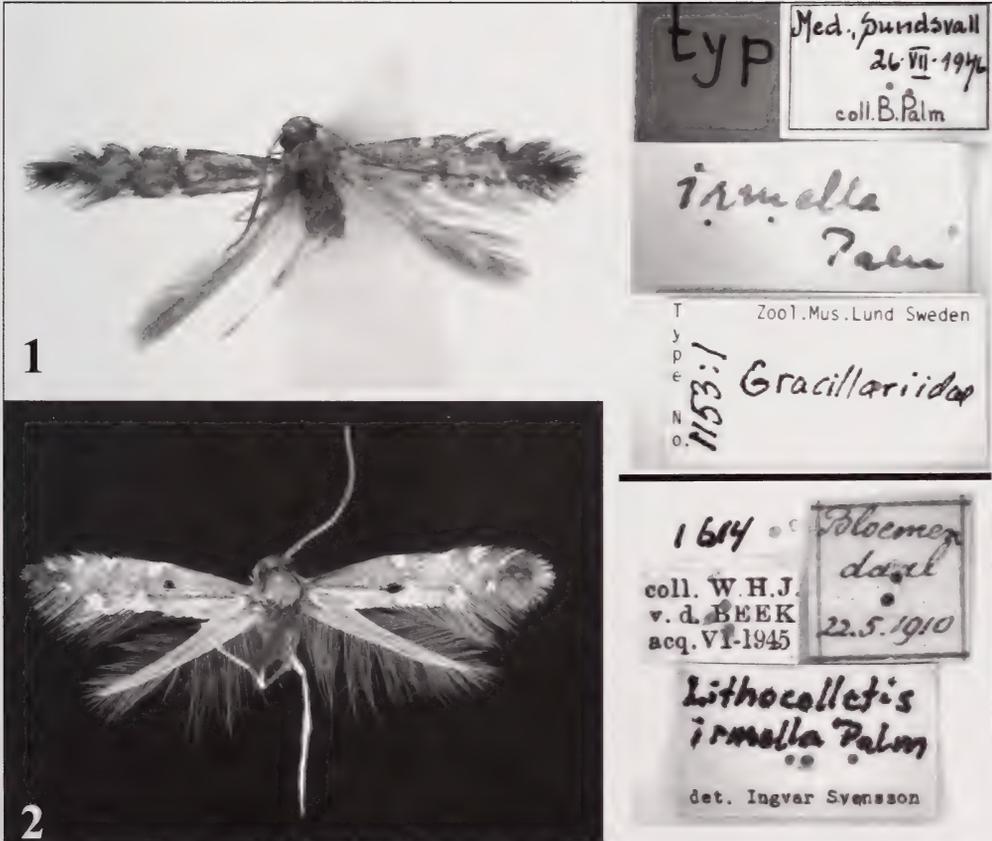
*Lithocolletis irmella* was described from Sundsvall, Province of Medelpad in Sweden (and not Nyhamn as stated by Kuchlein & Langohr 1998). Palm made clear himself that he was not certain of its status as a separate species, since he had a single specimen only (loc. cit. page 36: ‘yet it is with the greatest hesitation that I proceed to do this, as the material is very small, only one specimen of each species’). His suggestion that the species was probably associated with *Betula*, *Alnus*, *Sorbus* or *Salix* probably has misled subsequent authors, since the specimen is clearly different from all known species feeding on these hosts. After Palm’s description *Ph. irmella* appeared in some keys (i.e. Kuznetsov 1990), but as far as we know not in other publications.

We considered it most likely that *Ph. irmella* was an unusual form of one of the commoner species and compared first the published illustrations with those of other species. We even compared them with Japanese species (Kumata 1963), especially since Kumata mentioned that his *Ph. maculata* (Kumata, 1963) on *Alnus hirsuta* Turcz. ex Rupr. resembles *Ph. irmella*. On the basis of the genitalia illustrations, we considered *Ph. lautella* (Zeller) as the most likely candidate, a conclusion also reached by G. Deschka (*in litt.* to O. Karsholt 1997).

### Comparative notes

Wing pattern. – The holotype of *Ph. irmella* (Figs. 1, 3) is rather worn. The colour pattern is a reduced pattern of *Ph. lautella*, and seems to lack the characteristic basal streak and dorsal mark. There are four costals and three dorsals, poorly edged; the first streaks do not form a fascia. When looking carefully under larger magnification, there still appear to be some silver scales present in the place of the basal streak in the right wing. The absence of these marks and the poor edging are largely caused by wearing, and not a characteristic pattern.

The Dutch specimen is very similar to the holotype, and thus was ‘correctly’ identified as *Ph. irmella*. The basal streak and dorsal mark seem to be missing as well (Figs. 2, 4), and were left out in the figure by Kuchlein & Langohr (1998). However, here remaining silver scales are even easier to see. There are also four costals and three dorsals and a fascia is missing.



Figs. 1–2. *Phyllonorycter lautella*: 1 – Holotype ♂ of *Lithocolletis irmella* Palm, with labels; 2 – Dutch specimen identified as *P. irmella*, with labels. All photographs by EJvN, with Zeiss AxioCam digital camera on Stereomicroscope Stemi SV11 (moths) or Zeiss Axioskop (genitalia).

We compared these specimens with a range of *Ph. lautella* from the Netherlands and Denmark, and noticed a considerable variation in colour pattern. Most specimens have three costal and dorsal strigulae (Fig. 8), but quite a few have an additional fourth costal and the first dorsal and costal often form a fascia (Fig. 7). The basal streak and dorsal mark are sometimes reduced, but in most cases this seems to be the effect of abrasion, though some less worn specimens show some reduction (Figs. 5–6). Actually, specimens without a fascia cannot be identified using the keys by Bradley *et al.* (1969), those with four costals are not mentioned by Emmet *et al.* (1985), but are keyed out correctly.

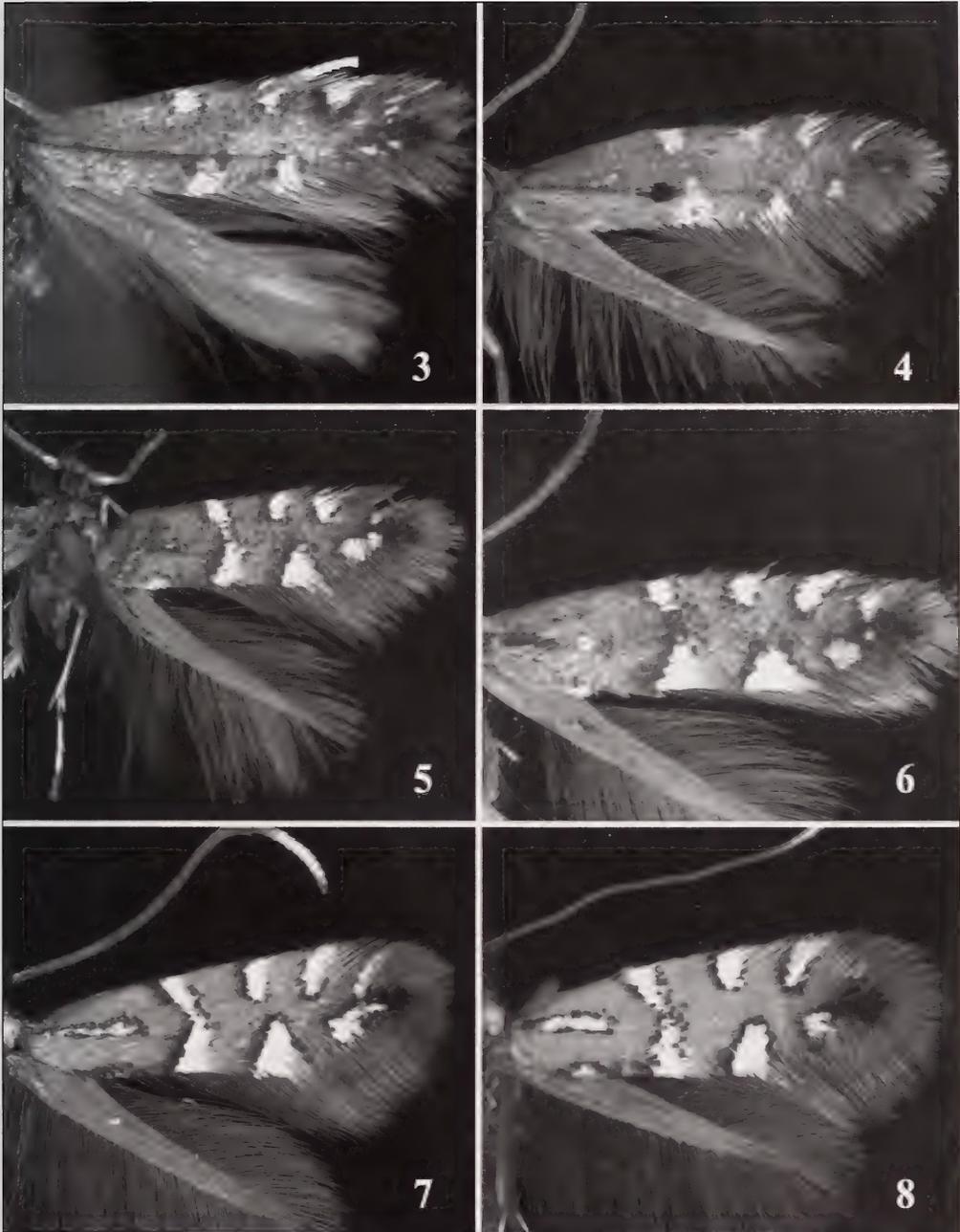
In conclusion: externally both specimens fall within the variation of *Ph. lautella* especially when the worn condition is taken into account.

The variability of this species is further shown by a ‘variety’, described in the 19th century as the species *Lithocolletis irradiella*. This was described from one specimen, having olivaceous-fuscous forewings, with a slender, short, silvery basal streak, and three costal and three dorsal streaks. Descriptions of *L. irradiella* were published independently by Stainton and Scott in 1854, based on the same specimen that Scott presented to Stainton. The description by Scott was apparently published before that of Stainton: the title page of Stainton (1854: v) was dated 1st July 1854, whereas Scott’s paper was ‘read’ 3rd October, 1853. The holotype of *irradiella* is not present in the Natural History Museum in London (BMNH) and most likely lost, but there are several other British *Ph. lautella* specimens labelled as *irradiella* in the Stainton collection. They fall easily within the above-described variability and resemble the ‘*irmella*’ specimens. Already Snellen (1882) considered *L. irradiella* most likely to be *lautella*, and since then it has always been regarded as a synonym or variety of *lautella*.

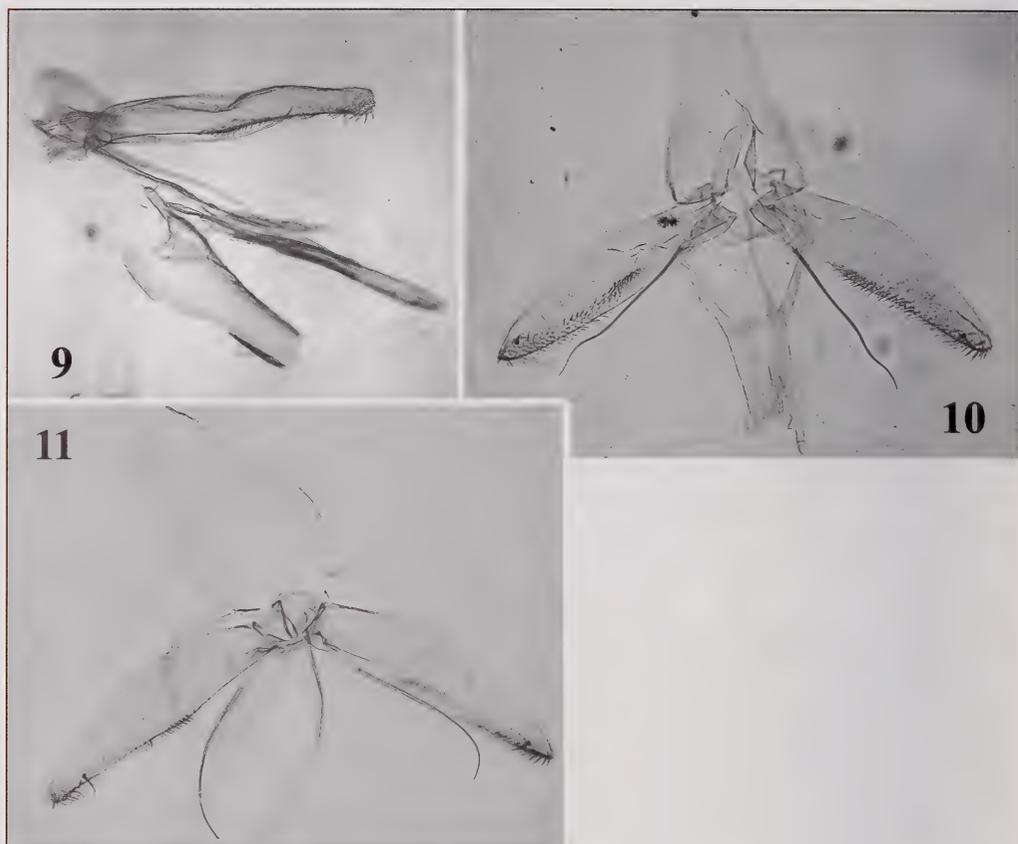
**Male genitalia.** – In the figures in Palm (1947) and Kuchlein & Langohr (1998) there are some differences with published figures of *Ph. lautella*. We studied the genitalia under high magnification (Figs. 9, 10, 12–15) and prepared several *lautella* males for comparison (Figs. 11, 16–18). Both the holotype and the Dutch specimen show the characteristic spine on the valvae, also seen on Palm’s figure, but not in Kuchlein & Langohr (1998). These authors especially mention that this spine is lacking, we suppose because they did not use sufficient magnification. When comparing the illustrations here it is very clear that the genitalia are identical to those of *Ph. lautella*. Few species have similar genitalia, probably only *Ph. pseudolautella* (Kumata, 1963) and *Ph. pygmaea* (Kumata, 1963) from Japan, and no European species could be confused with *lautella*. We therefore conclude that *Ph. irmella* is a synonym of *Ph. lautella*.

## Discussion

One problem has not yet been solved: the holotype of *Phyllonorycter irmella* was collected along the Botnian Gulf, about 300 km north of the nearest occurrence of oaks (*Quercus robur* L.), the only known host plant for *Ph. lautella*. There is no mention of oaks in Palm’s paper, but according to Nils Ryrholm (*pers. comm.*), planted oaks occur in most towns along the Botnian Gulf. Still, oak-feeding *Phyllonorycter*-species are not listed from this province (‘landskap’) in the most recent version of the Swedish checklist (Gustafsson 2001).



**Figs. 3-8.** *Phyllonorycter lautella*, variability of wing pattern: **3** – Holotype ♂ of *Lithocolletis irmella* Palm: four costals, no fascia, basal and dorsal streak worn; **4** – Netherlands, Bloemendaal: four costals, no fascia, basal and dorsal streak worn, but visible; **5** – Netherlands, Breda, four costals, fascia present, basal and dorsal streak very small, but visible; **6** – Same specimen, inverted left wing, four costals, no fascia, basal and dorsal streak small; **7** – Netherlands, Schipborg, complete pattern with four costals and fascia; **8** – Netherlands, Vijlenerbosch, ditto, but with three costals.

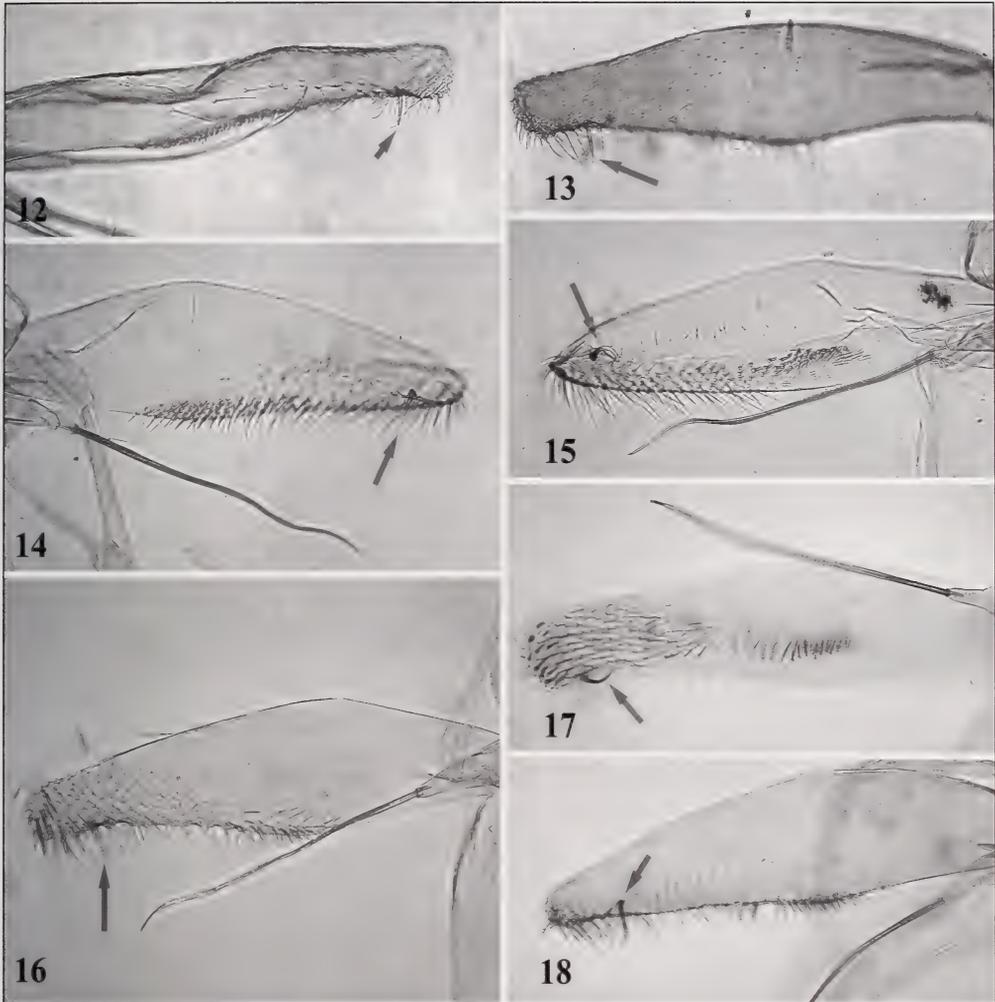


**Figs. 9–11.** *Phyllonorycter lautella*, male genitalia: **9** – Holotype ♂ of *Lithocolletis irmella* Palm, lateral view; **10** – Netherlands, Bloemendaal, slide GRL1614; **11** – Netherlands, Denekamp, slide JCK2593.

We consider that there are three possible explanations.

1. The specimen was introduced with oak saplings from tree nurseries further south.
2. Many insects migrate or disperse along coasts, and the specimen was taken on a ship near the coast or on the coast during high summer. Dispersal often takes place on warm days and is most likely to occur in central Sweden with a southern or south-eastern wind. It is very well possible that a specimen can be carried about 300 kilometres on the wind, either from the Stockholm area where oaks are common or from south-western Finland or Åland. Spreading of tiny gracillariid moths occurs frequently, as now can be seen in the fast colonisation of Europe by such species as *Cameraria ohridella* Deschka & Dimic, 1986 and *Phyllonorycter robiniella* (Clemens, 1859). It is assumed that wind plays an important role in this expansion.
3. A further explanation might be mislabelling of the specimen. In large collections this happens now and then, and there are some suggestions that Palm in his later days was rather careless with his material (I. Svensson *in litt.* to O. Karsholt).

Whichever of the explanations is true, the synonymy presented here is beyond doubt. The fact that it was not recognized earlier is of some concern to us, and prompts us to



**Figs. 12-18.** *Phyllonorycter lautella*, male genitalia, valva, showing variability in different views. Strong spine indicated by arrows: **12, 13** – Holotype *L. irmella*; **14, 15** – Netherlands, Bloemendaal, slide GRL1614; **16** – Netherlands, Zwanenwater, slide JCK2592; **17** – Netherlands, Breda, slide JCK4874; **18** – Netherlands, Denekamp, slide JCK2593.

plead for more careful re-examination of types when studying large and difficult groups of insects, especially when one wants to describe new species.

We also would like to make a plea against describing new species on the basis of single specimens, especially in well-studied regions. Although characters such as colour pattern are fairly constant and diagnostic in *Phyllonorycter*, aberrant specimens do occur, and these aberrations are probably caused by rather simple mutations. We have seen examples of *Phyllonorycter* species missing one or two of their fasciae or spots, which could easily be held for a different species when not compared with other material. In general when describing a new species, the considerations on which basis this decision was taken should be outlined in the paper. Yet few taxonomists do so. A good

example is Kaila (1997) who explained at length why it was warranted in that case to describe some species on the basis of single specimens.

### Acknowledgements

We would like to thank Roy Danielsson (Lund, Sweden) and Willem Hogenes (Amsterdam, Netherlands) for the loan of respectively the holotype and Dutch specimen of *Ph. irmella*. We are grateful to Jaroslaw Buszko (Toruń, Poland), Zdenek Lastuvka (Brno, Czech Republic), Carlos Lopez Vaamonde (Ascot, UK), Nils Ryrholm (Uppsala, Sweden), Ingvar Svensson (Österslöv, Sweden), Paolo Triberti (Verona, Italy) and Kevin Tuck (London, UK) for providing valuable information and discussion. Kevin Tuck also kindly provided comments on the manuscript.

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## Two new species of Depressariidae (Lepidoptera) from Portugal

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**Summary.** Two new species of Depressariidae, *Agonopterix mendesi* sp. n. and *Depressaria cinderella* sp. n. are described from Portugal. The larva of each species is described together with information on host-plants and parasitoids.

**Zusammenfassung.** Aus Portugal werden zwei neue Depressariidae-Arten, *Agonopterix mendesi* sp. n. und *Depressaria cinderella* sp. n., beschrieben. Für jede Art wird die Raupe beschrieben, und Angaben zu ihrer Nahrungspflanze und ihren Parasitoiden werden gegeben.

**Résumé.** Deux nouvelles espèces de Depressariidae, *Agonopterix mendesi* sp. n. et *Depressaria cinderella* sp. n., sont décrites du Portugal. Pour chaque espèce la chenille est décrite, avec en complément des données sur sa plante-hôte et ses parasitoides.

**Key words.** Lepidoptera, Depressariidae, *Agonopterix*, *Depressaria*, new species, larva, host-plants, parasitoids, Portugal.

### Introduction

Many species of Depressariidae are rarely taken at light but are readily found in the larval stage and easy to rear. Moreover the main plant families involved as host-plants are few, so that it is always worth examining species of Apiaceae, Asteraceae, particularly the group of genera related to *Centaurea* L., and shrubby species of Fabaceae during spring and early summer.

Since 1989 the author has been studying Portuguese Lepidoptera and has taken a particular interest in the Depressariidae. During that time 17 species of Depressariidae have been added to the Portuguese list (Passos de Carvalho & Corley 1995; Corley *et al.* 2000; Corley unpublished data). In addition, two species have been found and reared that remained undescribed thus far. The first species was found by speculatively examining plants of *Centaurea* for larvae. The second species was initially taken at light. When it became clear that it was a new species, a successful search was made in the locality for larvae on Apiaceae. In recent years it has been quite unusual for new species of Microlepidoptera to be described with bionomic data (larva, host-plant, parasitoids) presented here.

Most of the European species of Depressariidae were treated by Hannemann (1953), who gave figures of the male genitalia. There has been no full revision since that date. The subfamily is rather less well known in southern Europe, North Africa and Asia than is the case in central and northern Europe. Lvovsky (1981) treated the species of European Russia. A full revision of the family is desirable, but unlikely to be produced in the foreseeable future. Currently the female genitalia of a number of species have never been figured and published information on infrageneric relationships in *Agonopterix* is non-existent.

Many professional taxonomists consider that new species should only be described as part of a taxonomic revision, or where additional species are discovered after a taxonomic revision has been published. The argument for this position is that random de-

scription of new species by various authors scattered through time and in various journals is likely to produce superfluous synonyms and such papers can be overlooked in subsequent revisions. This is not the place to discuss this, beyond pointing out that taxonomy is a service industry which should be run for the benefit and convenience of all biologists and others who need names for species of organism, rather than for the convenience of taxonomists. As professional taxonomists are few in number, progress is inevitably slow and recognized species can remain undescribed for many years. Throughout the time before the new species is described it may continue to be misidentified and assigned to another species, thus causing regrettable inaccuracies in the knowledge of the other species.

Against this background it could be argued that description of a couple of new species is not particularly useful. It can be justified because the bionomic data would probably be lost if the species were unnamed. Furthermore, following description of the new taxa complete with biological information, other workers are more likely to discover them in new sites.

### *Agonopterix mendesi* sp. n.

Holotype ♂, P3608 [Corley collection number] Portugal, Algarve, Praia de Castelejo, 15 m, 26.v.1996 from larva 14.iii.1996 on *Centaurea sphaerocephala* L., Corley leg., gen. prep. BMNH 30231, coll. BMNH.

3 Paratypes: 1 ♀ P3612, same locality as holotype 27.v.1996, gen. prep. Langmaid 975, coll. Langmaid; 1 ♂ 3609, same locality as holotype 27.v.1996, gen. prep. BMNH 30232, coll. BMNH; 1 ♂ P1637, Portugal, Algarve, Bordeira, Carrapateira, 30 m, 2.vi.1993 from larva 18.iv.1993 on *Centaurea sphaerocephala*, Corley leg. et coll., gen. prep. MFVC 423.

Other material examined: 1 ♀ Portugal, Estremadura, Setúbal (no date) [P. Vieilledent], gen. prep. MFVC 1546, coll. Joannis, MNHN.

Larvae found on *Centaurea sphaerocephala* L. on the Costa Dourada, Algarve (the west facing coast of southern Portugal), were found to belong to a previously undescribed *Agonopterix* species. In April 1993 four larvae were collected at Carrapateira, near Bordeira, from which one moth and three parasitoids were reared. In March 1996 three more larvae were collected at Praia de Castelejo, near Vila de Bispo which produced three moths in May.

Description of imago (Fig. 1). – Wingspan 18–20 mm. Head pale ochreous, face whitish ochreous; labial palpus pale ochreous with a few greyish fuscous scales on outer side of segment 2; antenna with scape and base of flagellum pale ochreous, remainder of flagellum greyish fuscous. Thorax ochreous to deep ochreous. Forewing ochreous with a dark fuscous spot near dorsal side of base, a sparse scattering of greyish fuscous and ochreous brown scales over much of wing, chiefly along veins, forming small spots at vein ends, costal area free of such scales; cilia pale ochreous at base, whitish ochreous at apex. Hindwings whitish, weakly tinged ochreous, sometimes with light greyish fuscous scales along veins, one to four greyish fuscous spots between vein ends near apex; cilia concolorous with wing. Legs ochreous, dark fuscous on outer side of fore and mid femur and tibia, fore tarsus mixed fuscous on outer side. Abdomen whitish ochreous.



Fig. 1. *Agonopterix mendesi* sp. n. holotype male.

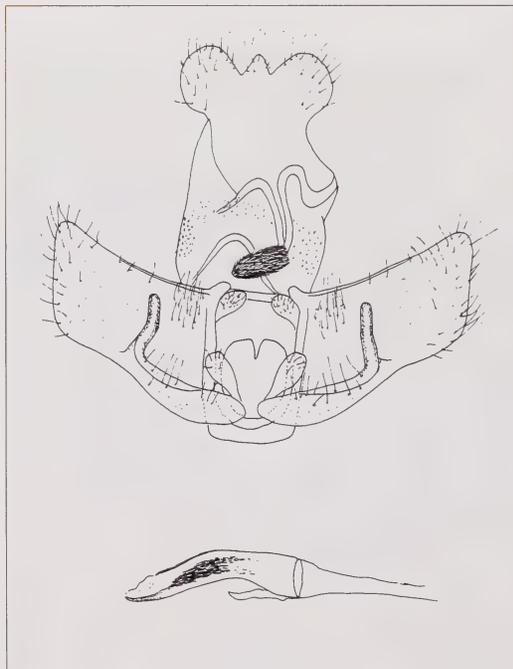


Fig. 2. *Depressaria cinderella* sp. n. holotype male.

Male genitalia (Fig. 3). – Resembling *Agonopterix squamosa* (Mann, 1864) illustrated by Hannemann (1953) but differing in the short truncated valva, straighter cuiller and more rounded anellus.

Female genitalia (Fig. 4). – Similar to those of *Agonopterix kaekeritziana* (Linnaeus, 1767) illustrated by Hannemann (1995) but with ostium close to posterior margin of sternite VIII and signum with large teeth confined to the mid-line and small marginal teeth. The ostium of *A. kaekeritziana* is near the middle of sternite VIII and the signum teeth are largest on the margin. *A. squamosa* (P. Leraut gen. prep. 917, MNHN) has the ostium close to the anterior margin of sternite VIII and the signum lobed at the margin with all the teeth small, although the marginal teeth are larger than those near the centre.

Biology. – Larvae have been found on *Centaurea sphaerocephala* in March and April, pupating before the end of April. The leaves at the shoot tip are spun together untidily, with the larva living and feeding in the upper part of the stem. Affected shoots do not flower. Solitary larval parasitoids have been reared: *Lissonota* sp. (Ichneumonidae: Banchinae) and ?-*Diadegma* sp. (Ichneumonidae: Campopleginae). In captivity the adults emerged in late May after about 35 days in the pupal stage. It is not known if the moth hibernates and lays eggs in early spring or if the eggs are laid in summer. Both strategies are known in related species. Adult moths have not been found in the field, apart from the Setúbal specimen mentioned below. Of the three sites known for this species two are coastal hills covered in blown sand, but are not strictly sand dunes; the third is a steep slope at the top of a ravine leading to the sea.



Description of larva. – Purplish-brown; head blackish-brown, prothoracic plate black; pinacula and anal plate concolorous with body.

Etymology. – The species is named after Cândido Mendes de Azevedo, the great Portuguese lepidopterist, whose works form the foundation of knowledge of the Portuguese Microlepidoptera. The specific name is a noun in the genitive case.

Additional material. – A single female labelled simply “Setúbal” was found among unnamed material in the Joannis collection (MNHN). Specimens so labelled were collected by P. Vieilledent (or one of his co-workers) in the vicinity of Setúbal, Portugal around 1900. Vieilledent sent material to J. de Joannis to be named, and some speci-

Fig. 3. *Agonopterix mendesi* sp. n. male genitalia.

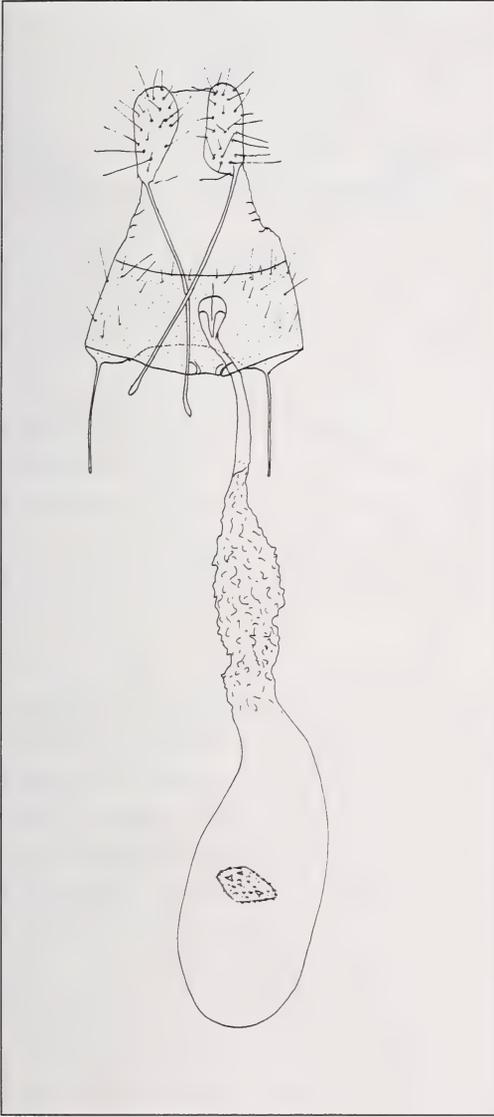


Fig. 4. *Agonopterix mendesi* sp. n. female genitalia.

mens were retained by Joannis. There is no mention of this specimen in Vieilledent (1905). The specimen is not in good condition, and the genitalia differ from those of the Algarve specimens in lacking a signum. This is presumably an aberration, and there is no reason to suppose that it belongs to another species, but in view of this difference it is not included in the type series.

**Remarks.** – Several species have similar coloration to *A. mendesi*. However *A. kaekeritziana*, *Agonopterix pallorella* (Zeller, 1839), *Agonopterix bipunctosa* (Curtis, 1850), *Agonopterix straminella* (Staudinger, 1859) and *A. squamosa* are all distinguished from *A. mendesi* by the presence of two blackish discal dots. *Agonopterix farsensis* Hannemann, 1958 from Iran has the valva somewhat truncate, with similar uncus and anellus, but more tapering cuiller. This species has a single discal dot and a dot at the base of the costa.

Several of these species have more or less green larvae, but *A. kaekeritziana* has larva coloured like those of *A. mendesi* but with the anal plate black. The larva of *A. squamosa* has not been described. Where known, the larvae of most related species live in leaves spun into tubes. *A. kaekeritziana* and *A. bipunctosa* feed initially in spun shoot tips and can feed in the apex of the stem in the same way as *A. mendesi* (Langmaid, pers. comm.)

### ***Depressaria cinderella* sp. n.**

Holotype ♂, P4905, Portugal, Alto Alentejo, Serra de São Mamede, Minhota, 650 m, 27.v.1998 from larva 10.iv.1998 on *Conopodium capillifolium*, Corley leg., gen. prep. BMNH 30233, coll. BMNH.

8 Paratypes: 1 ♀ P4900, same data as holotype, em. 22.v.1998, gen. prep. BMNH 30234, coll. BMNH. 1 ♀ P3842, 1 ♂ P3843, same locality as holotype, 5.vi.1996, Corley leg. et coll., gen. preps. MFVC 914 ♀, 921 ♂; 1 ♀ P4342, same locality, 14.iv.1997, Corley leg. et coll., gen. prep. MFVC 1120; 2 ♀ same locality, em. 3.vi.2000, Corley leg., P5705 in coll. Langmaid; P5709 in coll. BMNH; 1 ♀ P5712 Portugal, Alto Alentejo, Serra de São Mamede, São Mamede, 730 m, em. 3.vi.2000, Corley leg. et coll.; 1 ♀ P5714, same data em. 9.vi.2000, coll. Sauter.

Two specimens of an unusually grey *Depressaria* were taken on 5 June 1996 at light on a rocky hillside near the village of Minhota, north-east of the hilltop town of Marvão in the Serra de São Mamede, Alto Alentejo, Portugal. Although clearly belonging to the *douglasella* group, they did not appear to belong to any of the known species. The following year a single specimen was obtained at the same locality on 14 April 1997. This was an unusually early season. All three moths were in good condition, so it seemed probable that they had not hibernated.

In April 1998 the locality was revisited to search for larvae on Apiaceae. Only one species of umbellifer was found, *Conopodium capillifolium* (Guss.) Boiss. On 10 and 11 April ten larvae were found in tubular spinnings on the basal leaves of the *Conopodium* plants. After returning to England a few days later, the larvae proved difficult to rear. The basal leaves of the *Conopodium* are particularly delicate and did not remain in edible condition for as long as expected. The larvae refused the leaves of *C. majus* (Gouan) Loret, apparently because they were too thick or too tough. Eventually leaves of *Anthriscus sylvestris* (L.) Hoffm. were offered and proved acceptable. Unfortunately half the larvae died. Two moths and three parasitoids emerged in late May.

In April 2000, two larvae were collected at the original site and four at a new site, on São Mamede, Serra de São Mamede, producing two moths from each site and two parasitoids from the new site.

**Description of imago** (Fig. 2). – Wingspan 16.5–19 mm. Head whitish, with a few grey scales on vertex, face white or creamy white. Antenna blackish fuscous, indistinctly ringed lighter and darker. Labial palpus with brush of scales on segment two, whitish above and on inner side, mainly dark grey on outer side; segment three blackish, with a creamy white ring at one third and apex creamy white to ochreous. Thorax white, blackish anteriorly. Forewing greyish fuscous in dorsal half and in apical area, blackish fuscous at base and in costal half, blackish at base of dorsum and on costa to mid-wing, two indistinct blackish discal spots, and sometimes a plical spot also; blackish spots between veins at apex; white or whitish grey scales widely scattered over wing, also forming more or less extensive patches at base of costa, on costa at two-fifths extending to between discal spots and at two-thirds extending to mid-wing; smaller whitish spots between veins at apex proximal to blackish spots. Cilia greyish fuscous, darker at base, light at apex. Hindwings whitish grey, greyish fuscous on dorsum and towards apex; cilia light grey with greyish fuscous base. Legs creamy whitish on femur and on inner sides, with few dark scales, tibia and tarsus heavily mixed dark fuscous, tarsal segments creamy white to ochreous distally. Abdomen greyish fuscous above, creamy white below.

**Male genitalia** (Fig. 5). – Most similar to those of *Depressaria sordidatella* Tengström, 1848 but differing in the smoothly tapering cuiller, distinctly angled inwards as it crosses costa, never bifid at apex; clavus without hairs; anellus more rounded and more deeply incised; aedeagus slightly longer and less curved.

**Female genitalia** (Fig. 6). – Differing from those of *D. sordidatella* in the position of the ostium, close to the posterior margin of sternite VIII, the four-sided signum and the apophyses posteriores being three to four times as long as the apophyses anteriores. *D. sordidatella* has the ostium in the centre of sternite VIII, a triangular

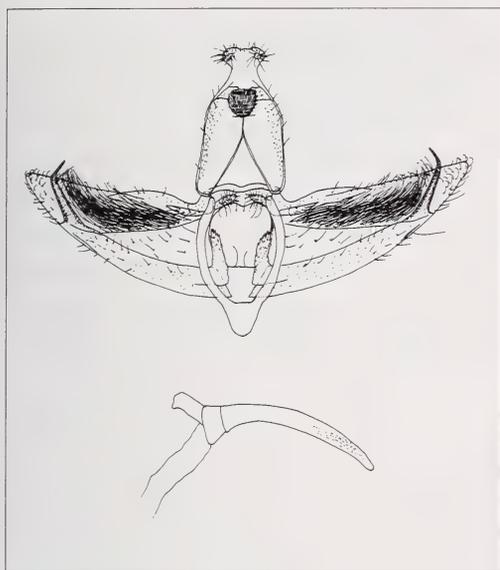


Fig. 5. *Depressaria cinderella* sp. n. male genitalia.

signum and apophyses posteriores twice as long as apophyses anteriores.

**Biology.** – Adults have been taken in April and June, but it is not known if they hibernate, laying eggs in spring, or lay eggs in summer which hatch the following spring. The latter strategy is more probable, as it is that used by other species in the *douglasella* group. Adults were not seen at the Minhota site on two nights in September, nor on one in October, but neither were they seen on one night in May, when they would have been expected to be present. Larvae have been found in April, most being full-fed by the end of the month. In early seasons, such as 1997, some larvae would be fully developed before the end of March. In captivity the pupal stage lasted about 28 days.

The host-plant *Conopodium capillifolium*

was the only umbellifer at the site. Only the basal leaves which have broad leaflets were eaten, the leaflets being spun into a tube.

The upper leaves of the plant are filiform and less delicate in texture than the basal leaves. No larvae were found on these leaves, nor on the flowers. One species of solitary larval parasitoid (*Lissonota* sp. (Ichneumonidae: Banchinae)) and one species of solitary pupal parasitoid (*Exochus* sp. (Ichneumonidae: Metopiinae)) have been reared. The habitat in the original site is a steeply sloping rocky hillside facing north-east at 640–700 m. The second site is among north facing rocks at 730 m. The host-plant grows at the foot of the acid rock slabs and in crevices.

**Description of larva.** – Dull pale green with 3 darker lines. Head and prothoracic plate yellowish green, both edged black posteriorly, sometimes markings almost absent from head. Pinacula and anal plate concolorous with body. Younger larva (before last instar) has head and prothoracic plate black.

**Etymology.** – Named from its beautiful variegated dark grey coloration and its occurrence with its two ‘ugly sisters’ *Depressaria beckmanni* Heinemann, 1870 and *Depressaria badiella* (Hübner, 1796). The specific name is a noun in apposition.

**Remarks.** – Variation occurs mainly in the darkness of the ground colour and the whiteness and extent of the pale scales on the forewing. No other species of *Depressaria* except sometimes *D. douglasella* Stainton, 1849, is completely free of brown coloration in the forewing. *D. cinderella* appears, from the male genitalia, to be closest to *D. sordidatella* (*D. weirella* Stainton, 1849). The differences in the female genitalia are more obvious.

Sauter (in Baldizzone 1996) mentions an undescribed *Depressaria* of the *douglasella* group from north-east Italy, which has the cuiller not bifurcate at apex, and surpassing

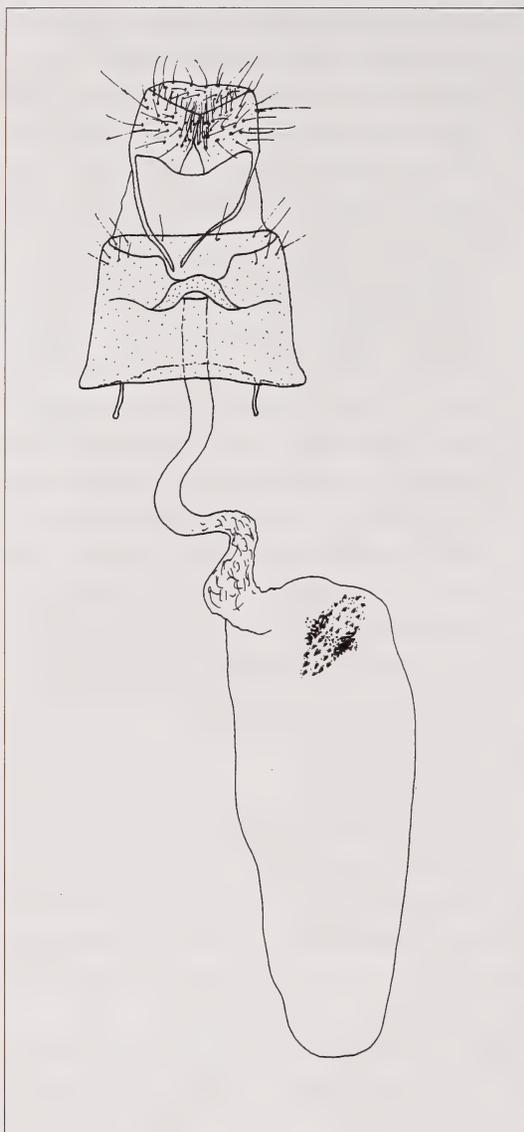


Fig. 6. *Depressaria cinderella* sp. n. female genitalia.

the costa, much more than in *sordidatella*. Professor Sauter (*in litt.*) has informed me that this is *D. incognitella* Hannemann, 1990, and that it differs from *D. cinderella* in the cuiller which is slightly angled at one third from the base, not where it crosses the costa, more slender valva and different forewing coloration (see paper of Huisman & Sauter in this issue).

The larva of *D. sordidatella* has yellowish green head and green prothoracic plate, both without markings, and black pinacula. The larvae of *D. sordidatella*, *D. douglasella* and *D. beckmanni* all spin leaflets of their host-plants into a tube in the same way as *D. cinderella*. *Depressaria pulcherrimella* Stainton, 1949, does the same when feeding on *Daucus* L. or *Pimpinella* L., but on *Conopodium majus* it spins flowers or seeds together. At the time when it is feeding flowers would not be available on the other host-plants. *D. cinderella* does not utilise the flowers although they would be available at least to the later instar larvae.

### Discussion

The distribution of many Depressariidae in Europe is wide (Lvovsky 1996), with rather few local endemic species. In the Iberian Peninsula *Depressaria genistella* Walsingham, 1903 is the only endemic

species known. *Depressaria peniculatella* Turati, 1922 was described from North Africa. *A. mendesi* might be a Portuguese endemic, as the south-west coast of Portugal does have a number of endemic taxa in various groups of organisms, but its host-plant is more widespread on the Atlantic coast of south-west Europe and North Africa and the coasts of the western Mediterranean, so that a wider distribution of the moth can be expected. *D. cinderella* will almost certainly be found in Spain since the type locality is just 5 km from the Spanish border. Because of its preference for the unusually delicate basal leaves of *C. capillifolium*, it may well be confined to the one host-plant species. *C. capillifolium* also occurs in Italy and Sicily.

The two new species bring the total of *Depressariidae* species in the Iberian Peninsula to 69, of which 61 occur in continental Spain and 34 in Portugal (data derived from Lvovsky 1996; Corley *et al.* 2000, Vives Moreno 1994, 1996; Corley unpublished data). Thus eight species are recorded from Portugal but not Spain and 35 from Spain but not Portugal. In well worked families of Lepidoptera such as the Noctuidae it is unusual for there to be any species found in Portugal but not Spain, which therefore suggests that a substantial number of species of *Depressariidae* remain to be found in Spain. The rate at which additional species have been found in Portugal in recent years indicates that more species can be expected there also. Thus the possibility of finding further species new to the Iberian Peninsula and perhaps new to science is quite high.

### Acknowledgements

I am most grateful to the following people who have assisted in various ways: Eng. José Passos de Carvalho for the loan of specimens, and for help in many other ways; Dr Rui Santana Coreia, Director of the Parque Natural da Serra de São Mamede, for allowing me to collect in the Parque Natural and for accommodation there; Dr John Langmaid for genitalia preparations of *A. mendesi* and for the loan of genitalia slides of *A. kaekeritziana*; Clive Jermy for help with the identification of *Conopodium capillifolium*; the photographic unit of the Natural History Museum, London for the photographs of adult moths; Kevin Tuck for assistance at the Natural History Museum; Prof. Joel Minet and M. Patrice Leraut for allowing me access to the collections at MNHN; Prof. Dr Willi Sauter for reading the manuscript and comparing *D. cinderella* with *D. incognitella*; Ole Karsholt for comments on the manuscript; Dr Mark Shaw for identifying parasitoids to genus; Dr Axel Hausmann for the German summary; the trustees of the Professor Hering Memorial Research Fund for a grant enabling me to visit the Muséum National d'Histoire Naturelle, Paris.

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## Redescription of the female and Distribution of *Depressaria incognitella* Hannemann, 1990 (Depressariidae)

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**Summary.** The authors examined 24 specimens of *Depressaria incognitella* Hannemann, 1990, collected in the French, Swiss and Italian Alps and in the Abruzzi. Hitherto only two specimens, a male and a female, had been known. Comparing the new-found females with the female paratype, there appeared to be great differences. The authors show that the female paratype, described by Hannemann, is probably *Depressaria ululana* Rössler, 1866 and that the new females are true *D. incognitella*. They give a new description of the female genitalia and a short description of the imago and the male genitalia, a short differential diagnosis and data about the distribution.

**Zusammenfassung.** Die Autoren konnten 24 Exemplare von *Depressaria incognitella* Hannemann, 1990 untersuchen, die in den Französischen, Schweizer und Italienischen Alpen sowie in den Abruzzen gefunden wurden. Bisher waren nur ein Männchen und ein Weibchen bekannt. Beim Vergleich der neu gefundenen Weibchen mit dem weiblichen Paratypus zeigten sich grosse Unterschiede. Wir sind der Auffassung, dass der weibliche Paratypus zu einer anderen Art gehört, nämlich zu *Depressaria ululana* Rössler, 1866, und dass die neugefundenen Weibchen tatsächlich das Weibchen von *D. incognitella* darstellen. Eine neue Beschreibung der weiblichen Genitalien, eine kurze Beschreibung der Imago und der männlichen Genitalien, eine Differentialdiagnose und Daten über die Verbreitung werden gegeben.

**Résumé.** Les auteurs ont eu l'occasion d'étudier 24 exemplaires de *Depressaria incognitella* Hannemann, 1990, pris dans les Alpes françaises, suisses et italiennes, ainsi que dans les Abruzzes. Jusqu'à présent, deux exemplaires seulement étaient connus, un mâle et une femelle. Après comparaison des femelles nouvelles avec le paratype femelle, de grandes différences sont apparues. Les auteurs démontrent que le paratype femelle, décrit par Hannemann, est en réalité la femelle d'une autre espèce, *Depressaria ululana* Rössler, 1866 et que les nouvelles femelles peuvent réellement être attribuées à *D. incognitella*. Ils présentent une nouvelle description de l'armure génitale femelle, une brève description de l'adulte et de l'armure génitale mâle, une diagnose différentielle et un aperçu des données existantes quant à la distribution de cette espèce.

Key words. Lepidoptera, Depressariidae, *Depressaria incognitella*, identity, distribution, Alps.

### Introduction

The genus *Depressaria* Haworth forms a relatively large group of moths which generally are hard to differentiate by external features, but easy by examination of the genitalia. Nevertheless a small number of species are so closely related that diagnosis is difficult even after preparation of the genitalia.

Unlike the allied genus *Agonopterix* most species of *Depressaria* present clear differences in the genitalia, especially in the males. Based on the male genitalia, Hannemann divided the genus into six groups (Hannemann 1953), which he later reduced to four: the *artemisiae*-, *douglasella*-, *pastinacella*- and *discipunctella*-groups (Hannemann 1995). The *douglasella*-group is distinguished by the presence of a clavus and a cuiller or clasper.

In this study we prefer to subdivide this latter group in two parts: a subgroup *douglasella* s. str. and a subgroup *albipunctella*. The species of the *douglasella*-subgroup s. str. have an oblong valve and are in particular characterized by the presence of

a band of long, caudally or laterally directed bristles on the inner side of the valve below the costa, reaching from the base of the valve as far as the cuiller. The females all have a more or less triangular ostium with a W-like fold below it and short apophyses anteriores.

The *albipunctella*-subgroup generally has the valve broader and shorter; the species always lack the long band of hairs below the costa. In the females the ostium shows more variation; the apophyses also vary, but as a rule they are longer than in the former group.

To the *douglasella*-subgroup s. str. belong *D. douglasella* Stainton, 1849, *D. sordidatella* Tengström, 1848, *D. pulcherrimella* Stainton, 1849, *D. beckmanni* Heinemann, 1870, *D. nemoella* Svensson, 1982 and the recently described *D. incognitella* Hannemann, 1990. This reduced *douglasella*-group corresponds with 'Artsgruppe 2' of Palm (Palm 1989).

To the *albipunctella*-subgroup belong in Central- and Western-Europe: *D. albipunctella* ([Denis & Schiffermüller], 1775), *D. hoffmanni* Stainton, 1861, *D. olerella* Zeller, 1854 and *D. ululana* Rössler, 1866.

Within the *douglasella*-subgroup s. str. diagnosis in the males mainly depends on the form of the cuiller: forked or unforked, longer or shorter. In the female genitalia the differences between the species may be so slight that in certain cases an exact determination is very difficult.

Many years ago the first author started an investigation of the Depressariidae he had caught in Wallis, Switzerland. He found two males belonging to the *douglasella*-subgroup s. str. with unforked cuiller. At that time only one species with such a cuiller was known, viz. *D. nemoella*; diagnosis was as yet impossible.

Quite independently the second author was working on the Pyralidae, Oecophoridae and Depressariidae caught by Baldizzone in the Aosta valley in the Italian Alps. Among that material he discovered a male of a *Depressaria* species, also from the *douglasella*-subgroup s. str. with straight, unforked cuiller, differing from all other species he was acquainted with. Therefore he sent drawings of the genitalia to some specialists. Prof. Hannemann considered the species to be unknown to him. Having but one specimen the author refrained from describing and naming it and referred to it as a '*Depressaria* sp. n.' (Sauter in Baldizzone 1996).

When we could take note of the description of *D. incognitella* (Hannemann 1990) it was at once clear that our males were conspecific with that species, the differences between the respective drawings being relatively insignificant.

However another problem arose. At the time of the description of Hannemann only two specimens were known, a male and a female. Meanwhile we had made a search in several collections. Investigations in the collections of Dutch colleagues had resulted in the discovery of four more identical males and two females from the French and Swiss Alps. In addition a fine series from the Abruzzi was found in the Löbbecke Museum at Düsseldorf, consisting of four males and two females. Two further males were reported from Wallis and the Aosta valley.

The new problem was in the females. The drawing of the female genitalia in the publication of Hannemann did not agree with the slides of our females. Hence we

decided to make a closer study of the two 'unforked' species *D. nemolella* and *D. incognitella*. Fortunately we were able to examine the typematerial of *D. nemolella* from the museum at Lund and of *D. incognitella* from the museum at Copenhagen.

It became obvious that *D. nemolella* and *D. incognitella* are two separate species, differing externally and in the male and probably also in the female genitalia. As to the typematerial of *D. incognitella*, we doubt that the male and female belong to the same taxon. In our opinion the female paratype is a misidentified specimen of *D. ululana*.

Hannemann described *D. incognitella* from a single male and female, caught respectively on 28. and 26.vi.1985 in the French Alps at Guillestre (Dep. Hautes Alpes) (Hannemann 1990).

At that time more material was not available. As the differences in wingdesign between species of this group are minimal, it is difficult to prove with absolute certainty that a given male and female belong to the same taxon if they do not originate from an ex-ovo-breeding. You can only assess the probability.

We have the following arguments in support of our view that the female from Guillestre does not belong to *D. incognitella* and that the females in our series represent the true *incognitella*.

In the original description the only link between the male and the female is that they were caught at the same place and at about the same time. We found three such links (from Ovindoli, Fiesch and Reotier), with the series from Ovindoli and Fiesch each including two females.

More important is the difference in the structure of the genitalia, in particular the form of ostium, ductus bursae and signum and the length of the anterior apophyses. The genitalia of the species in the *douglasella*-subgroup s. str. much resemble one other, both in the males and in the females. The genitalia of the females have a triangular, not very conspicuous ostium with a W-shaped fold, a ductus which is not or scarcely sclerotized, a large rhombic or triangular signum and short apophyses anteriores. They are often difficult to distinguish from each other. The genitalia of the females we found are uniform and show all these characteristics. The female from Guillestre, on the other hand, has a cylindrical, laterally strongly sclerotized ostium, a ductus with a small bulge near the ostium and with a distinct sclerotization in the adjacent one-third of its length, apophyses anteriores which are relatively long and a bursa without a clearly visible signum. Lacking a signum is an unknown feature in the genus. Perhaps a very weak signum is hidden behind the spermatophore, which is visible in the middle of the bursa. (This spermatophore is not shown in Hannemann's drawing). The signum of *D. ululana* is much weaker than those in the *douglasella*-subgroup s. str.

The male genitalia of *D. incognitella* completely fit within the *douglasella*-subgroup, so it is plausible that the female genitalia should do also.

Finally, the distal part of the ductus of the female from Guillestre contains a long, narrow, sclerotized streak. This is most probably the cornutus or part of the cornuti of the male. We found this phenomenon on several occasions in other members of the genus. Now the male of *incognitella* only has very tiny, hardly visible cornuti in the vesica. On the contrary the cornutus of *D. ululana* quite accords with it.

The preceding conclusion makes it necessary to redescribe the female genitalia. As the original description of *D. incognitella* is based on two different taxa we also give a short redescription of the imago and of the male genitalia.



**Fig. 1.** *Depressaria incognitella*, imago. Female. (Abruzzi)

### *Depressaria incognitella* Hannemann, 1990

*Depressaria incognitella* Hannemann, 1990: 137–144. Holotype ♂, FRANCE, Hautes Alpes: Guillestre, 28.vi.1985, leg. P. Stadel Nielsen (Museum Copenhagen) (Examined).

**Material examined.** – *Italy*: 6♂, 2♀, Ovindoli (Abruzzi), 1450 m, 3–13.vii.1959, leg. Groß (slides LM-H-1, LM-H-10, LM-H-20 and LM-H-21, Huisman); ♂, Gran Sasso (Abruzzi), 1400 m, 2.viii.1970, M. S. Franko, leg. Groß (slide LM-H-22, Huisman) (all Löbbecke Museum); ♂, Mont Avic, prati sopra Völla, 1400 m, 27.vii.1994, leg. G. Baldizzone (slide GP 95 Bz 23, Sauter) (coll. Sauter); ♂, Parco Natur. Reg. Alpi Marittime, Entracque, Trinità, Tetti Prer, ca. 1300m 16.vii.1996 (lux) leg. G. Baldizzone (slide GP 15, det. Sauter) (coll. Baldizzone). *Switzerland*: 3♂, 2♀, Fiesch (Wallis), 1000 m, 14.viii–1.ix.1973, 2♂, 6.vii and 14.vii.1980, leg. K. J. Huisman (slides respectively 1827, 1828, 1829, 1022, 1830, 1019 and 1018, Huisman) (coll. Huisman); ♂, Zeneggen (Wallis), 9.ix.1965, leg. A. Schmidlin (slide GP 4626 Sauter) (coll. Sauter). *France*: ♂, les Vernays (Savoie), 1500 m, 16.vii.1989, leg. J. E. F. Asselbergs (slide 1269 Asselbergs) (coll. Asselbergs); ♂, Reotier (Hautes Alpes), 1000 m, 24.vi.1990, ♀, 25.vi.1990; ♂, 21–24.ix.1994, leg. A. L. Cox (slides AC-H-21, AC-H-20 and AC-H-43, Huisman); ♂, Risoul (Hautes Alpes), 1600 m, 13.vii.1988, leg. A. L. Cox (slide AC-H-24, Huisman) (all coll. Cox).

**Adult** (Fig. 1). – Head light, greyish. Thorax brownish grey. Patagia dark brown. Labial palpi: second segment on the inner side yellowish grey, on the outer side strongly covered by brown brush-like scales. Third segment dark brown with a yellow apex and a broad yellow ring at one third. Wingspan 16–18 mm. Forewings brown, mixed with darker and lighter scales, which can give it a mottled appearance. In particular the Italian specimens have a faint purple sheen. The indistinct postdiscal fascia is somewhat irregularly bordered in the lower part and is angled at 80–95 degrees. There is no sexual dimorphism.

**Male genitalia** (Fig. 2). – Valve long, elongated oblique-laterally. Length, measured in the middle of the valve, more than one and a half times the greatest width at the base. Valve with clavus and cuiller. Clavus long, reaching the row of hairs below the costa. Cuiller long, very slightly bent inwards, about half its length extending beyond the costa, unforked, with a rounded tip. The part of the valve distal to the cuiller is small and narrow. This width differs in the various slides, as does the length of the clavus and the extent of the cuiller beyond the costa. This variation may be partly due

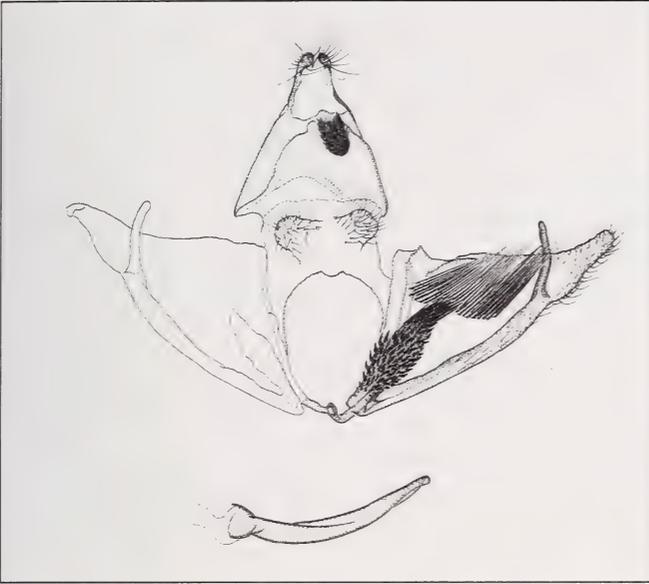


Fig. 2. *Depressaria incognitella*, male genitalia (slide 1019, Huisman)

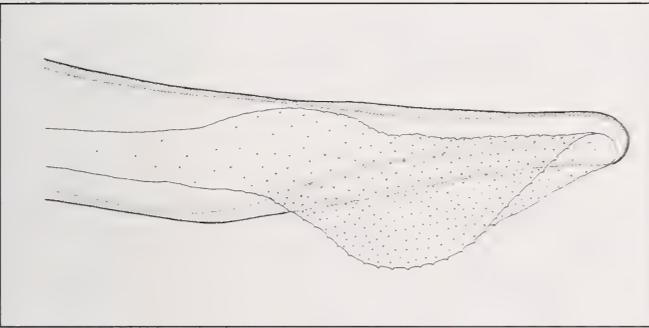


Fig. 3. *Depressaria incognitella*, tip of aedeagus with vesica (enlarged) (slide AC-H-21, Huisman)

to the manner of making the preparations. However, the tip of the valve is never as narrow, not even in the holotype itself, as is suggested in the drawing of Hannemann. There is a row of long hairs below the costa, reaching from the base of the valve to the cuiller. These hairs are directed oblique upwards and nearly always reach above the costa. Gnathos rounded oval. Aedeagus stout, curved, tapering to the blunt tip. Vesica with numerous minute teeth (Fig. 3). These teeth are not always clearly visible.

**Female genitalia** (Fig. 4). – Genital plate low-trapezoid, with a smooth indentation ventrally. The proximal edge is straight, without lumps. Apophyses anteriores short, one third to one quarter of the length of the apophyses posteriores. Ostium triangular with a broad, shallow W-like fold beneath it. Ductus bursae without any sclerotization. Bursa long with a large triangular dentate signum with largest teeth on the longest side.

**Differential diagnosis.** – The adult of *D. incognitella* most resembles *D. douglasella*. The forewings of most specimens of *D. incognitella* are somewhat paler. The post-discal fascia is slightly more angled. The palpi of *D. douglasella* tend to be

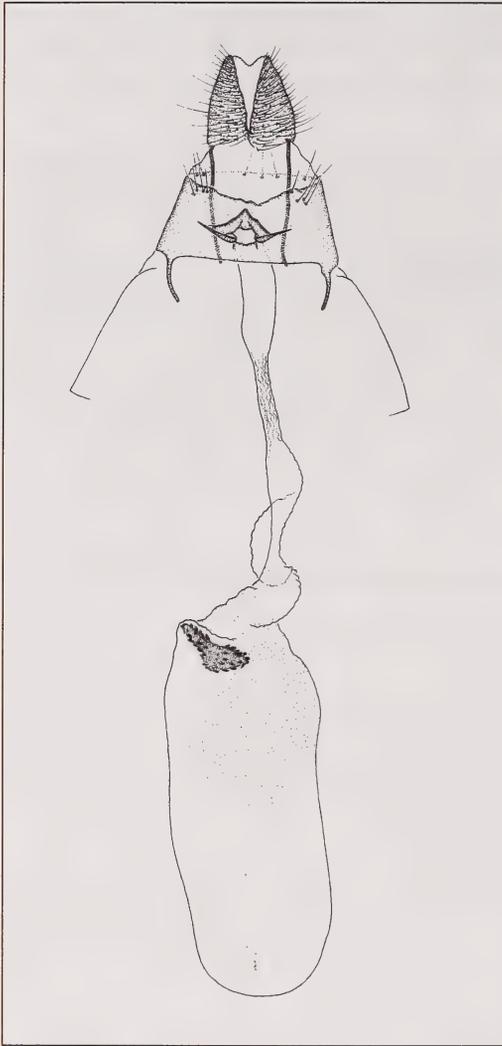


Fig. 4. *Depressaria incognitella*, female genitalia (slide LM-H-21, Huisman)

darker, the second light ring is less distinct. In the male genitalia *D. douglasella* has a shorter and furcate cuiller. In the female genitalia *D. douglasella* has sclerotized semi-circular lumps at the base of the apophyses anteriores. Moreover most specimens of *D. douglasella* have some unilateral sclerotization in the distal part of the ductus bursae. In the characteristic male genitalia *D. incognitella* much resembles *D. nemolella*. There are the following points of difference between these two species:

**A d u l t .** – *D. nemolella* is larger, 19–22 mm, *D. incognitella* 16–18 mm. The forewings of *D. nemolella* are more uniformly coloured with more distinct black longitudinal streaks before the postdiscal fascia. Third segment of palpi with a broader, yellowish-brown ring.

**M a l e g e n i t a l i a .** – Both species have an unfurcate cuiller, but that of *D. incognitella* is longer and nearly half its length extends beyond the costa, being slightly bent inwards in the distal part. The part of the valve beyond the cuiller is distinctly broader

and somewhat longer in *D. nemolella*. The clavus is longer in *D. incognitella* and at least reaches the row of hairs in the costal half of the valve. Those hairs are in the latter species always directed obliquely upwards and often reach beyond the costa.

**Female genitalia.** – The differences are small. According to Svensson (1982) the distal edging of the eighth segment of *nemolella* is more indented, the ostium is less obviously triangular, more rounded, the W-like fold is less distinct, the ductus has some sclerotization laterally and the signum seems to be more rhomboidal.

**Biology.** – As yet nothing is known about the early stages. *D. incognitella* has only been collected in mountainous areas at an altitude of 1000–1600 m, from the end of June till the last third of September.

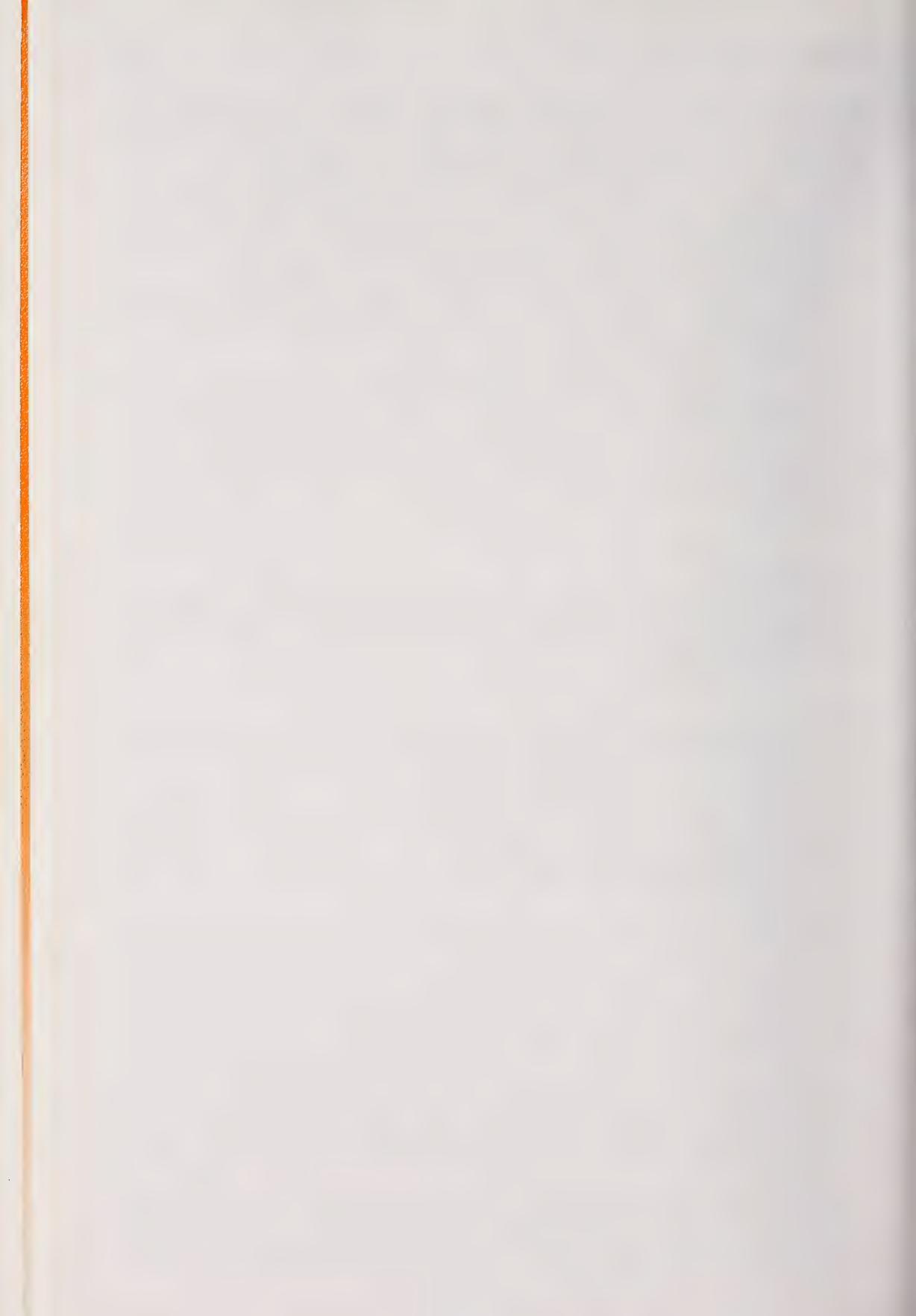
**Distribution.** – The species is known from the Alps in France, Switzerland and Italy, from the Abruzzi (Italy). We have also seen a single female from Spain (Benasque, Huesca, 1500 m) which agrees with the other females we have seen, but in view of the difficulty of distinguishing females within this group, we are not entirely confident that it belongs here. So the occurrence in the latter country has to be confirmed by the catch of males.

#### Acknowledgements

The authors wish to thank Mr. R. Danielsson from the museum of Lund and Mr. O. Karsholt of the museum at Copenhagen for the loan of the typespecimens of *D. nemolella* and *D. incognitella*, Mr. E. J. van Nieukerken for making the photo of the imago, Mr. J. C. Koster for drawing the genitalia and Mr. M. Corley for linguistic assistance.

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## *Gelechia atlanticella* (Amsel, 1955) (Gelechiidae) newly recorded for the European fauna and a review of the *Gelechia* species feeding on Cupressaceae

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**Summary.** *Gelechia atlanticella* (Amsel, 1955) is newly recorded for Europe (Spain). The adult of this hitherto poorly known species is redescribed. The male and, for the first time, the female genitalia structures are illustrated. Information on the habitat and host plant affiliation (Cupressaceae: *Juniperus thurifera* L.) is provided, and the significance of Cupressaceae as host plants of Gelechiidae is discussed in detail.

**Zusammenfassung.** *Gelechia atlanticella* (Amsel, 1955) wird erstmals aus Europa (Spanien) gemeldet. Die bisher kaum bekannte Art wird wiederbeschrieben, Falter sowie männliche und erstmals weibliche Genitalstrukturen werden abgebildet. Informationen zur Habitat- und Futterpflanzenwahl (Cupressaceae: *Juniperus thurifera*) werden gegeben und die Bedeutung der Cupressaceae als Substrat für Gelechiidae wird ausführlich diskutiert.

**Résumé.** *Gelechia atlanticella* (Amsel, 1955) est mentionné pour la première fois d'Europe (Espagne). L'adulte de cette espèce peu connue jusqu'à présent, est redécrit. Les armures génitales mâle et femelle sont illustrées, celles de cette dernière pour la première fois. Des informations sont présentées à propos de l'habitat et de l'affiliation trophique (Cupressaceae: *Juniperus thurifera* L.), et la signification des Cupressaceae en tant que plantes nourricières des Gelechiidae est discutée en détail.

**Key words.** Lepidoptera, Gelechiidae, *Gelechia atlanticella*, Europe, host plant, Cupressaceae, *Juniperus thurifera*.

### Introduction

Although representing one of the most important families of Lepidoptera as far as species richness in Europe (Karsholt & Razowski 1996) is concerned, the fauna of Gelechiidae has received very little attention for almost 200 years of research on Lepidoptera. Generic revisions were almost completely lacking for long periods and species identifications could be achieved by only very few specialists. During the last few decades the situation has much improved and long-awaited identification guides to all species should be available in the foreseeable future (Huemer & Karsholt 1999). The taxonomy of a particularly problematic group, the genus *Gelechia*, has already been resolved by Sattler (1960). Currently, 20 European species are attributed to this genus (Huemer & Karsholt 1999), which is exceptionally well known with regard to data on distribution, taxonomy and biology. Therefore the record of a new species for the European fauna, *viz.* *Gelechia atlanticella*, came as a real surprise. Hitherto, this species was largely unknown, and therefore it is re-described here in some detail. Furthermore, biological information is included and is of particular interest because of the exceptional host plant, *Juniperus thurifera* L.

***Gelechia atlanticella* (Amsel, 1955)**

*Nothris atlanticella* Amsel, 1955: 59, text-fig. 4, pl. 6 fig. 3.

*Gelechia atlanticella* Sattler, 1960: 21, fig. 13.

**Material examined.** – 4 ♂, 2 ♀, Spain, Teruel, Puebla de Valverde, larvae 21.vi.1998, leg. J. Domingo; 1 ♂, e.l. 15.viii.1999, leg. J. Domingo (colls. ICBBE, Universitat de València, València; TLMF, Tiroler Landesmuseum Ferdinandeum, Innsbruck); 1 ♀, Spain, Teruel, Sarrión, larvae 30.vii.1998, leg. J. Domingo & M. Domínguez (TLMF).

**Diagnosis.** – Adult (Fig. 1). Wingspan 19–20 mm. Segment 2 of labial palpi with triangular brush of raised scales, basal half black, distal half off-white mottled with fuscous; segment 3 whitish grey mottled darker. Head whitish grey, thorax and tegulae whitish grey with numerous brown-tipped scales; antenna dark brown; ventral surface of abdomen pink to whitish grey with black lateral and sublateral lines. Forewing greyish brown mottled with whitish; short black streaks at base and in fold; broad median longitudinal streak interrupted by two whitish spots; termen with several black spots. **Similar species.** *G. atlanticella* is practically indistinguishable from *G. sabinellus* externally, though the whitish mottling of the forewing is usually stronger, the black markings indistinct, and the sublateral lines of the ventrum are more distinct.

**Male genitalia** (Figs. 3–5). – Uncus broad, posterior margin strongly serrate; tegumen broad, about breadth of uncus; fultura superior with rounded flaps; valva slender and moderately long, extending to about base of uncus, distally rounded, with short tooth; sacculus very slender, falcate, almost reaching tip of valva; saccus moderately broad, with rounded tip; aedeagus stout, with curved apex.



**Fig. 1.** Adult ♂ of *Gelechia atlanticella*.



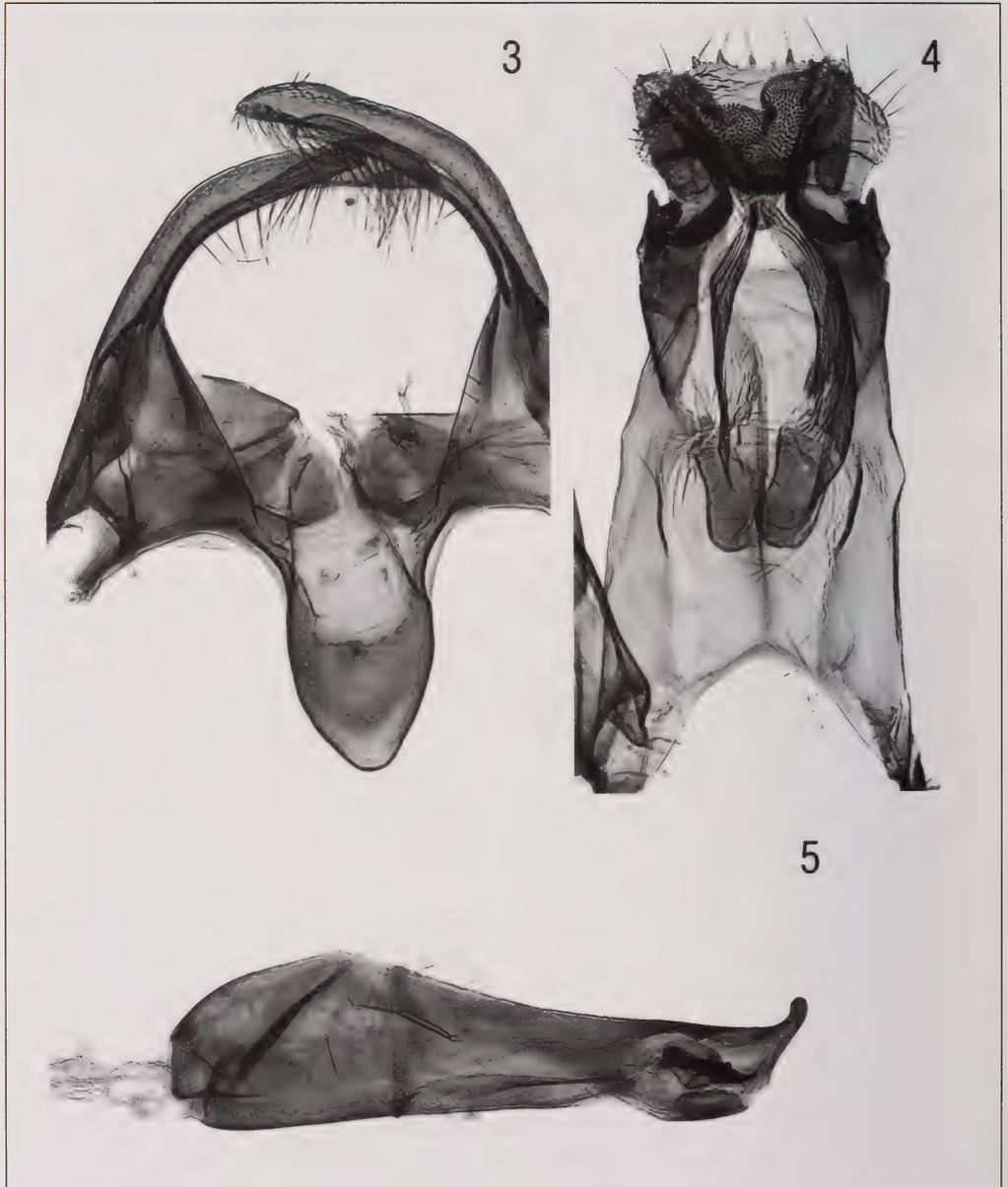
Fig. 2. Habitat of *Gelechia atlanticella* (Spain, Teruel).

Female genitalia (Figs. 6–7). – Segment 8 about 2.5 times longer than broad; ventromedial part with long, narrow zone of microtrichia; apophyses anteriores extremely short, close to subgenital plate; subgenital plate a pair of sub-oval lobes, caudally with subtriangular processes; ductus bursae coiled medially, corpus bursae elongated; signum large, sub-oval, with weakly serrate margin.

Distribution. – *G. atlanticella* is known only from a few isolated localities in Morocco (Ain Kahla) and Spain (Teruel: Puebla de Valverde, Sarrión). The distribution is closely associated with the larval host plant *Juniperus thurifera*, which is regarded as a Tertiary relict (Ozenda 1988; Suarez *et al.* 1992).

Bionomics. – The life-cycle and morphology of early stages are still insufficiently known. The larva is similar to those of other *Gelechia* feeding on Cupressaceae such as *G. senticetella* or *G. nervosella*. Body light green with head blackish brown, more slender than *G. senticetella* or *G. nervosella* and reaching 12–14 mm in the final stage. Its characteristic behaviour differs from the other *Gelechia* species found during this study. Larvae make nervous movements when collected, walking very quickly forward or backward when disturbed. However, a similar behaviour has been observed in many other gelechiids. The first larval stages are unknown but later stages feed on the leaves. Larvae were collected from *Juniperus thurifera* trees by using a beating tray and reared in the laboratory on leaves of the host plant. In the laboratory, pupation took place in a cocoon between the leaves. Collected larvae pupated within a few days, and adults emerged after approximately 30 days (indoors in València, Spain). The species is univoltine, at least in the Iberian mountains (Central Spain), as our annual survey

has shown. Adults emerged solely in July and August, indicating a single generation. Habitat. – *G. atlanticella* was found in the Spanish juniper forests of the Iberian mountains (Central Spain) (Fig. 2). *Juniperus thurifera* grows in forests where trees are represented only by this species and other Cupressaceae such as *J. phoenicea* and *J. communis*, mixed with some sclerophyllous *Quercus* (e.g. *Q. ilex* or *Q. faginea*), or as natural fences between crops. Some *Pinus* species such as *P. sylvestris* or *P. nigra*



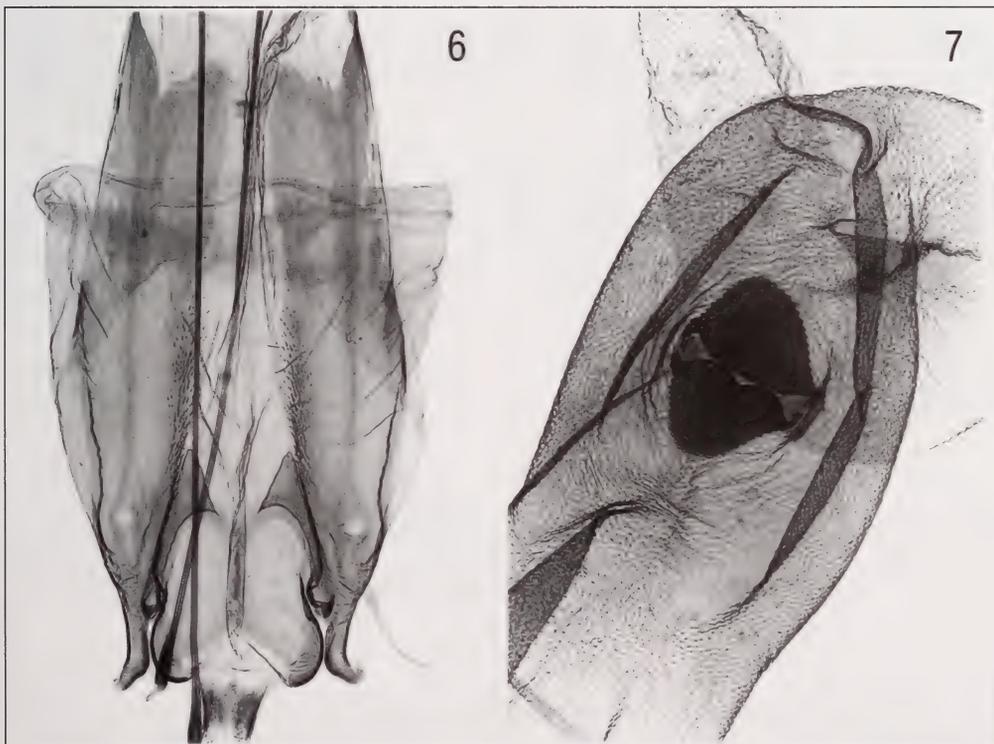
Figs 3–5. *Gelechia atlanticella* ♂ genitalia (slide GEL 967 P. Huemer): 3 – vinculum-valva complex; 4 – uncus-tegumen complex; 5 – aedeagus (same magnification).

subsp. *salzmanii* can grow in these habitats. This landscape shares with North Africa (where H. Powell found *G. atlanticella*) a remarkable number of North African floristic elements (Súarez *et al.* 1992). This flora is associated with a sizeable number of endemic or vicariant Lepidoptera exclusively found in this habitat on the Iberian Peninsula (Dominguez *et al.* 1997).

**Remarks.** – *Nothris atlanticella* was described from a single male bred from *Juniperus thurifera* by H. Powell (Amsel 1955) and was later placed in the genus *Gelechia* (Sattler, 1960). The female had remained unknown until now.

## Discussion

*G. atlanticella* belongs to the *sabinellus* group of *Gelechia*, which has already been defined by Sattler (1960), based on host plant selection and morphological structures of the genitalia. This species-group also includes *Gelechia senticetella* (Staudinger, 1859), *G. sabinellus* (Zeller, 1839) (including the distinct subspecies *s. corsella* (Rebel, 1930)), *G. nervosella* (Zerny, 1927) and *G. allotria* Meyrick, 1925 (= *G. anarsiella* Chrétien, 1915, preocc.). Due to the courtesy of Dr. K. Sattler we have been able to examine a drawing of the female genitalia of a syntype of the latter. Accordingly, *G.*



**Figs 6–7.** *Gelechia atlanticella* ♀ genitalia (slide GEL 963 P. Huemer): 6 – segment 8; 7 – corpus bursae-signum (same magnification).

*atlanticella* is most closely related to *G. sabinellus* and *G. allotria*. These species share, in particular, the extremely reduced apophyses anteriores and sub-oval signum. Moreover, species of the *sabinellus* group are very similar externally and examination of the genitalia is recommended for their identification. The male genitalia of *G. atlanticella* are characterized by the shape of the uncus, valva and sacculus. The female genitalia differ from related taxa by, for example, the subtriangular processes of sternum 8.

Compared with other microlepidopteran families, gelechiids use an extreme diversity of plants with no strong preferences (Powell 1980; Powell *et al.* 1998). Even though many Gelechiidae genera are associated with particular host plant groups, for example *Ornativalva* Gozmány with *Tamarix*, *Caryocolum* Gregor & Povolný with Caryophyllaceae, *Mirificarma* Gozmány with Fabaceae, or *Metzneria* Zeller, *Isophrictis* Meyrick and *Apodia* Heinemann with Asteraceae (Sattler 1976; Pitkin 1984; Huemer 1988; Elsner *et al.* 1999), in the genus *Gelechia* a different tropical pattern is found (Sattler 1960). The division of species-groups within the genus is corroborated by host plant preferences, though precise relationships between host plants and *Gelechia* phylogeny remain unknown.

Among all the species-groups of the genus, only the *sabinellus* group is associated with Cupressaceae (the host-plant of *G. allotria* is unknown), while the remaining species-groups within *Gelechia* show a clear preference for other families such as Salicaceae, Rosaceae, Elaeagnaceae and Aceraceae (Sattler 1960; Huemer & Karsholt 1999). Host-plants of some species such as *G. dujardini* Huemer 1991, *G. mediterranea* Huemer, 1991 and *G. aspoECKi* Huemer, 1992 are unknown, but it seems likely that they could be associated with Aceraceae and Salicaceae (Huemer 1991, 1992).

Tab. 1. Distribution and host plants of the *Gelechia sabinellus* species-group.

Species	Distribution	Host-plants	References
<i>Gelechia atlanticella</i>	Only known from two isolated areas: Ain Kahla (Morocco) and Puebla de Valverde (Spain)	<i>Juniperus thurifera</i>	Amsel (1955)
<i>Gelechia nervosella</i>	France, Spain and Morocco	<i>J. thurifera</i>	Cleu (1928); Huemer & Karsholt (1999)
<i>Gelechia allotria</i>	Only known from Frenda, Oran (Algeria)	Unknown	Chrétien (1915)
<i>Gelechia senticetella</i>	Western Palearctic (excluding northern Europe). Recently spread to various countries.	<i>J. thurifera</i> , <i>J. sabina</i> , <i>J. oxycedrus</i> , <i>J. communis</i> , <i>J. phoenicea</i> , <i>Thuja</i> sp.	Cleu (1928); Lhomme (1935–1949); Gómez de Aizpúrua (1995); Huemer & Karsholt (1999); Blasco Zumeta (2000); Domingo <i>et al.</i> (2000)
<i>Gelechia sabinellus</i>	Western Palearctic	<i>J. thurifera</i> (?), <i>J. communis</i> , <i>J. sabina</i> , cultivated Cupressaceae	Lhomme (1935–1949); Emmet (1979); Huemer & Karsholt (1999); Elsner <i>et al.</i> (1999)

Cupressaceae are also larval host plants of other unrelated European gelechiids, *viz.* *Chionodes electella* (Zeller, 1839), *Dichomeris juniperella* (Linnaeus, 1761) and *D. marginella* (Fabricius, 1781). Nevertheless, within the Microlepidoptera, only Argyresthiinae (Yponomeutidae) seem to have developed appreciable speciation on Cupressaceae (Powell 1980; Powell *et al.* 1998).

Previous studies on *Juniperus* and its associated Lepidoptera have been done in Spain, France and Morocco (Cleu 1928; Wiltshire 1976; Lainé 1983; Roques *et al.* 1984; Gómez de Aizpúrua 1990, 1995; Blasco-Zumeta 2000; Domingo *et al.* 2000). Consequently, there is good knowledge about the distribution and host-plants of the Lepidoptera species associated with this gymnosperm family. Surprisingly, previous surveys have ignored the complex of *Gelechia* species (Wiltshire 1976; Lainé 1983). Only Cleu (1928), Gómez de Aizpúrua (1990, 1995) and Blasco-Zumeta (2000) have included at least one of these species. In our Spanish juniper study, three species of the *sabinellus* group have been found (*G. atlanticella*, *G. senticetella* and *G. nervosella*) showing a trophic succession. The larvae of *G. nervosella* have been found during the winter months (adults emerged in late winter and early spring in the laboratory), *G. senticetella* during early spring (adults emerged in mid spring) and, finally, *G. atlanticella* in late June and July (adults emerged in July and August). Externally, these gelechiid species share a similar wing pattern (when resting on juniper bark, the forewings – grey with dark lines – are cryptic), which also occurs in some other Lepidoptera species of different families feeding on the leaves of Cupressaceae, such as *Afriberina tenietaria* (Staudinger, 1900) (Geometridae), *Menophra harterti* (Rothschild, 1912) (Geometridae), *Ecleora solieraria* (Rambur, 1834) (Geometridae), *Pachypasa limosa* (Serres, 1827) (Lasiocampidae) and *Lithophane leautieri* (Boisduval, 1829) (Noctuidae).

Individual species of the *sabinellus* group are restricted to one or a few *Juniperus* species. This kind of monophagy has been found in other gelechiids (Pitkin 1988) and is closely related to the distribution area of each species (see Table 1). In fact, the inability to utilize a wider range of species within *Juniperus* has restricted the distribution of the species of *Gelechia*. Monophagous specialists on *Juniperus thurifera* such as *G. atlanticella* and *G. nervosella* are therefore local endemics. Though species of the *sabinellus* group use a limited number of host species in nature, most *Juniperus* species are acceptable to them in culture, even introduced Cupressaceae that do not occur in their natural habitat.

#### Acknowledgments

We are specially indebted to Dr. Martí Domínguez (València) for his continuous support during the field work and for his helpful contribution to the Spanish juniper studies. Furthermore we express our gratitude to Dr. Joaquín Baixeras (València) and to Ole Karsholt (Copenhagen) for their helpful comments on the manuscript. Dr. Klaus Sattler (Natural History Museum, London) kindly made available a genitalia drawing of *G. allotria*.

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## On the systematic position of some Palaearctic Pyraustinae (Pyraloidea, Crambidae)

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**Summary.** Re-examination of type material of *Metasia ossealis* Staudinger, 1880 **stat. rev.** and *Stenia ferrealis* Hampson, 1900 revealed nomenclatural corrections of these two taxa. *Metasia ossealis* **stat. rev.** does indeed belong to the genus *Metasia* and is resurrected from synonymy with *Palepicorsia ustrinalis* (Christoph, 1877) **comb. rev.**, of which *Palepicorsia* Maes, 1995 **stat. rev.** is resurrected from synonymy with *Achyra* Guenée, 1849 and *P. ustrinalis* **comb. rev.** is again combined with this genus. Diagnostic characters of *Palepicorsia* and *Achyra* are given. *Pyrausta ferrealis* (Hampson, 1900) **comb. n.** is removed from *Mardinia* Amsel, 1952 **syn. n.** and the latter is synonymized with *Pyrausta* Schrank, 1802. Genitalia and tympanal organs of *Metasia ossealis* and *Stenia ferrealis* are illustrated.

**Zusammenfassung.** Die Nachuntersuchung von Typenmaterial von *Metasia ossealis* Staudinger, 1880 **stat. rev.** und *Stenia ferrealis* Hampson, 1900 ergab nomenklatorische Korrekturen dieser zwei Taxa: *Metasia ossealis* **stat. rev.** gehört tatsächlich zu der Gattung *Metasia* Guenée, 1854 und wird aus der Synonymie mit *Palepicorsia ustrinalis* (Christoph, 1877) **comb. rev.** sowie *Palepicorsia* Maes, 1995 **stat. rev.** aus der Synonymie von *Achyra* Guenée, 1849 herausgenommen und *P. ustrinalis* **comb. rev.** wird wiederum mit dieser Gattung kombiniert. Diagnostische Merkmale von *Palepicorsia* und *Achyra* werden beschrieben. *Pyrausta ferrealis* (Hampson, 1900) **comb. n.** wird aus *Mardinia* Amsel, 1952 **syn. n.** herausgenommen und diese Gattung mit *Pyrausta* Schrank, 1802 synonymisiert. Die Genitalien und Tympanalorgane von *Metasia ossealis* und *Stenia ferrealis* werden abgebildet.

**Resumé.** On a étudié le matériel-type de *Metasia ossealis* Staudinger, 1880 **stat. rev.** et de *Stenia ferrealis* Hampson, 1900. On propose les changements nomenclaturaux suivants: *Metasia ossealis* **stat. rev.** fait bien partie du genre *Metasia* et n'est pas synonyme de *Palepicorsia ustrinalis* (Christoph, 1877) **comb. rev.**; le genre *Palepicorsia* Maes, 1995 **stat. rev.** est enlevé de la synonymie d'*Achyra* Guenée, 1849. On donne les caractères diagnostics de *Palepicorsia* et *Achyra*. *Mardinia* Amsel, 1952 **syn. n.** devient synonyme de *Pyrausta* Schrank, 1802. On illustre les génitalia et les organes tympaniques de *Metasia ossealis* et de *Pyrausta ferrealis* (Hampson, 1900) **comb. n.**, l'espèce-type de *Mardinia* **syn. n.**

**Key words.** *Metasia ossealis*, *Palepicorsia ustrinalis*, *Achyra*, *Stenia ferrealis*, *Mardinia*, *Pyrausta*, lectotype designations, synonymy

### Introduction

Turkey with its high, diverse biota provides a very rich fauna of Pyraloidea that is far from well examined. Many systematic problems remain to be solved.

In 1995, I considered *Metasia ossealis* as a junior subjective synonym of *Palepicorsia ustrinalis* (Christoph, 1877) based on (wrongly identified) specimens at The Natural History Museum London (Maes 1995). The type specimens of *M. ossealis* could not be traced at the time of my publication but were later recovered by Dr. M. Nuss and kindly put at my disposal. The study of the type material showed that my results from 1995 need to be revised. In addition, Speidel (1996) synonymised *Palepicorsia* Maes, 1995 with *Achyra* Guenée, 1849 which contradicts my own results while studying *Achyra* species on a world scale.

Another species, *Mardinia ferrealis* (Hampson) proved to be wrongly placed after studying the genitalia and tympanal organs.

The material was dissected following methods described by Maes (1985). The nomenclature of the structures (genitalia and tympanal organs) follows Maes (1995).

*Metasia ossealis* Staudinger, 1880 stat. rev.

(Fig. 1, Pl. 1 Fig. A, B, C, D)

Staudinger, 1880:182 (*Metasia*); type locality: Amasia.

**Material examined.** – Lectotype ♂, pink label “Origin.”, yellow label “Amasia | Joh.”, white label “ossealis Stgr.”, white label “30/4”, “Lectotype | *Metasia ossealis* Staud. | det. K. Maes 1998” (hereby designated), (MNHU); Paralectotypes: ♂, Mardin 97 Man. (abdomen missing) (MNHU); ♀, Mardin, K. Maes Gen. Prep. ♀20415 (MNHU); ♂, Amasia, Genit. unters. Nr.1481 Zool. Mus. Berlin (MNHU); ♂, “270” K. Maes Gen. Prep. nr. ♂20414 (MNHU); ♂, no data label, K. Maes Gen. Prep. nr. ♂20426 (MNHU); ♂, no data label (MNHU).



Fig. 1. *Metasia ossealis* Staudinger, Lectotype

**Diagnosis.** – Fibula very robust and broad, corpus bursae without signum.

**Description.** – External characters: ground colour light brown to whitish-brown. Antemedian and postmedian band dark brown; median field lighter in colour as ante- and postmedian fields. Hind wings much lighter coloured as fore wings.

**Head.** – Frons rounded, labial palpi correct, long triangular; maxillary palpi well developed, clearly visible; antennae filiform in females, unipectinate in males.

**Wings.** – Wingspan: 18–23mm; frenulum hook simple in males and females; retinaculum in both sexes consisting of a series of bristles near the Cu stem, males have an additional retinaculum hook originating from the Costa.

**Tympanal organs.** – Praecinctorium bilobed; tympanal organs invaginated but with fornix tympani above the venula prima; bulla tympani widely separated;

no saccus tympani; specific sclerotizations on zona glabra tympani lacking.

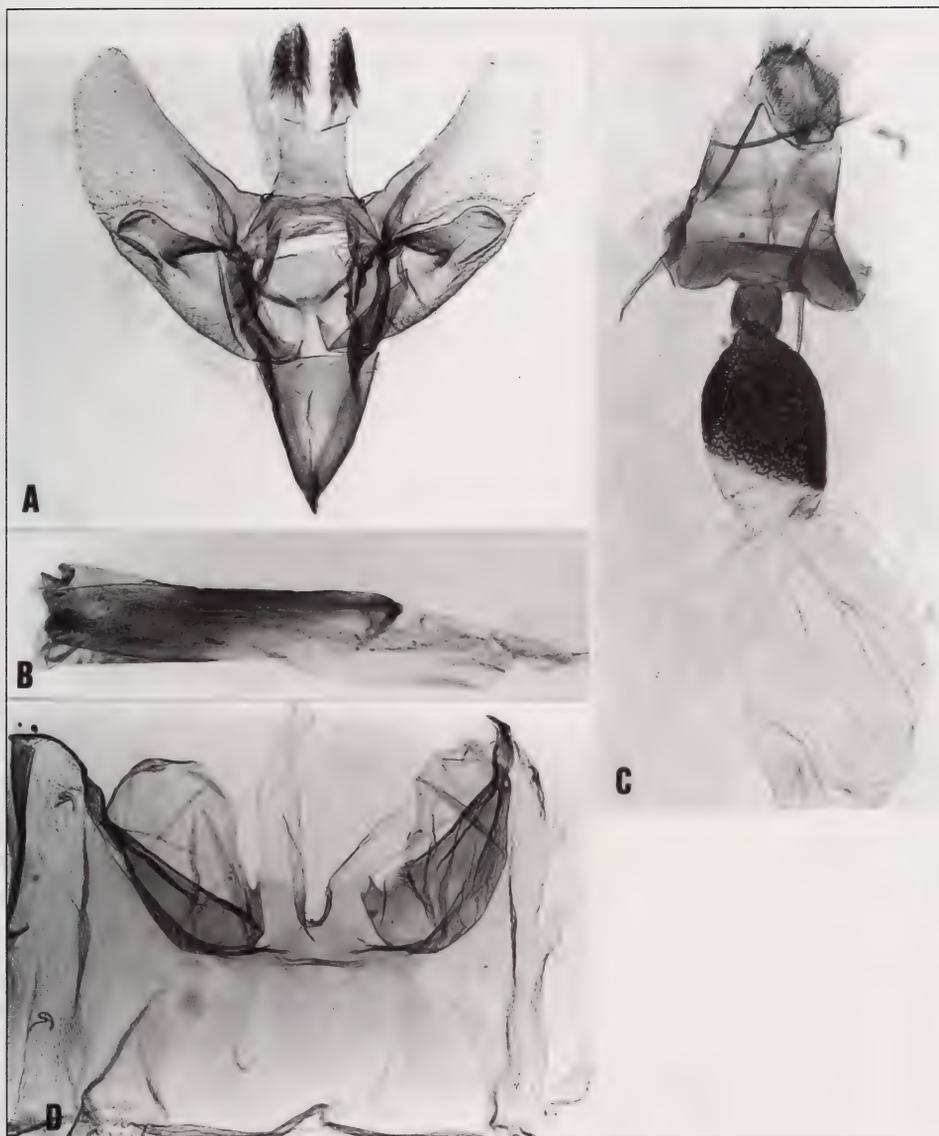
**Male genitalia.** – Typical *Metasia* genitalia: uncus bilobed, dorsally with modified setae (flattened, terminally bilobed); ventral part of valva rounded towards the apex, costa straight; spoon-like fibula, rather broad and extending to the ventral side of the valva; saccus strongly developed. Aedeagus straight, broad without spicula or a cornutus.

**Female genitalia.** – Ostium bursae broad but shallow; antrum strongly sclerotized; no clear ductus bursae present; apical part of corpus bursae modified: proximal part more sclerotized than distal part and bearing folds, this part could be considered as the colliculum; distal part of corpus bursae membranous, signum lacking.

**Life cycle.** – Unknown.

**Distribution.** – Mardin [Turkey].

**Remarks.** – The characters studied clearly show that Staudinger placed the species correctly in the genus *Metasia*, and the species is resurrected here from synonymy with *Palepicorsia ustrinalis*.



Pl. 1. *Metasia ossealis* Staudinger. A – male genitalia, K. Maes Gen. Prep. ♂ 20414; B – aedeagus; C – female genitalia, K. Maes Gen. Prep. ♀ 20415; D – tympanal organs.

***Palepicorsia* Maes, 1995 stat. rev.**

Type species. – *Botys ustrinalis* Christoph, 1877, by original designation.

***Palepicorsia ustrinalis* (Christoph, 1877) comb. rev.**

*Botys ustrinalis* Christoph, 1877: 274–275.

*Scopula palmalis* Swinhoe, 1884: 524.

*Metasia emiralis* Oberthür, 1888: 36, pl. 6 fig. 33.

*Metasia excavatalis* Ragonot, 1892: 294, pl. 3 fig. 14.

Remarks. – In the checklist of the European Lepidoptera the generic name *Palepicorsia* is placed as a junior synonym of *Achyra* Guenée, 1849 stating that "the morphological differences indicated seem not to be sufficient for a separate genus" (Speidel 1996: 326). Older authors like Hampson made generic combinations based on external characters. This has caused quite some confusions with genera like *Achyra* Guenée, 1849 and *Loxostege* Hübner [1825]. True *Achyra* species were until recently generally placed under *Loxostege*. Even at this moment a complete view on world basis of the genus *Achyra* is not achieved and more species will probably be placed in this genus as soon as the genitalia become investigated. The object of these remarks are to clarify the present definition of *Achyra*. A phylogenetic analysis of this genus is beyond its present scope and has to be prepared in the context of all pyraustine genera on a world basis, which are approximately 187 valid genera K. Maes, unpublished).

Externally, *Palepicorsia ustrinalis* looks like certain species of the genus *Achyra*. This may be due to an adaptation to similar habitats. Differences are obvious when it comes to the male genitalia: the uncus, sella and editum on the valva and the transtilla are different in structure. Typical *Achyra* species have the editum consisting of simple setae clearly at a distance from the base of the sella. The uncus is never fused to the tegumen as in *P. ustrinalis*. This has proved consistent with *Achyra* species from different continents. The following species were dissected for this purpose. *A. massalis* (Walker, 1859); *A. nigrirenalis* (Hampson, 1913); *A. nudalis* (Hübner, 1796); *A. rantalis* (Guenée, 1854); *A. takowensis* Maes, 1987; *A. affinitalis* (Lederer, 1863); *A. brasiliensis* (Capps, 1967); *A. coelatalis* (Walker, 1859); *A. eneanalis* (Schaus, 1923); *A. llaguenalis* Munroe, 1978; *A. occidentalis* (Packard, 1873); *A. piuralis* (Capps, 1967); *A. protealis* (Warren, 1892) and *A. similalis* (Guenée, 1854). No *Achyra* species has the uncus fused to the tegumen nor has any *Achyra* species the editum near the base of the sella. The fused uncus/tegumen occurs in *Arenochroa* Munroe, 1976; *Xanthostege* Munroe, 1976; *Lamprophaia* Caradja, 1925 just to name a few. It is also not clear at this moment if this condition evolved once or at different occasions. The placement of the editum and sella varies also greatly. The most extreme forms occur in the *Cryptosara* Martin, 1956 *Portentomorpha* Amsel, 1956 group. Because of the above reasons, retaining *Palepicorsia ustrinalis* in *Achyra* would make the latter a polyphyletic genus. Therefore, *Palepicorsia* is here considered as a valid genus.

### **Pyrausta Schrank, 1802**

Synonyms. – *Botys* Latreille, [1802 Nov.6]; *Heliaca* Hübner, [1806] (rejected name); *Heliaca* Hübner, 1808 (rejected name); *Haematia* Hübner, 1818; *Heliaca* Hübner, 1818 (not nomenclaturally available); *Pyraustes* Billberg, 1820 (unjustified emendation); *Botis* Swainson, 1821 (unjustified emendation); *Heliaca* Hübner, 1822; *Tholeria* Hübner, 1823; *Porphyritis* Hübner, [1825] 1816; *Syllythria* Hübner, [1825] 1816; *Pyrausta* Hübner, [1825] 1816 (incorrect authorship); *Panstegia* Hübner, [1825] 1816; *Perilypa* Hübner, [1825] 1816; *Ostreophana* Sodoffski, 1837 (misspelling); *Ostreophana* Sodoffski, 1837 (unnecessary replacement name for *Botis* Swainson, 1821); *Rhodaria* Guenée, [1845] 1844; *Botis* Agassiz, 1847 (misspelling); *Herbula* Guenée, 1854; *Synchromia* Guenée, 1854; *Cindaphia* Lederer, 1863; *Proteroeca* Meyrick, 1884; *Sciorista* Warren, 1890; *Autocosmia* Warren, 1892; *Anthocrypta* Warren, 1892; *Aplographe* Warren, 1892; *Hyaloscia* Dognin, 1908; *Trigonuncus* Amsel, 1952; *Mardinia* Amsel, 1952 syn. n.; *Rattana* Rose & Pajni, 1979.

***Pyrausta ferrealis* (Hampson, 1900) comb. n. (Fig 2, Pl. 2 Fig. A, B, C, D)**

*Stenia ferrealis* Hampson, 1900: 385; typelocality: Mardin.

**Material examined.** – Lectotype ♂, Mardin 97 Man, K. Maes Gen. Prep. nr. ♂ 20.412, “Lectotype | *Stenia ferrealis* Hmpsn | Det. K. Maes 1998” (hereby designated), (MNHU); Paralectotypes: ♀, Mardin 97 Man; K. Maes Gen. Prep. ♀ 20.413 (MNHU); ♂? GU 812a, Typus, *Stenia ferrealis* Hps = *Metasia acutalis* Mardin, BH i. l. (MNHU); ♂, [no data] (MNHU); ♀, Mardin 91 Man (MNHU); ♀, Syrien (MNHU).

**Diagnosis.** – Ground colour of fore wings reddish-brown with pale yellow or white transverse lines. Hind wings pale brown to white.

**Description.** – External characters: Ground colour ochreous brown with white antemedian and postmedian bands. Hind wings lighter in colour, postmedian area ochreous brown as fore wings.

**Head.** – Frons rounded, labial palpi porrect, maxillary palpi above labial palpi, clearly visible.

**Wings.** – Wingspan 14–20mm; Frenulum hook simple in males, double in females. Retinaculum identical in both sexes, consisting of a series of bristles near the Cu stem.

**Tympanal organs.** – Praecinctorium terminally with a tuft of elongated scales; tympanal organs deeply invaginated, fornix tympani underneath the venula prima; venula prima narrow over its whole length; saccus tympani deep, well developed; venula prima extending in the venula secunda, the latter extends beyond the bottom of the saccus tympani.

**Male genitalia.** – Uncus simple, elongate, terminally rounded and dorsally covered with simple setae; valva with rounded tip, simple lobe-shaped sella with flattened setae, no separate editum present; aedeagus with needle-shaped spicula.

**Female genitalia.** – Papillae anales membranous; ostium bursae membranous, tube-like with numerous small sclerotizations, antrum strongly sclerotized continuing in a membranous and strongly coiled ductus bursae; posterior part of ductus bursae with a sclerotized band over its length; corpus bursae membranous with a rhomboid signum and an appendix bursae near the middle.

**Life cycle.** – Not known.

**Distribution.** – Mardin, Marash [Turkey].

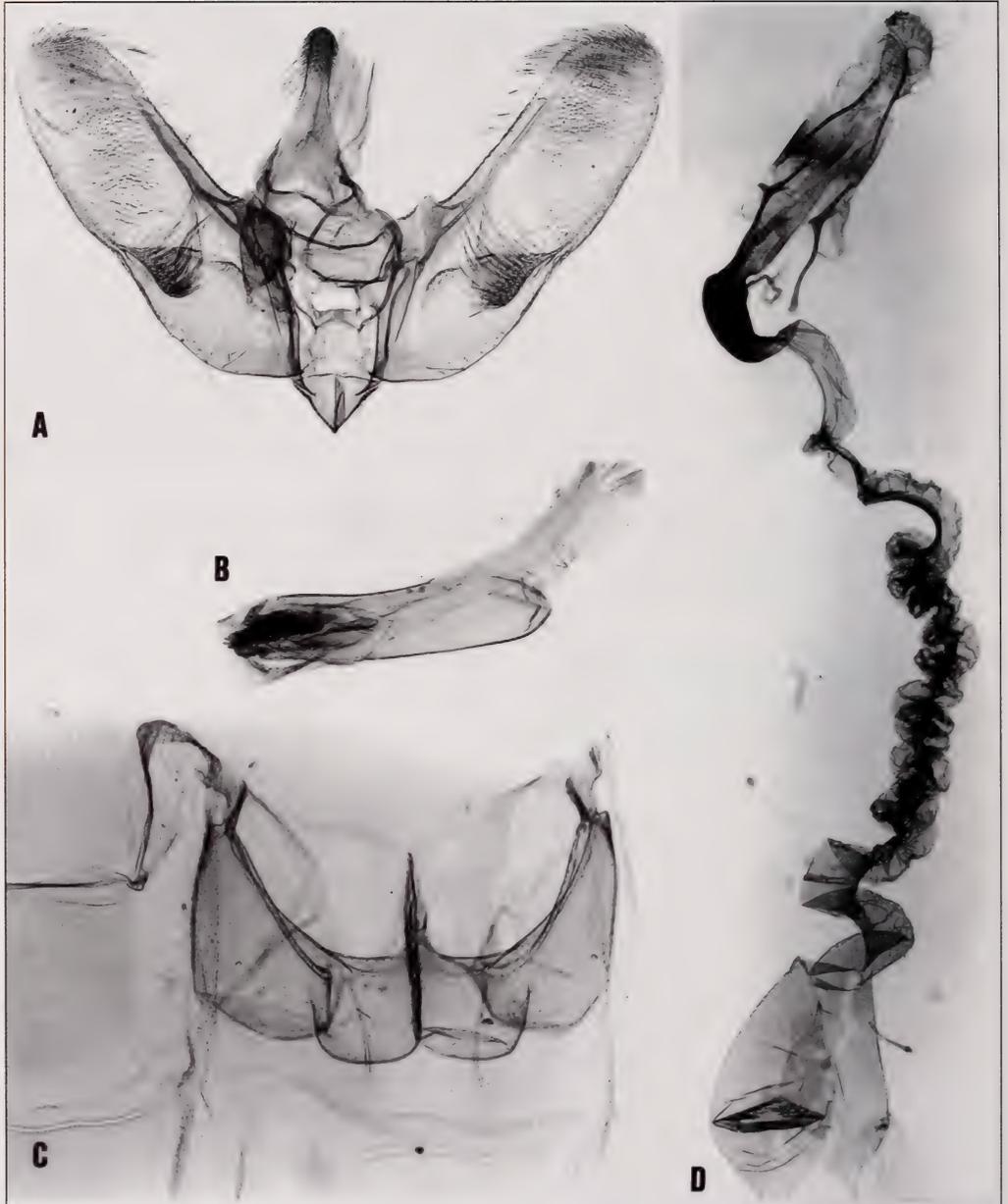
**Remarks.** – Amsel (1952) established the genus *Mardinia* **syn. n.** with *Stenia ferrealis* Hampson as type species. The slides made by Amsel were not traced for study but there was ample material to make new genitalia



Fig. 2. *Pyrausta ferrealis* Hampson, Paralectotype.

slides. Amsel (1952) did not select any lecto- or paralectotypes among the type series which is done here.

The male and female genitalia of *ferrealis* show that this species belongs to the genus *Pyrausta* Schrank, 1802. The genitalia and even the tympanal organs show no differences with typical *Pyrausta* species like *P. nigralis* (Fabricius, 1781); *P. purpuralis*



Pl. 2. *Pyrausta ferrealis* Hampson, Lectotype. A – male genitalia, K. Maes Gen. Prep. ♂20412; B – aedeagus; C – tympanal organs; D – female genitalia, *Pyrausta ferrealis* Hampson, Paralectotype, K. Maes Gen. Prep. ♀20413.

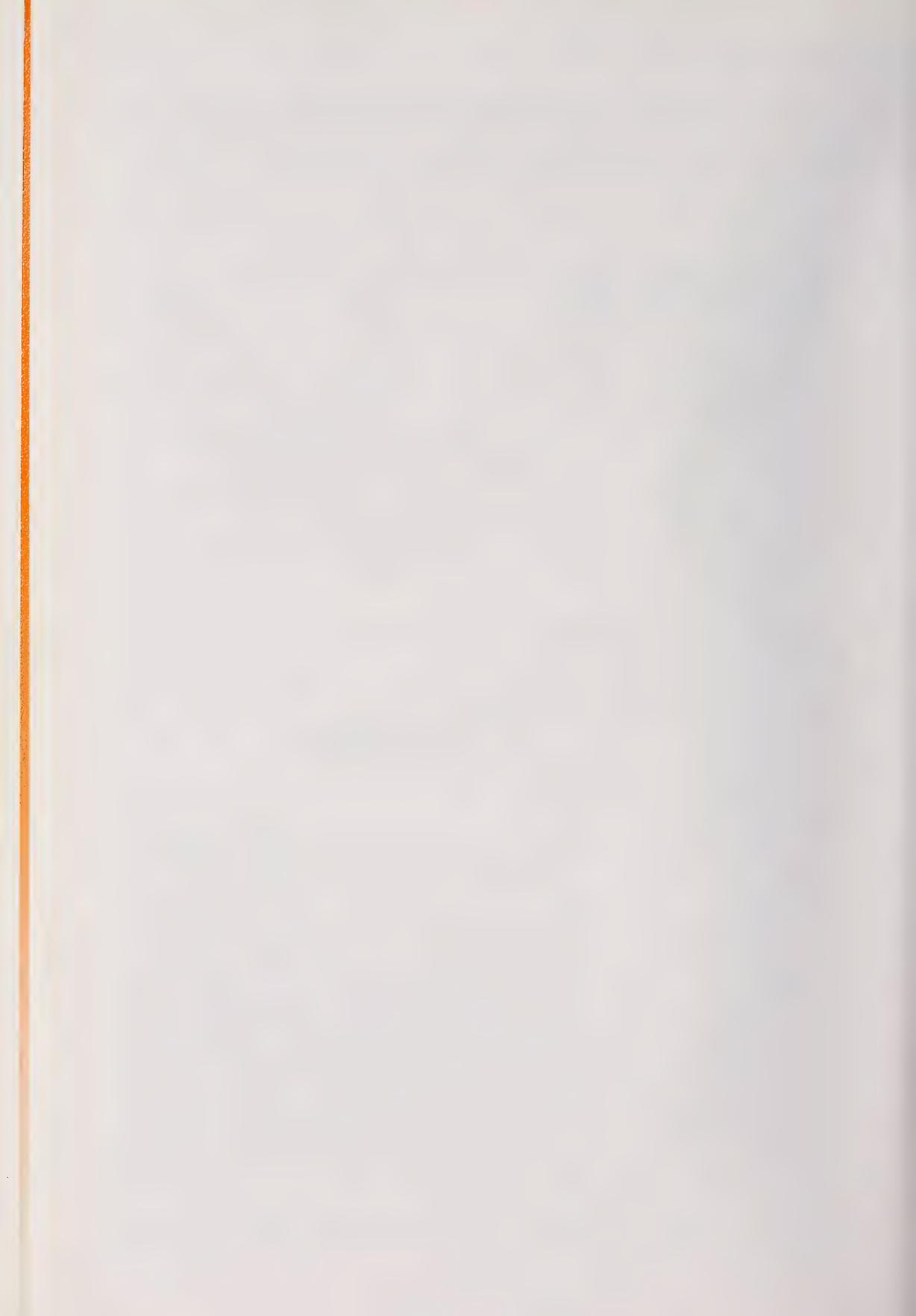
(Linnaeus, 1758); *P. aurata* (Scopoli, 1763); *P. gutturalis* (Staudinger, 1880); *P. aerealis* (Hübner, 1796) or *P. castalis* (Treitschke, 1829) just to name a few. As a result, following synonymy is established: *Pyrausta* Schrank, 1802. = *Mardinia* Amsel, 1952 **syn. n.**

### Acknowledgements

I wish to thank Dr. M. Nuss for going through the collections of the Museum für Naturkunde, Humboldt-Universität zu Berlin (MNHU) and providing me with the type series of *Metasia ossealis* Staudinger, 1880 and *Stenia ferrealis* Hampson, 1900.

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## Remarks on the morphology and habitat of *Glacies belzebuth* (Praviel, 1938) (Geometridae)

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**Summary.** On the basis of recent captures of *Glacies belzebuth* (Praviel, 1938) in the Cottian Alps (Italy), the external habitus of this geometrid moth is redescribed and detailed illustrations of the genitalia of both sexes are provided. Genitalia structures are compared with the taxonomically closest species-group taxa within the genus *Glacies* Millière. Brief remarks about habitat associations and phenology are also given. It is concluded that, contrary to views proposed in the literature during the past 50 years, *G. belzebuth* is a distinct species and neither a subspecies of *G. noricana* nor *G. bentelii*. The new records of *G. belzebuth* are the first from Italy.

**Zusammenfassung.** *Glacies belzebuth* (Praviel, 1938) wurde erstmalig in den Cottischen Alpen und damit neu für die Fauna Italiens nachgewiesen. Auf der Grundlage der Belegexemplare wird der Habitus der seit der Originalbeschreibung nur selten beobachteten Art nochmalig beschrieben. Die äußeren Genitalarmaturen beider Geschlechter werden beschrieben, abgebildet und im Vergleich mit verwandten Artengruppen-Taxa der Gattung *Glacies* Millière diskutiert. Habitatbindung und Phänologie der italienischen Population werden kurz charakterisiert. Konstante morphologische Merkmale in Verbund mit Angaben zur bisher bekannten Verbreitung und Ökologie lassen den Schluß zu, daß *G. belzebuth* eine distinkte Art darstellt und nicht als Unterart *G. noricana* oder *G. bentelii* zuzuordnen ist.

**Résumé.** À partir d'exemplaires de *Glacies belzebuth* (Praviel, 1938) capturés tout récemment dans les Alpes Cottiennes Italiennes, l'auteur présente une redescription de l'habitus de ce Géomètre, accompagnée d'illustrations détaillées de l'armure génitale des deux sexes. Ces dernières structures sont comparées à celles d'autres taxons du groupe-espèce les plus proches au sein du genre *Glacies* Millière. L'auteur fournit aussi quelques données relatives à l'habitat et à la phénologie du taxon en question. Contrairement à l'interprétation existante dans la littérature du demi siècle dernier, il arrive à la conclusion que *belzebuth* peut être considéré comme une espèce distincte et non comme sous-espèce de *G. noricana* ou de *G. bentelii*. *G. belzebuth* est signalé ici pour la première fois d'Italie.

Key words: Geometridae, *Glacies belzebuth*, *Psodos*, taxonomic status, Italy.

### Introduction

*Glacies belzebuth* was originally described within the genus *Psodos* Treitschke by Praviel as a new species in 1938, the type locality being Mont Mounier (Alpes Maritimes, France). Although Praviel provided a figure of the male copulatory apparatus in the original description, *G. belzebuth* was considered in later works on the genus *Psodos* (s. lato) as a very problematical taxon. Its status as separate species has been systematically questioned.

Wehrli (1953) treated *belzebuth* in a section independent from both *noricana* Wagner, 1898, and *bentelii* Rätzer, 1890, pointing out the differences also with respect to *alpmaritima* Wehrli, 1924 (currently treated as a subspecies of *bentelii*: Scoble 1999), especially regarding the habitat and the corresponding geological substrate. Nonetheless, in the final part of his treatment, Wehrli stated that owing to the variability of the genitalia in *G. bentelii* and considering that *alpmaritima* shows a great polymorphism, *belzebuth* may be regarded as a subspecies of *bentelii*, which, using the words of Wehrli, 'has not left the species [*bentelii*] nearly so strongly as ssp. *panticosea* Wehrli' (*panticosea* Wehrli, 1945 is currently also regarded as a subspecies of *bentelii*: Scoble

1999). With this unclear statement Wehrli seems to provisionally assess the three taxa *alpmaritima*, *belzebuth* and *panticosea* as subspecies of *bentelii*.

In their important monograph, Povolný & Moucha (1955) treated *G. belzebuth* in a rather superficial way. This may be explained by the fact that these authors had no specimens at their disposal to deal with which belonged to this taxon. Praviel himself unintentionally contributed to this situation of uncertainty by pointing out, in the original description, the close affinity of *G. belzebuth* to *G. noricana*, whilst in a previous work (Praviel 1937) *G. belzebuth* had been confused with *G. bentelii*.

Wolfsberger (1966) regarded *belzebuth* as a subspecies of *noricana*, however he did not give any reasons for this interpretation differing from Wehrli's view. Nevertheless Wolfsberger's interpretation has been maintained in all subsequent catalogues (see for example Müller 1996; Leraut 1997; Scoble 1999). Müller (1996), in particular, did not include *belzebuth* in his list, but indicated *G. noricana* as a component of the French fauna. This can only be explained by considering *belzebuth* as a subspecies of *noricana*. In fact, *G. noricana* 'sensu stricto' has not been reported from the Alps of France (if we exclude a quotation given by Praviel (1937), preceding the description of *belzebuth*, and that very likely referred to this latter entity), reaching its western distributional limit in the Lechtaler Alpen (Austria) (Tarmann 1984), about 400 km away from the type locality of *G. belzebuth*.

It must be stressed that the assignment of *belzebuth* as a subspecies or local form to either *noricana* or to *bentelii* is actually merely an expression of opinion. Thus far, no formal nomenclatural act on this regard has ever been published, and a critical reappraisal of morphological or other characters to solve this issue has not been undertaken.

I have not been able to ascertain whether the type material (22♂, 4♀) is still preserved in Praviel's collection, now at the National Museum of Natural History of Paris. However, Scoble (1999) reports as syntypes the 26 specimens already cited by Praviel in the original description. Moreover, in the original description, Praviel stated that the female genitalia of the three related species *bentelii*, *noricana* and *belzebuth* were to be treated in a later work, but this apparently never happened.

I recently discovered, on the Italian slopes of southern Cottian Alps, a population of *Glacies* whose general appearance is in full concordance with the figure and the description of *Glacies belzebuth* given by Praviel. Praviel's remarks about the habitat and morphology of *belzebuth* are so unequivocal that I feel safe to interpret this newly discovered population as belonging to this taxon, even without examination of the type material. Moreover, the site where the newly found population lives is geographically close to the type locality of *belzebuth* (only about 30 km apart). Since almost no further observations on *G. belzebuth* have been published since its original description, the aim of this contribution is to provide a detailed description of both the male and female copulatory apparatus and to report my observations about its habitat. Such information will be crucial for a better understanding of the taxonomic status and ecological characteristics of *G. belzebuth*.

*Glacies belzebuth* (Praviel, 1938)

Material examined. – 1♂, Italy, Southern Cottian Alps, Cima Fauniera, 2500 m, 21.vii.1999; 2♂, 1♀, idem., 27.vii.2000; 6♂, 31.vii.2000; 1♀, 10.viii.2000; 1♂, 19.vii.2001; 4♂, 23.vii.2001; all leg. and coll. M. Gianti. 3♂, Cima Fauniera, 2500 m, 31.vii.2000; leg. M. Gianti, coll. TLMF Innsbruck.

Italy, Southern Cottian Alps, Colle Valcavera, 2400 m, 1♂, 21.vii.1999; 2♂, 19.vii.2001; 2♂, 6.viii.2001, leg. and coll. M. Gianti

Genitalia examined. – *belzebuth*: 11♂ and 2♀ from Cima Fauniera and Colle Valcavera; preps. M. Gianti ns. MGH 37, MGH 85, MGH 89, MGH 90, MGH 96, MGH 97, MGH 185, MGH 207, MGH 208, MGH 209, MGH 210, MGH 211, MGH 212 (all preparations in author's collection); ♂, France, Basses Alpes, Digne, 1923, leg. E. Wehrli; prep. G. Dobler n. G620. – *noricana*: ♂, Austria, Styria, Hochschwab, 10.vii.1921, leg. Schwingschuss, prep. G. Dobler n. G237. ♂, Austria, Dachstein, 2.viii.1906, prep. G. Dobler n. G240. ♂, Austria, Tyrol, Innsbruck, 26.viii.1926, prep. M. Hreblay n. 1121. ♂, Wallisertal, Tyrol, 2000 m, 7.viii.1940, Nt.Nr.3977/1, prep. M. Hreblay n. 1333. ♂, Germany, Oberbayern, leg. H. Meinicke, prep. M. Hreblay n.1159. – *bentelii*: ♂, Switzerland, Gornergrat, 25.vii.1920, leg. E. Wehrli, prep. M. Hreblay n. 1737. ♂, Italy, Trentino, Adamello, Rif. Madron. 2900 m, M.viii.1958, leg. K. Burmann, prep. G. Tarmann n. G54. ♂, Switzerland, Poschiavo Valley, Piz Campascio, 1.viii.1922, leg. E. Wehrli, prep. G. Dobler n. G316. ♂, Switzerland, way to Britannia Hütte, 2800 m, 26.vii.1941, leg. E. Wehrli, prep. G. Dobler n. G244. – *panticosea*: ♂, France, Pyrénées Orient., Arête Nord du Cantigou [possibly Canigou?], 31.vii.1.viii.1909, H. Powell, prep. G. Dobler n. G210. 4♂, France, Frontière espagnole du Pyrénées orient., Esquerdes de Routja, 23.vii.1909, leg. H. Powell, preps. G. Dobler ns. G212, G214, G216, G217. – *alpmaritima*: ♂, Italy, Alp. maritimes, Cima Argentera, 30.vii.1923, leg. E. Wehrli, prep. G. Dobler n. G259. ♂, Italy, Mont Gelas, 20.vii.1923, leg. E. Wehrli, prep. G. Dobler n. G260. – *bentelii*?: ♂, Italy, Cima Argentera, 31.vii.1923, leg. E. Wehrli, prep. G. Dobler n. G255.

The preparation n. G54 (Tarmann) is preserved in the Tiroler Landesmuseum Ferdinandeum (TLMF, Innsbruck). All other preparations are found in the Wehrli collection, currently held at the Zoologisches Forschungsinstitut und Museum Alexander Koenig (ZFMK, Bonn).

**Description.** – *Glacies belzebuth* is a medium to small sized *Glacies* (average forewing length, males: 11.35 mm [n = 22], females: 10.25 mm [n = 2]) (Fig. 1). The ground colour is of a shade of greenish-grey on all the wings, giving rise to a golden reflectance under sunlight and proper angulations, better noticeable in some individuals than in others. The upper surface of the forewing shows two crossing lines of a darker shade, delimiting a discal band that encloses the small but well visible discal spot. The shape of the discal band is rather regular, the shrink in the sector delimited by the anal vein and the second cubital vein (respectively designated with A and CuA following Hausmann (2001), Fig. 45, p. 48) is generally less marked than in related species (e.g. *G. canaliculata* Hochenwarth, 1785). Upperside hind wings with a dark irregular line delimiting the disco-basal zone.

On the underside of the four wings (Fig. 2) a wide and distinctly lighter marginal band is clearly visible. Discal spots detectable also on this side.

The general habitus is similar to that of *G. noricana*, but *G. belzebuth* is distinctly smaller, being comparable in size to *G. burmanni* Tarmann, 1984. The average forewing length in *G. noricana* is 13.5 mm (n = 32) in males and 12.9 mm (n = 20) in females, whilst *G. bentelii* males measure 13.5 mm (n = 12) and females 11.9 mm (n = 2; all data from Tarmann (1984)).

**Male genitalia.** – The general structure of the copulatory apparatus suggests the allocation of *G. belzebuth* to the *Trepidina* group of species, formerly erected as a subgenus of *Psodos* by Povolný & Moucha (1955). The valva does not reveal any particular diagnostic character. The shape of the saccus is rather variable, in some cases the top is flat, in others rounded or quite pointed (Fig. 3). Aedeagus similar to



**Fig. 1.** *Glacies belzebuth*, dorsal view, ♂ (left) and ♀ (right). Italy, Cima Fauniera Argentera, 2500 m, 27.vii.2000. **Fig. 2.** *Glacies belzebuth*, ventral view, ♂ (left) and ♀ (right). Specimen data as in Fig. 1.

that of *G. noricana*, but the distal portion is comparatively longer and slender. In close proximity to the insertion of the ductus ejaculatorius, the proximal section forms an angle of approximately 120 degrees with the median portion, whilst in *bentelii* and *noricana* this angle is almost always wider, rising to about 180 degrees. This means that the proximal section and the median section of aedeagus are, in some specimens of these latter species, almost aligned (Fig. 4). In *belzebuth* the median portion is slightly concave on the upper side. Compared to *noricana* and *bentelii*, the spinosity of the apex is coarser in *belzebuth*. The form of the juxta ('innere Valven' sensu Wehrli 1921) is the most peculiar character of *G. belzebuth*. It is of the symmetrical type, even if the number, dimension and shape of the apical processes show a certain degree of variability. The distal portion, long and progressively slender, lacks the spined processes, except at the apex, whilst in the median portion, in proximity to the point in which it becomes narrower, a large and often curved tooth occurs (Fig. 5). The shape and position of this strong median tooth is clearly visible in the figure given by Praviel in the original description. As many authors have stressed, the structure of the juxta is of basic importance to discriminate between species of the genus *Glacies*. Even if a

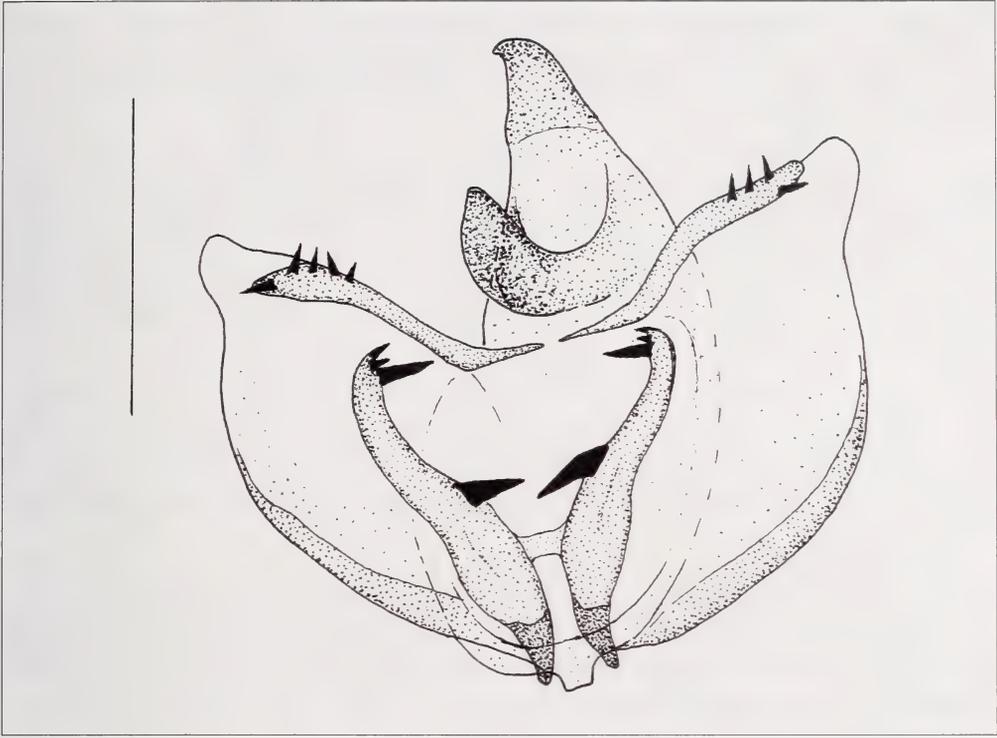


Fig. 3. *Glacies belzebuth*, ♂ genitalia (penis removed). Prep. MG H 90. Reference bar: 1 mm.

certain extent of intraspecific variability in the number and size of the spines is a rule, their arrangement, in addition to the shape of the juxta, are characters that are constant within the species. Eleven ♂ specimens of *G. belzebuth* have been dissected, and in all these the basic structure of the juxta proved to be constant. Especially the position, shape and size of the median tooth showed a great stability. Only in two specimens the left branch of the juxta lacks this strong process. The shape of the aedeagus also seems to be very constant within the population.

Comparative illustrations of the genitalia of other *Glacies* species (*Psodos* s. l.) are found in the works of Wehrli (1921), Povolný & Moucha (1955), Burmann & Tarmann (1983) and Tarmann (1984).

**Female genitalia.** – The general structure of the ♀ genitalia does not deviate from that of the other representatives of the *Trepidina* species group. However, some morphological characters are well defined, even if a greater number of specimens should have been analysed in order to evaluate the degree of stability, within the population, of these characters. The eighth sternite ('freier Analwulst' sensu Wehrli 1921) shows a more rounded profile than in the closest taxa. In particular, compared to *noricana*, the distal margin appears convex rather than concave, the centre of which bears the typical structure acting as a lodge for the uncus of the male ('Uncuslücke'). The form of the ostium bursae ('Vagina' sensu Wehrli) is similar to that of *noricana*. Bursa copulatrix globular, of regular shape, weakly sclerotized, as appears in all the representatives of

the genus. The most significant feature is found in the seventh sternite ('vorderer Haftwulst' sensu Wehrli), the centre of which shows a well marked wrinkle (Fig. 6), very similar to that observed in *G. burmanni*. This attribute is present in both examined specimens.

**Distribution, habitat, phenology.** – *Glacies belzebuth* is at present known from very few localities in the southwestern Alps. It seems to be confined to restricted areas of this alpine sector. Besides the type locality (Mont Mounier, Alpes Maritimes), Praviel (1938) recorded a specimen captured above Colmars (Basses Alpes). Both these localities, located within the French boundaries, are situated but 30–40 km away from the two Italian sites known today (spacing each other about 1 km only).

A specimen reputed by Praviel as belonging to the species *noricana* was collected on 12 July 1925 by Le Charles on the massif of Grande Chartreuse, about 150 km NW from Mont Mounier (Praviel 1937). This specimen could in reality belong to *belzebuth*, but at the time of its publication Praviel apparently had not yet recognized *belzebuth* as a distinct taxon.

The single examined genitalia preparation of *belzebuth* belonging to the Wehrli collection bears the label 'Digne', but this vague indication does not improve significantly the knowledge about the distribution of *belzebuth*. The corresponding specimen was probably collected by Wehrli himself since on the slide label the date '1923' is reported. In this same year Wehrli collected specimens of *alpmaritima* in the same alpine district (Maritime Alps).

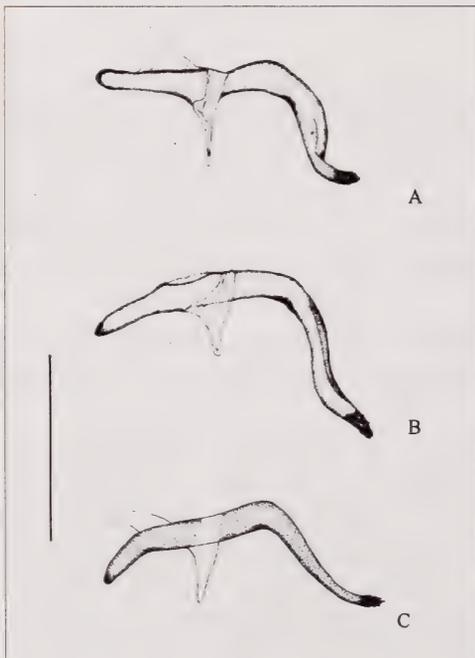


Fig. 4. Aedeagus: A – *Glacies bentelii* (after Tarmann 1984); B – *G. noricana* (after Tarmann 1984); C – *G. belzebuth*. Prep. MG H 89. Reference bar: 1 mm.

It cannot be excluded that in private collections, and perhaps also in public ones, further specimens of *belzebuth* may be present, confused amongst other species of the genus *Glacies*. In particular, confusion may arise with worn specimens of *G. canaliculata*. This species sometimes occurs in the same localities, although it usually inhabits a different biotope. While *canaliculata* occurs in areas covered with short grass, often interspersed by scattered rocks, *belzebuth* as well as *noricana* show a preference for areas almost free of vegetation, where the ground is bare to a great extent. Like *noricana*, *belzebuth* seems to occur exclusively on calcareous soil. *G. canaliculata* was reported by Povolný & Moucha (1955) as occurring on limestone soil in the Carpathian Mountains. This species also

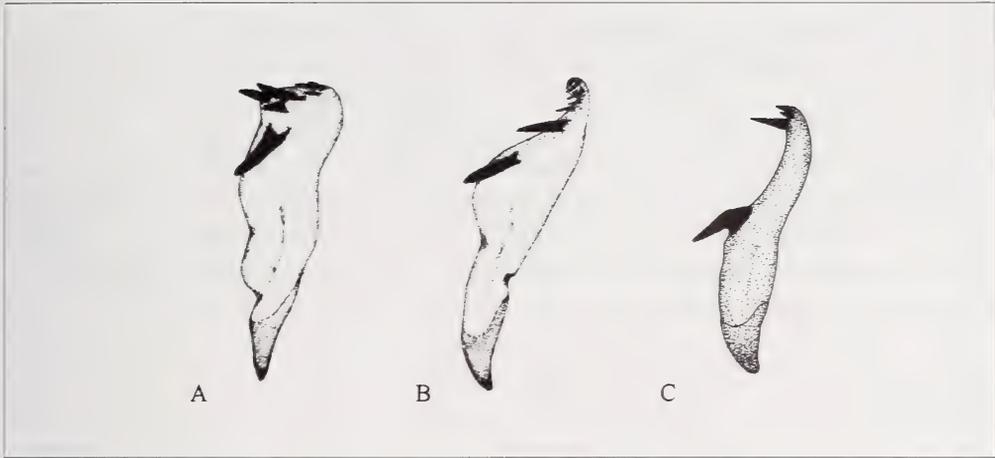


Fig. 5. Right branch of juxta: A – *G. bentelii* (after Tarmann 1984); B – *G. noricana* Wagner (after Tarmann 1984); C – *G. belzebuth*. Prep. MG H 90. Reference bar: 1 mm.

occurs on grassy areas around the sites inhabited by *belzebuth*, revealing a possible predilection for calcareous substrates. *G. bentelii* is reported to occur on Tonalit soil, whilst *G. burmanni* is known exclusively to occur on siliceous soils (Tarmann, *in litt.*).

All specimens of *belzebuth* were collected on south-facing slopes. The habitats seem to be restricted to very strongly wind-exposed areas with high erosive impact of rain and snow. The geological substrate appears to be rather unstable due to mechanical stress, being composed by formations with low cohesion characteristics.

Thus far it is unknown how widespread this type of habitat may be in the neighbouring mountainous districts around the known localities of *belzebuth*. Similarly an investigation for possible occurrences of *belzebuth* at other sites in the vicinity has not been undertaken until today.

The flora of the Italian localities is quite varied. Some of the most representative species or endemics (marked by \*) of the Cottian Alps are: \**Allium narcissiflorum* Vill., \**Brassicella richerii* Schultz, *Astragalus australis* Lam., *Bupleurum petraeum* L., \**Tulipa australis* Lk., \**Pedicularis allionii* Rchb., \**Achillea herba-rota* All. More typical of the calcareous gravel-ruins is *Elyna myosuroides* Fritsch. (all data from Mondino 1958). Within the habitat of *belzebuth*, *Leontopodium alpinum* Cass. is commonly found.

The vegetation of the site is reported by Bono & Barbero (1976) as belonging to the *Caricetum firmae* association. This association is often extremely fragmentary (i.e. interspersed among other vegetational formations) and represents one of the early stages of alpine plant colonization on wind-exposed calcareous substrates (Balletto *et al.* 1982).

As already observed by Praviel, *belzebuth* inhabits the medium alpine zone. On the Massif du Mounier maximum abundance is observed around elevations of 2300 m, but the species is found down to 2100 m (as reported by Praviel himself in the original work). The population recently discovered on the Cima Fauniera (upper Grana Valley) and at Colle Valcavera lives at around 2400–2500 m.

The brief flight period of adults, deduced from the scarce data available today, ranges from the third decade of July to the first decade of August. All specimens were collected during daytime, especially in the morning, indicating diurnal activity as in other *Glacies* spp. They seem to start their activity very early (8–9 a.m.), but this strongly depends on the sunlight conditions, whilst in the afternoon fewer specimens have been observed. The moths frequently rest on the ground or on rocks, where they spread the wings presumably to bask in the sunlight. Their flight is often short and fast. Very few individuals were spotted to feed on flowers and rarely they fly off from rocky places. Larval food plants are not known.

### Discussion

The taxonomic status of *belzebuth* (i.e., its relationships to the related taxa *bentelii*, *noricana*, *burmanni*, *alpmaritima* and *panticosea*) can only be definitively established by means of a thorough investigation of the entire genus *Glacies*. Nevertheless some points are worth discussion.

Examination of a number of genitalia preparations of *G. noricana* and *G. bentelii* from different localities, including the type localities, did not reveal any characters that would induce me to affiliate *belzebuth* as subspecies with either *noricana* or *bentelii*. In all examined genitalia preparations of *bentelii* the structure of the juxta looks very strong, the distal end is wide and relatively flat, bearing a number of small teeth and few stronger teeth. The proximal tooth is of variable size, but always placed at about one third of the length of the juxta, measured from the apex. In *belzebuth*, in contrast, the presence of a large tooth placed approximately in the middle of the juxta is a constant feature, and the entire structure is more slender and less massive than in *bentelii*.

The examined preparations of *noricana* are characterized by the presence of numerous teeth,

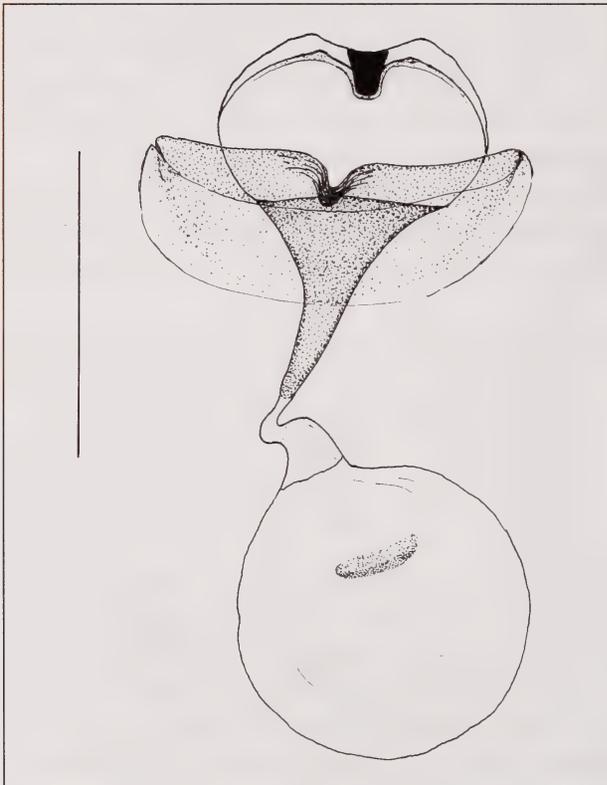


Fig. 6. *Glacies belzebuth*, ♀ genitalia. Prep. MG H 85. Reference bar: 1 mm.

quite uniformly sized and distributed along the distal half of the juxtal branch. The corresponding part in *belzebuth* always lacks spines, and only the apex shows a large pointed process and a few smaller ones.

The taxon *panticosea* shows marked differences from all other related taxa. As compared to *belzebuth*, the juxta is shorter, wider and seems to be constantly distinguished by the presence of two large teeth arranged in a different way. The aedeagus is shorter, with very small apical spines.

Regarding the relationship between *belzebuth* and *alpmaritima*, more material of the latter would be necessary to compare. The two genitalia slides of *alpmaritima* that I have been able to examine look very different from the genitalia of *belzebuth*. Therefore, I have no reason to believe that what Praviel called *belzebuth* could belong to the same species of what he called, in the same work, *alpmaritima*. I concur with Praviel in recognizing *belzebuth* and *alpmaritima* as two morphologically different entities. Following the observations of Praviel (1938), *alpmaritima* lives at higher altitudes, being collected between 2800 and 3150 m on the Cima Argentera (type locality) and Monte Gelas, and very rarely at lower altitudes (2400–2500 m between the Pas des Ladres and Col de Fenestre, always on the massif of Gelas). Also the geological substrate of the habitats is different, being represented by calcareous formations for *belzebuth* and by gneiss for *alpmaritima*.

One examined genitalia preparation of a *Glacies* specimen from Wehrli's collection (prep. Dobler n. G255), labelled to be taken on the Cima Argentera, is very interesting. It looks similar to typical *bentelii* in both size of the apparatus and shape of the juxta, but is very different from the two preparations of *alpmaritima*. This suggests the need of a more thorough investigation of the populations from the Argentera massif, since the coexistence of *bentelii* and *alpmaritima* at the same locality would undermine the view of the latter being a subspecies of the former.

The stability of characters seen in the male genitalia of *belzebuth*, and the corresponding attributes of the females permit to diagnose *belzebuth* against all other related forms in a quite safely way, so it can be regarded as a distinct phenotype. Since genetic and breeding data are still lacking, the interpretation of *belzebuth* as a good species is thus far exclusively based on morphological evidence. Whether this entity is a distinct species in the biological sense (i.e. really showing reproductive isolation against all others) is a matter that remains to be solved.

On these grounds, I conclude that *belzebuth* should actually be accepted as a good species, occurring in allopatry to all related taxa currently assigned to the species *noricana* and *bentelii*. Considering *belzebuth* at specific rank does not imply any status change, since Praviel described it as a distinct species, and no formal rearrangement of its status by means of a nomenclatural act has successively been done.

#### Acknowledgements

I am sincerely indebted to Dr. Gerhard Tarmann of the Tiroler Landesmuseum Ferdinandeum (Innsbruck) for valuable information on the genus *Glacies*, and to Sven Erlacher (Friedrich Schiller Universität, Jena) for his courtesy in allowing me to examine some material of the Wehrli collection and for provision of literature. Moreover, I am grateful to Prof. Dr. Konrad Fiedler (University of Bayreuth) for his

useful criticism on the manuscript and for some practical hints improving considerably the present form of the paper. Special thanks are due to my friend Dr. Enrico Gallo (Genova) for much helpful advice during the preparation of this work and for his kind help in bibliographic research. Finally I wish to thank Mr. Mario Fiorot who photographed the specimens, and my aunt Annamaria Gianti for checking my English.

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## Behaviour and within-habitat distribution of adult *Erebia sudetica sudetica*, endemic of the Hrubý Jeseník Mts., Czech Republic (Nymphalidae, Satyrinae)

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**Summary.** Using quantified observations along a transect route, we studied behaviour, utilisation of habitat patches, and behavioural changes during flight season in the butterfly *Erebia sudetica sudetica* Staudinger, 1861, a potentially endangered high-mountain endemic of the Eastern Sudetes. We constructed a generalised linear model that accounted for over 52.6% of variation in the transect records. Diurnal behaviour followed a distinct temporal pattern: males patrolled in early mornings, both sexes devoted increasing time to nectaring in afternoon hours. A corresponding temporal pattern was found in differences of behaviour early vs. lately in the flight season. Towards the end of flight season, the males flew less and both sexes nectared more, relative to the beginning of the flight season. We suggest that decreasing availability of unmated females in late hours and/or lately in flight period caused the shifts towards a maintenance strategy in behaviour of males. Both distribution and behaviour of the butterflies varied in different sections of their habitat; this variation reflected distribution of adult resources. We observed the majority of egg-laying activities at one of the mown sections, but we can not exclude a recording bias; still, the mowing management, if executed in a patchy manner, probably does not harm the butterflies. We also describe courtship, copulation and egg-laying in *E. sudetica*, and report observational notes on utilisation of nectar plants and predators of the butterfly.

**Zusammenfassung.** Auf der Grundlage quantitativer Beobachtungen entlang eines Linientransektes analysierten wir Verhalten, Habitatnutzung und Verhaltensänderungen über die Flugzeit hinweg von *Erebia sudetica sudetica* Staudinger, 1861. *E. sudetica sudetica* ist ein potentiell gefährdeter Endemit der hochmontanen Stufe des Altvater-Gebirges (Tschechische Republik). Wir konstruierten ein generalisiertes lineares Modell, das 52.6% der Varianz der Beobachtungsdaten erklärt. Das Verhalten folgte im Tagesverlauf einem deutlichen Muster. Männchen patrouillierten am frühen Morgen, beide Geschlechter zeigten vor allem nachmittags Nektaraufnahme. Ein ähnliches Muster wurde im Vergleich der frühen bzw. späten Flugperiode beobachtet. Am Ende der Flugzeit waren die Männchen weniger flugaktiv, und beide Geschlechter zeigten intensivere Nektaraufnahme, verglichen mit dem Beginn der Emergenz. Wir vermuten, daß die geringere Verfügbarkeit unbegatteter Weibchen am Nachmittag bzw. am Ende der Flugperiode die Ursache dieser Verschiebung zugunsten einer auf Aufrechterhaltung der Körperfunktionen ausgerichteten Strategie der Männchen ist. Verteilung der Tiere im Habitat und Verhalten der Falter variierten zwischen den verschiedenen Habitatabschnitten; dies spiegelte die Verteilung der adulten Ressourcen wider. Wir beobachteten die Mehrheit der Eiablagen in einem gemähten Teilabschnitt des Transekts, können aber einen Bias durch unsere Datenaufnahme nicht ausschließen. Habitatmanagement durch fleckenhafte Mahd beeinflusst die Population vermutlich nicht negativ. Wir beschreiben darüber hinaus Balz, Paarung und Eiablageverhalten von *E. sudetica*. Beobachtungen zur Nektarpflanzennutzung und zu Prädatoren werden ebenfalls dargestellt.

**Resumé.** Sur base d'observations quantitatives au long d'une route fixée, nous avons étudié le comportement, l'utilisation de l'habitat ainsi que les modifications du comportement au long de la période de vol, d'*Erebia sudetica sudetica* Staudinger, 1861, endémique menacé de haute montagne de l'est des monts des Sudètes. Nous avons élaboré un modèle linéaire généralisé qui explique 52,6 % de la variation des données du transect. Le comportement diurne suivait un modèle temporel distinct: les mâles patrouillaient en début de matinée et les deux sexes consacraient plus de temps à l'alimentation l'après-midi. Un modèle temporel similaire a été trouvé au niveau de différences de comportement au début par rapport à la fin de la période de vol. Vers la fin de la période de vol, les mâles volaient moins et les deux sexes se nourrissaient plus fréquemment, comparativement au début de cette période. Nous suggérons qu'une disponibilité réduite.

**Key words.** *Erebia*, ringlets, alpine butterflies, diurnal behaviour, temporal patterns, generalised linear model, mate-location strategies, conservation management.

## Introduction

*Erebia sudetica* (Staudinger, 1861) is a European species of global conservation concern, owing to its highly restricted distribution (Cupedo 1995; Van Swaay & Warren 1999). Its several subspecies occur discontinuously in a few mountain areas (Cupedo 1997), of which the Hrubý Jeseník Mts. (= Altvater, Eastern Sudetes, Czech Republic) are inhabited by the nominal subspecies *E. sudetica sudetica*. It forms there a system of relatively sedentary colonies in wet, floristically rich sites near timberline.

This study, a part of comparative research of *Erebia* satyrines in the Hrubý Jeseník Mts. (related papers, e.g., Beneš *et al.* 2000; Kuras *et al.* 2000; Kuras, Konvička *et al.* 2001), focuses on adult behaviour and within-habitat distribution of *E. sudetica*. During a parallel work on two related species, *E. epiphron silesiana* Meyer & Dür, 1852 and *E. euryale euryale* (Esper, 1805), we found 1) that micro-distribution of the two species differed in relation to micro-habitat patterns even in sympatry, and 2) that diurnal activity of both satyrines followed a clear diurnal pattern. The males tended to patrol in morning hours, whereas both sexes devoted afternoons mainly to nectar-feeding. The latter observation was expected on the basis of maximising male fitness in a species, in which females emerge early in the morning (cf. Kuras, Beneš *et al.* 2001) and the males benefit from mating with fresh females. However, existence of a diurnal rhythm of activity was never mentioned for any *Erebia* species (e.g. Brussard & Ehrlich 1970; Porter & Emmet 1989; Kirkland 1995). On the contrary, Ikejiri *et al.* (1980) proposed that behavioural schedule of mountainous representatives of that genus should not be governed by time of day, but should be rather opportunistic and closely tied to momentary weather. Such opportunism should allow the butterflies to respond rapidly to changing external conditions and to utilise most of the time when weather is favourable for flight and reproduction.

We aim to contribute to resolving the above contradiction by quantifying diurnal behaviour of another mountainous *Erebia*. Besides, we provide additional observations on the adult life history of this little-known species, and investigate possible impacts of recent management of the locality, which is one of the largest existing colonies of *E. sudetica* in the entire mountains. The management consists of patchy mowing that seeks to mimic traditional, long-abandoned grazing/hay-making. We included two of the mown patches into the study.

We first construct a statistical model, based on quantified observations along a transect route, in order to explore the effects of time of day, weather, and vegetation structure on behaviour of the butterfly. We specifically ask (a) whether there is any detectable diurnal pattern in activity of *E. sudetica*; (b) how is the distribution of adults of *E. sudetica*, and their respective behaviour, related to within-habitat structure of vegetation, including the recent mowing management.

## Methods

**Study site, field work.** – We established a line transect across the largest colony of *E. sudetica* in the area of interest, which is situated at the tall-herb alpine grasslands of the glacial cirque Malá Kotlina, Hrubý Jeseník Mts. (50°02' N, 17°12' E, ca 1250 m alt.).

In the year of the study, total adult recruitment was ca 4500 individuals, and the flight period lasted from July 18 until shortly after August 16. The locality is one of the floristically richest in the mountain system of Eastern Sudetes. The timberline is naturally depressed there as a result of avalanche-caused disturbances. The site had been grazed until World War II, now it is protected as reserve. The experimental mowing began a decade ago.

It was not feasible, due to the rugged terrain of the habitat with steep slopes and waterlogged sites, to cover the entire site of the studied colony by our transect route. We thus established one short transect (100 m) that nevertheless included all distinct types of vegetation inhabited by the butterfly. It was divided into 7 sections defined by overall characters of vegetation.

These were: (1) A section with species-poor *Molinia* grassland, low abundance of potential nectar sources, length 15 m. (2) Experimentally mown dry patch, a higher cover of short grasses (*Festuca* spp., *Nardus stricta*, *Avenella flexuosa*), low supply of nectar sources, length 15 m. (3) A 'ruderalised' site, possibly due to influx of nutrients from dumping of biomass from mowing. Extended patches of *Senecio nemorensis* agg. were the principal nectar source; length 10 m. (4) Experimentally mown wet patch, high cover of *Phalaroides arundinacea*; length 10 m. (5) Wet site with numerous springs, high abundance of flowering plants with prevailing *Allium schoenoprasum*; length 20 m. (6) A shady section with scattered dwarf spruces, high abundance of *Senecio nemorensis*; length 10 m. (7) A partially shady section with scattered trees and herbaceous vegetation with a high density of species typical for a spruce climax forest understory (*Luzula sylvatica* and *Vaccinium myrtillus*), but still rich in nectar sources including *Senecio nemorensis*; length 20 m.

We walked the route on July 19, 20 and August 1, 6, 7, 1998, attempting to cover entire days and counting all individuals of *E. sudetica* and their behaviours at the moment when we spotted them. For each walk, we recorded the following variables: Hour, Temperature (ambient temperature prior to walk), Sunlight (estimated on 4-point scale, 1 being overcast, 4 fully clear sky), and Wind (3-point relative estimate). The categories of butterfly activities were: 'Patrolling' (if males), 'Flight', 'Nectaring' (including feeding on mud, sweat etc.); 'Basking', 'Resting', 'Mating', 'Oviposition', and 'Chasing'.

Because the data were collected by repeated observation along a single transect, we are aware that they do not constitute true replications. However, the design used was the only plausible way to assess diurnal changes of behaviour of the butterfly, given its highly restricted distribution and the nature of the terrain. In analysing the data, we at least partially ameliorate this problem by considering individual transect walks and dates as co-variates. We thus applied more stringent criteria for assessing significant effects of the independent variables of interest.

### Statistical analyses.

Because the potential explanatory variables were of both categorical and continuous nature, we employed generalised linear modelling (= GLM) to detect their effects on numbers of recorded butterflies. GLM procedures fit the response variables as linear functions, called link-functions, of the explanatory variables, which may be both cat-

egorical and continuous. Goodness of fit of the fitted models is assessed by analysis of deviance, which is defined as the difference between the maximum fit of a model in which the fitted values are identical with the observed values, and the log-likelihood of the values predicted by the model tested.

We constructed the model using the S-plus program package (S-Plus 2000, 1999). Since our response variables were counts of individuals, we used Poisson's regressions with the log link-function. Our response variable was the number of individuals per walk/section split into sexes and classes of observed behaviours. (These were as above with the exception that we included the 'Chasing' and 'Patrolling' under 'Flight' and collapsed 'Oviposition' and 'Mating' into 'Reproductive' behaviour.) The explanatory variables were Section, Sex, Hour, Sunlight, Wind, Temperature, and Period, the last one denoting the beginning (the July walks) vs. end (the August walks) of the flight season. We also considered three additional variables with potential influence on the variation in our data: the day of observation ('Date'), the identity of a transect walk ('Transect'), and the length of transect section ('Length'). Since effects of these variables were not of interest in our hypotheses, we worked with them in the same manner as with co-variables in analysis of variance, considering significance of all explanatory terms after including the effects of the three co-variables into the models.

In building the model, we first defined two null models, NULL and NULL-COV, the latter containing the three co-variables. Then, because GLM procedures assume linear responses of a fitted variable to predictor variables and we had no a priori knowledge regarding the shapes of response curves, we controlled for possible non-linear interactions by fitting a generalised additive model (GAM) with all potential explanatory variables. We used the S-plus 'step.gam' procedure for model selection, entering each of the explanatory variables (if appropriate) in linear, quadratic and cubic alternatives. Next, after testing independent single-factor effects of all potential explanatory variables (including co-variables) by procedures corresponding to single term regressions (or ANOVAs), we constructed three 'saturated' models. These included all the potential explanatory variables (FULL-1), plus all their second- (FULL-2) and third- (FULL-3) order interactions. Such higher-order models typically explain large amounts of variation in data, but their utility for interpretation is limited due to their complexity. We used them as templates, against which we compared all simpler models that we constructed further.

We built the simpler models iteratively, based on results of analyses of deviance of all terms included in the saturated models. In cross-evaluations of alternative models, we considered the values of Akaike's information criterion (AIC), a statistics that weighs increasing explanatory power of more complex statistical models against their increasing complexity, penalizing models that are too complex (S-Plus 2000, 1999). We kept adding and/or deleting all nominally significant terms, until it was not possible to attain, by either of the procedures, any model with better performance than our final model (BEST). If we encountered some interactions of 2 (3) factors that were nominally significant and improved the fit of the model, but contained nominally non-significant single-factor terms, we included also the single-factor terms into the model.

## Results

**Model construction.** – We performed 69 walks and obtained 1011 behavioural records (513 males, 498 females: a not significant deviation from 1:1 ratio with  $\chi^2_{1df} = 0.12$  and  $p = 0.72$ ). Proportions of sexes differed between the July and August transects walks, with males prevailing in July (249 ♂♂, 90 ♀♀;  $\chi^2_{1df} = 8.46$ ,  $p < 0.001$ ) and females in August (264 ♂♂, 408 ♀♀;  $\chi^2_{1df} = 15.61$ ,  $p < 0.001$ ).

All single factors except Length, Sex, Wind and Temperature significantly influenced variation in the transect data (Table 1). After including the factors Length, Date and Transect as co-variables, the significant effect of Sunlight was lost, presumably as a result of collinearity between the amount of insolation and individual dates and/or transects walks. A plausible interpretation of the absence of a significant effect of the factor Length is that its effect on butterfly numbers was suppressed by biologically relevant differences among individual sections. (If raw counts of butterflies per section, disregarding the behaviours, were analysed by one-way ANOVA with Length as co-variable, the effect was highly significant:  $F = 5.76$ , d.f. = 1,6,  $p < 0.0001$ ). To control for the possibility that the lack of significance of the factor Temperature was caused by inflated degrees of freedom (due to missing measurements for 1 day of recording, cf. Table 1), we repeated the linear regression only for the walks for which the temperature records were available. The result was again not significant ( $\beta = 0.0026$ ,  $R^2 = 0.00003$ ,  $F_{1,3778} = 0.14$ ,  $p = 0.71$ ).

About one fifth of the variation in the recorded data was attributable to the co-variables (Table 2). The model GAM included the factors Date, Transect, Behaviour, Section and Wind, plus the quadratic effect of Hour. It explained about the same proportion of variance as the model FULL-1. The portions of explained variance increased after including all possible two-factor terms, but still growing complexity resulted into unacceptably high values of AIC (FULL-3 model).

After subtracting the variation due to co-variables from the model BEST (Table 3), it explained about 30% of variance in the data. Whereas the significant contributions of some of the terms, such as Behaviour, were trivial (different behaviours were observed in different frequencies), several of the included terms carried profound biological implications.

**Differences between sexes.** – Males flew more frequently than females. Relatively more basking and nectaring records came from the female sex. The pattern was similar to all the mountainous *Erebia* studied so far, in which the males seek for their mates by active patrolling (Brussard & Ehrlich 1970; Scott 1974; Porter & Emmet 1989; Bayfield & Taylor 1994). Considering the frequent basking of females, it should be recalled that their egg-laying activity is both energy demanding and occurs in relatively cool conditions near the ground. The females thus presumably intersperse oviposition with frequent basking, even in warm mid-days, to regain temporarily lost heat.

**Temporal patterns.** – Numbers of recorded butterflies and their activities varied with the time of day (Fig. 1). The pattern was further influenced by sunlight. In sunny conditions, the butterflies were active since ca 8 am until before 6 pm (C. European summer time). There was a clear peak in flight (i.e. patrolling) activity of males be-



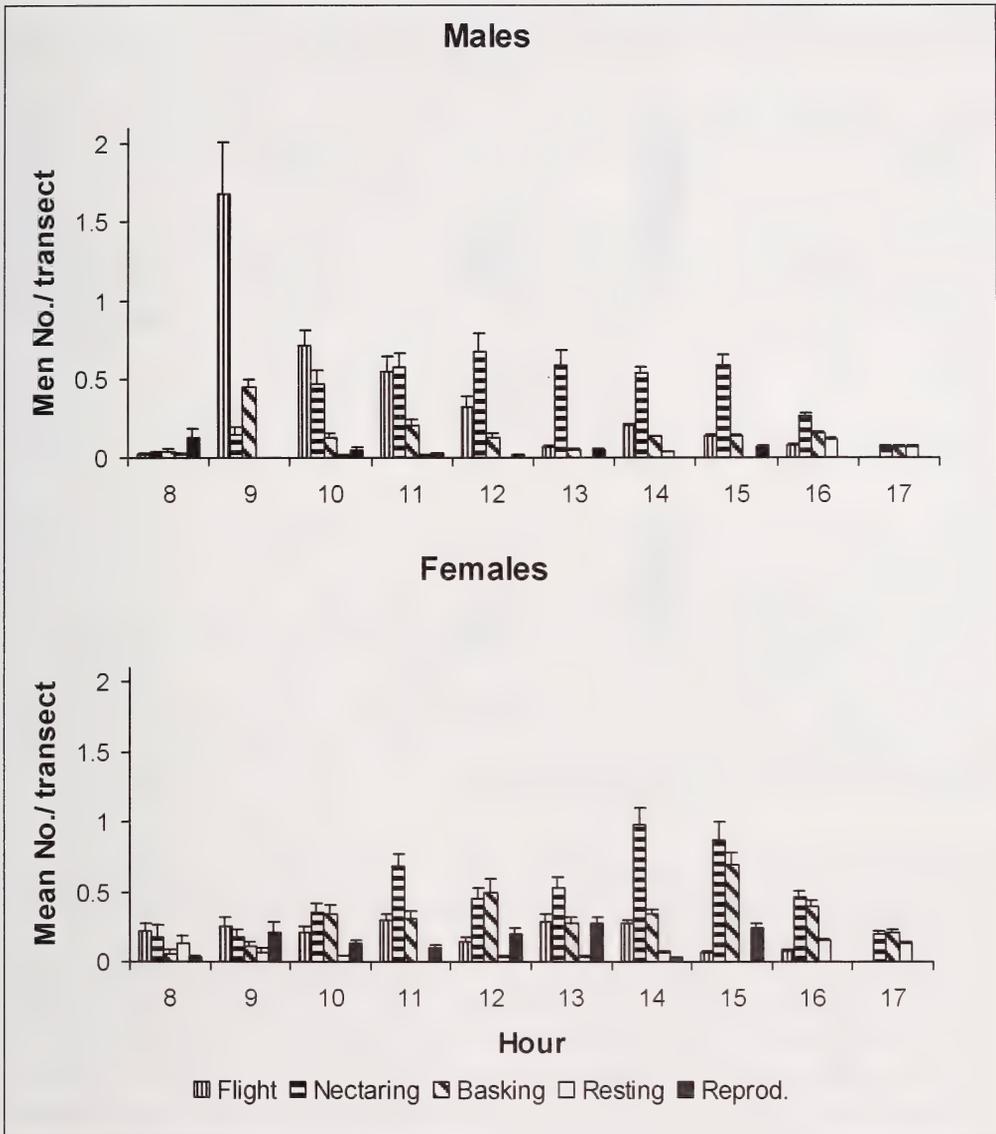


Fig. 1. Diurnal changes of behaviour of *Erebia sudetica sudetica* observed along a transect route in the Hrubý Jeseník Mts.

tween 9 and 10 am, whereas nectaring was the most frequent activity of both sexes in afternoons. In late afternoons, both sexes increasingly basked, and eventually rested. We typically observed resting on patches of long-bladed grasses, such as *Molinia coerulea* *Phalaroides arundinacea*. The butterflies spent nights at such sites, often in loose aggregations as described for *Erebia* spp. by Schwarz (1949) and Ribaric & Gogala (1996).

Activities of the butterflies further differed between the beginning (July records) and the end (August records) of their flight season (Fig. 2). Lately in the season, when there

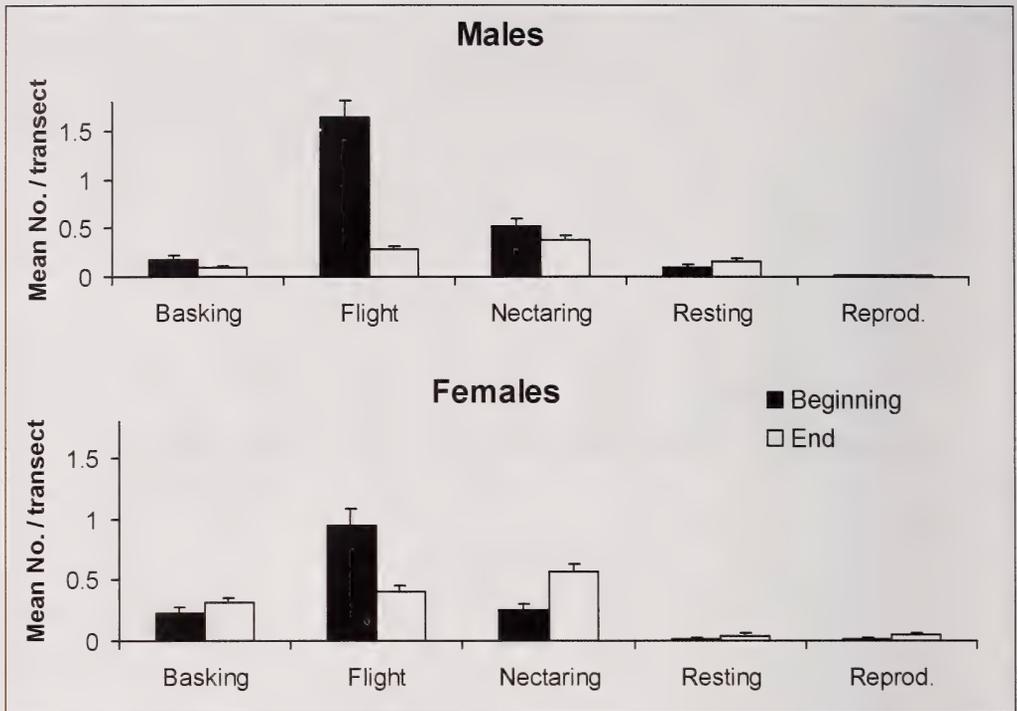


Fig. 2. Changes of relative proportion of activities of adults of *Erebia sudetica* in the beginning (July 1998) vs. in the end (August 1998) of its flight season.

were relatively fewer males and more females present (i.e. the significant term Sex $\times$ Period), both sexes flew less frequently, and fed on nectar more frequently, relative to the beginning of flight season.

**Vegetation structure.** – As indicated by the significant contributions of the terms Section, Section $\times$ Behaviour and Section $\times$ Hour<sup>2</sup> to the BEST model, distribution of the butterflies (and of their behaviours) was influenced by vegetation of the sites (Fig. 3). Records of feeding of both sexes prevailed at the sections with large patches of flowering *Senecio nemorensis* (3, 6). The males (prevailing on the July transects) nectared in large numbers at the section (5), which contained copious stands of *Allium schoenoprasum* (already senescent in August). The basking and resting records were centred at patches with long-bladed grasses (1, 4, 6). Records of ‘Reproductive’ behaviour, represented primarily by egg-laying in females, dominated on the mown section (2). These patterns were further influenced by changing insolation of individual sections during the days, as indicated by inclusion of the terms Section $\times$ Hour<sup>2</sup> $\times$ Sunlight and Hour<sup>2</sup> $\times$ Behaviour $\times$ Sunlight to the BEST model.

**Observational notes. Mating.** – Courtship is initiated by landing of a patrolling male next to a female. Both sexes then flap for ca 5 seconds with their antennae close to the other butterfly’s body. The male is very active in this phase, moving around the female and flapping with his wings. If a courtship results in mating, the couple assumes a vertical position with the female above the male as the pair-carrying sex.

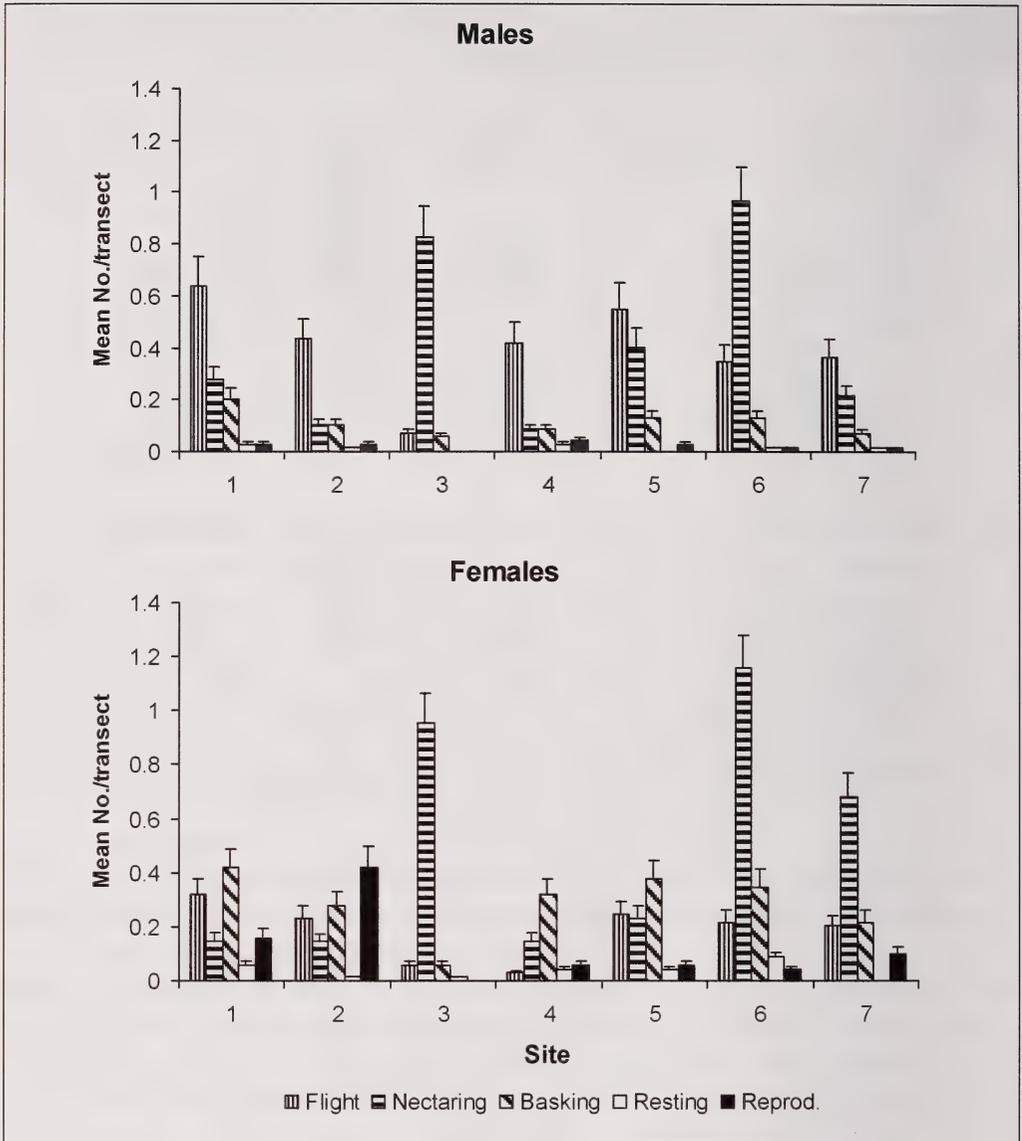
**Tab. 2.** Summary of the procedures of selecting the most appropriate model fitting the transect data on behaviour and distribution of *Erebia sudetica sudetica*. Fit of each of the successive models was tested against the null model (NULL). See Methods for details.

Model	Residual D.f.	Residual deviance	Model D.f.	Model deviance	AIC	F	p	Explained variance (%)
NULL	4739	5110.3			5111.4			
NULL-COV	4667	3948.2	72	1162.0	4162.0	11.0	< 0.001	22.74
GAM	4655	3171.2	84	1939.0	3465.2	13.3	< 0.001	58.24
FULL-1	3698	2133.7	1041	2976.6	5510.7	1.8	< 0.001	58.25
FULL-2	3584	1571.8	1155	3538.5	3861.7	3.1	< 0.001	69.24
FULL-3	3186	9140.5	1553	9140.5	10987.6	4.4	< 0.001	N.A.
BEST	4569	2420.7	170	2689.6	2781.2	15.0	< 0.001	52.64

We dissected 15 wild-captured females and found only a single spermatophore in the bursa copulatrix of each of them. However, the small sample does not allow us to exclude rare instances of repeated insemination, as they were reported for other *Erebia* species (Ehrlich & Ehrlich 1978; Mansell 1982; Kuras, Beneš *et al.* 2001). Indeed, we obtained indirect evidence of repeated insemination in *E. sudetica* in the context a mark-recapture study (Kuras *et al.* unpublished). We encountered *in copula* two females, which were previously individually marked and which were minimally 2 and 4 days old. Regarding males, we encountered 4 previously marked individuals while mating; they were minimally 1, 4, 5, and 12 days old (Table 4).

**Oviposition.** – It is a relatively quick act, during which a female lands on the ground, ‘runs’ back and front for a few seconds obviously exploring the substrate, and then bends her abdomen and releases one egg. We recorded the majority of egg-laying acts at the mown site (2) (Fig. 3) with a high cover of short-tuft grasses, which are the larval foodplants (Kuras, Beneš *et al.* 2001). However, we could observe the activities in detail only at this site, and we cannot be certain whether the females actively preferred such shortly trimmed substrates, or whether this was a recording artefact. We found deposited eggs on both living and dead leaves at the base of grass tufts up to 5 cm above the ground (Table 4).

**Adult feeding.** – At the study locality, the butterflies fed on a wide range of flowering plants. The diversity of nectaring records reflected the high floristic richness of the Malá Kotlina cirque. We did not test for nectar feeding preferences, and give the following list only for illustrative purposes. In descending order of frequency, the visited nectar plants along the transect were (N = 439): *Senecio nemorensis* agg. (75.2%), *Scabiosa lucida lucida* (5.6%), *Allium schoenoprasum alpinum* (6.6%), *Crepis sibirica* (4.3%), *Potentilla erecta* (3.3%), *Pilosella aurantiaca*, *Dianthus superbus alpestris*, *Pimpinella saxifraga*, *Ranunculus lanuginosus*, and *Scorzoneroides autumnalis* (each < 3%). Besides these species, the butterfly frequently visited other plant species in the Hrubý Jeseník Mts., most notably *Adenostyles alliaria*, *Laserpitium archangelica* (this one often after rains), *Solidago virgaurea alpestris*, *Trommsdorffia uniflora*, *Bistorta major*.



**Fig. 3.** Distribution of different types of behaviour of adults of *Erebia sudetica* along different sections of a fixed transect route. See Methods section for description of the sections.

Both sexes often puddled on a humid bare ground, or even on our sweat-covered bodies. Wocke (1850) noted frequent sucking on livestock excrements in times when the alpine elevations of the Hrubý Jeseník Mts. were extensively grazed.

**Predation.** – We observed three unsuccessful attacks by the common lizard (*Zootoca vivipara*) on basking/egg laying females. One sub-adult robin (*Erithacus rubecula*) obviously specialised on preying on the butterflies at our site (3). Finally, we found 8 butterflies captured in nets of the spider *Aculepeira ceropegia* (Walckenaer, 1802). We analyse the frequencies of marks of unsuccessful attacks by predators in the population

of *E. sudetica* elsewhere (Kuras *et al.* in press). Bureš (1994) reported *Erebia* adults in the diet of meadow pipit nestlings from the same area.

**Tab. 3.** Summary of the model BEST, used for fitting the transect observations of behaviour and distribution of adults of *Erebia sudetica sudetica*.

Term	D.f.	Deviance	Resid. D.f.	Resid. Deviance	F	p
(Null)			4739	5110.3		
Length	1	0.03	4738	5110.2	0.03	0.86
Date	4	317.8	4734	4792.4	75.4	< 0.001
Transect	67	844.2	4667	3948.2	12.0	< 0.001
Behaviour	4	706.7	4663	3241.6	167.6	< 0.001
Period	0	0.00	4663	3241.6	N.A.	N.A.
Sex	1	0.3	4662	3241.3	0.2	0.63
Section	5	41.0	4657	3200.3	7.8	< 0.001
Hour <sup>2</sup>	2	27.0	4655	3173.3	12.8	< 0.001
Sunlight	1	0.1	4654	3173.3	0.1	0.8269
Sex×Period	1	51.8	4653	3121.4	49.2	< 0.001
Hour <sup>2</sup> ×Behaviour	8	81.8	4645	3039.6	9.7	< 0.001
Period×Behaviour	4	55.1	4641	2984.5	13.1	< 0.001
Behaviour×Sex	4	79.2	4637	2905.4	18.8	< 0.001
Behaviour×Section	24	325.2	4613	2580.2	12.9	< 0.001
Section×Hour <sup>2</sup>	12	34.7	4601	2545.6	2.7	< 0.01
Section×Sunlight	6	27.5	4595	2518.1	4.4	< 0.001
Behaviour×Sunlight	4	21.5	4591	2496.6	5.1	< 0.001
Section×Hour <sup>2</sup> ×Sunlight	14	31.1	4577	2465.5	2.1	< 0.01
Hour <sup>2</sup> ×Behaviour×Sunlight	8	44.8	4569	2420.7	5.3	< 0.001

**Tab. 4.** Summary of observational records of reproductive activities of *E. sudetica sudetica*.

Activity	N	Mean duration (SD)	Time of day	Substrate
Copulation	7	35 (8.9) min	8:45 - 16:10	Grass tufts (8)
Copulation*	3	38 (6.4) min		Flowers (2)
Egg laying	47**	"10 - 30 seconds"	9:30 - 15:00	<i>Avenella flexuosa</i> (11) <i>Deschampsia caespitosa</i> (6) <i>Nardus stricta</i> (4)

\* These copulations were observed since the beginning to end.

\*\* We actually found the eggs only in 21 cases.

## Discussion

**Behaviour.** – We showed that diurnal behaviour of *E. sudetica* followed a well-defined pattern and that the behaviours observed along the transect differed between first and second half of flight season. Moreover, the seasonal pattern reflected the pattern observed on within-day basis.

On the during-day basis, patrolling flights of males prevailed in mornings, whereas nectaring of both sexes culminated in afternoons. In this respect, the diurnal rhythm of *E. sudetica* was practically identical to that found for related *Erebia epiphron* and *E. euryale* (Konvička *et al.* unpublished). In the three species, and probably also in *E. aethiops* (discussed in Lear 1989), the males presumably maximise their mate-locating effort in early morning hours, which is the eclosion time of females in that group of butterflies (Porter 1989; Lear 1989; Kuras, Beneš, *et al.* 2001). This strategy of males supports the prediction of Odendaal *et al.* (1985), according to which males should maximise searching effort at the time when a majority of fertilisable females is available. It also agrees with the model of Ide & Kondoh (2000), according to which males should change their mate-locating strategy if the expenditures invested to pursuing females prevail over fitness advantages from obtaining one.

The case of *E. sudetica*, however, differs from the situations modelled by Ide & Kondoh (2000) in one aspect: whereas the authors primarily considered switches of mate-locating tactics (such as patrolling vs. perching in Wickman 1985), we document here rather a non-effort on the side of males towards afternoons. Because no variant of a 'sit-and-wait' strategy was ever documented in the genus *Erebia*, evolutionary constraint on the existence of such an alternative to patrolling is the most plausible explanation of the difference. Indeed, under such a constraint, the declining flight activity and increasing concentration on nectaring represents exactly the alternative opened to males as soon as fertilisable females become scarce.

The afternoon decline of patrolling of males does not, however, entirely exclude the possibility of mating lately in the days; indeed, we observed one copulating pair at about 4 pm (Table 4). This does not conflict with the above reasoning. First, even if we had assumed that all females emerged early in the days, and that all newly eclosed females obtained their partners quickly after emergence (both assumptions are realistic, but there is no reason why exceptions should not exist), our finding of at least two old females *in copula* suggests that males occasionally mate with non-virgins females. Second, our data suggest that the decreased patrolling activity of males in afternoons was rather due to progressive alternation of flight with 'maintenance' (i.e. nectaring), than due to an abrupt change of activity. Rutowski (1991) suggested exactly such pattern as suitable for species in which males are sexually active for whole days.

Indeed, the progressive afternoon shift towards nectaring may provide the best strategy for the males, if we realise that their potential mates stay in vicinity of nectar plants for most of days (with the exception of the freshly eclosed virgins in the mornings). This effectively shifts the distribution of potential encounter sites of the sexes from the places where the females eclose (which is practically 'anywhere' under the foodplants, promoting the patrolling strategy) to patches that contain adult resources. Hence, the males that

feed on nectar in the afternoon both maximise their chances to meet a female that may be will copulate, and, by replenishing energy supplies, increase their potential survival.

The relative value of surviving to a next day may indeed be very high in *Erebia sudetica*. We show elsewhere (Kuras *et al.* unpublished) that the butterfly is markedly protandrous: the peak emergence of males preceded the peak of females by about a week in 1998. It is also relatively short-living, reaching average residences of 3–4 days, although the maximum recorded residence of a male was 15 days, and some males may mate at an old age. Because fresh females in such a species keep appearing even when the majority of males have already eclosed, we propose that the portion of males that achieves a prolonged residency may gain disproportional fitness advantage, thus selecting for a 'frugal' maintenance strategy.

Perhaps the most important finding was the striking parallel between the diurnal rhythm and the behavioural shift that we observed on a seasonal basis. Obviously, the changes were related to progressive ageing of the population. In a protandrous population, each individual is ageing into a world characterised by decreasing proportion of males and decreasing supply of virgin females. These facts predict exactly the same changes in activity of sexes lately in flight season as lately during individual days. Namely, both the late-season males and females should spend relatively less time in flight and more time with nectaring, which indeed was the case. An average male should devote increasing amount of time to feeding not only in order to replenish resources, but also because there are relatively few virgin females around, and thus a higher proportion of fertilisable females is likely to be found at flowers. Moreover, decreasing competition among the males (as a result of declining numbers) should relax the necessity to invest into patrolling flights.

The seasonal shift in behaviour documented here, although reasonably justified on the basis of relative advantage of active mate-locating by flight vs. a passive maintenance strategy, may be a widespread but overlooked phenomenon in butterfly biology. However, it may be relatively common; the above reasoning predicts its widespread occurrence in protandrous species that are either univoltine, or occur in discrete generations. Notably, shifts in mate-locating strategies were occasionally observed in the context of studying other phenomena (e.g. Shreeve 1987). The phenomenon deserves to be further explored, as it may, for instance, distort some results of mark-recapture studies. On the other hand, some of the vast amount of mark-recapture data accumulated by lepidopterists may be well suited for studying this seasonal shift in adult activity, because such data typically include records of behaviour prior to capture and wing wear of individuals. Therefore, they might allow statistical separation of the effects of individual age from the effects of phenological 'age' of entire populations.

**Relation to weather.** – We did not document any profound relation between activity of the butterflies and temperature. This was perplexing, since temperature crucially affects behaviour of several satyrines (e.g. Heinrich 1985; Wickman 1986), including species of the genus *Erebia* (Brussard & Ehrlich 1970; Konvička *et al.* unpublished). We explain this by the fact that the summer 1998 was unusually warm, with little variation in temperatures recorded while walking the transects (mean 17.73°C, median = 18, range = 14 - 21, SE = 0.026). Thus, we likely collected our data in condi-

tions that were nearly ideal for *E. sudetica* activity. This likely eased our position in documenting the above diurnal/seasonal patterns, but prevented us from answering the question whether the pattern would remain under less favourable conditions more typical for mountain habitats. We expect, however, that the behaviour should be more opportunistic under worse weather, since strictly following a daily rhythm would be too risky from the point of view of an individual's reproduction.

**Conservation management.** – Our results did not indicate that the mowing of patches of the habitat would harm the endangered butterfly. Rather contrarily, we saw a high number of ovipositions at one of the mown sections, and although we can not exclude a recording artefact, it was clear that *E. sudetica* did not actively avoid such patches. On the other hand, our results suggest that the butterfly requires diversified habitat structure with flowery patches for nectaring and patches of tall-bladed grasses for overnight resting. Therefore, a mosaic-like hay mowing management seems to be appropriate for the colony, provided that it preserves all distinct kinds of vegetation recently present.

### Acknowledgements

We are indebted to the administration of the Jeseníky Landscape Protected Area for arranging for us accommodation at their field station, to Zdeněk Fric for valuable discussions and help with statistical analyses, and to the Palacký University studentship No. 32503008/1998.

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## Book Review

**Lastůvka, Z. & Lastůvka, A., 2001. The Sesiidae of Europe. 245 pages, 9 colour plates, 107 plates with line drawings incl. distribution maps. -- Apollo Books, Stenstrup. ISBN 7-88757-52-8. Price: DKK 370,00.**

The book provides a comprehensive monograph on the European clearwing moths (Sesiidae) prepared by Zdeněk Lastůvka, one of the leading experts in this field, and by his brother Ales, a well-known lepidopterist and specialist in leaf mining moths (Nepticulidae). It is an updated and extended version of „An Illustrated Key to the European Sesiidae (Lepidoptera)“ which was published by the same authors in 1995 and became sold out only a few months after its appearance. The book summarises the information on the more than 100 known species of European clearwings including 10 taxa newly described and another four species newly discovered in Europe since publication of the first edition.

After a short historical outline of scientific research on European Sesiidae in the last two centuries, the authors give a very helpful introduction in the advanced morphology of clearwing moths including brief explanations and illustrations of the adult and preimaginal stages. This is especially helpful for entomologists who start to work on this interesting family. The following chapter is devoted to the biology of the Sesiidae. The authors give a general overview of the highly specialised bionomics, behaviours and feeding habits of the members of this family. Attached to this, a complete list of the hostplants recorded for the European species of Sesiidae is provided, followed by a general outline on collecting and rearing. The general part of this book closes with two chapters on the distribution and phylogenetics of European clearwing moths. The systematic fraction of the work is introduced by a checklist and separate keys to the subfamilies, tribes and genera as well as to all Sesiidae species occurring in Europe. The main part of the book is devoted to the systematic treatment of all European Sesiidae species. In a condensed way descriptions of the external characters and the genitalia are provided, followed by a short account of the bionomics, preferred habitats and distribution of each species in Europe. For all species, subspecies and synonyms the original descriptions are cited together with the type localities and the collection in which the types are preserved. The main focus of the book are the illustrations. On nine colour plates all European species, usually male and female specimens, are figured by photographs at about 1.8 x of their natural size. On 107 plates line drawings of male and female genitalia and additional illustrations of important species characters are given, enabling the reader to determine most European Sesiidae species quite easily. These plates also contain distribution maps for all species. The book closes with a distributional checklist and an extensive reference list on the taxonomy, biology and faunistics of European Sesiidae.

Overall, the book is produced in a fine quality and the plates and drawings are very valuable. However, the colour plates are not of the highest standard. Moreover, it would have been helpful to consistently figure male and female specimens of all species, especially of rather dimorphic species such as *Chamaesphex masariformis* (Ochsenheimer, 1808). It has to be appreciated that the treatment of the taxa was done in a rather strict way leading to new synonymizations of some poorly supported nominal species and of one genus. Several taxa formerly considered as valid species are now classified as subspecies, though this appears not always to be well founded and may partly be inconsistent. For example, *Bembecia psoralea* Bartsch & Bettag, 1997 is considered as a subspecies of *Bembecia albanensis* (Rebel, 1918)

although both taxa occur in sympatry. However, depending on the species concept adopted the treatment of taxa as valid species, subspecies or synonyms will always be an object of controversy among taxonomists to some degree, and the proposed changes in this book will stimulate further research.

In a future edition the authors will hopefully have the possibility to expand the presently rather short paragraphs on bionomics and ecology. It would also be helpful to include some information on the pheromone reactions and more specified differential diagnoses for species which are difficult to determine.

Overall, this book is the only handy, yet comprehensive work on European Sesiidae presently available. It combines detailed and specific data on the systematics and taxonomy useful for advanced entomologists with practical information and nice illustrations helpful for anyone who has the intention to become familiar with the European Sesiidae or who simply wants to identify specimens collected in the field. In view of the reasonable price it is a good alternative for all whose interest in Sesiidae does not exceed the European fauna. Moreover, since this book contains several recently described species and taxonomic changes it is as well a suitable supplement to the monograph on the Palaearctic Sesiidae published recently by Spatenka *et al.* (1999) and should not be missing in any entomological library.

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## CD-ROM Review

Meijerman, L. & K. R. Tuck 2000. **Arthropods of economic importance. Interactive tutorial for the preparation of genitalia in Microlepidoptera.** – World Biodiversity Database CD-ROM Series. – Expert Center for Taxonomic Identification (ETI), University of Amsterdam. – ISBN 90-75000-18-9. Price: 49.00 €.

The investigation of morphological features of the genitalia is a basic requirement for the precise identification of most Lepidoptera. Various methods are used to prepare the genitalia for investigation. Sometimes it may be sufficient just to remove some scales to reveal the necessary character to differentiate between two similar species. In most cases, however, a detailed investigation of genitalia structures is necessary and requires the preparation of the entire (sclerotised) genitalia complex. Generally, the preparation technique used is the same for all Lepidoptera, but to prepare genitalia of smaller moths requires a much more delicate touch than is necessary for most Macrolepidoptera.

The numerous papers explaining dissecting methods and standards of lepidopterous genitalia cannot replace a personal introduction into the practical preparation process. Just tuition in the many subtle “tricks of the trade” enables a beginner to produce a reasonable quality of genitalia slides or the “professional” to improve his standard. The novel “Interactive tutorial for the preparation of genitalia in Microlepidoptera”, produced by professionals, comes close to a personal teaching course. This CD-ROM explains by written text and colour photographs as well as spoken text and video-clips how to prepare lepidopterous genitalia using a stereo-microscope.

The user can watch the entire preparation procedure on the screen as if watching through the oculars while the speaker explains every step. It enables one to see how to handle instruments (such as the mounted snipe feathers<sup>1</sup> used in the cleaning process) and objects under the microscope. Additionally, the user can view an introduction into the morphology of lepidopterous genitalia, look up terms in the glossary or literature references as well as obtain an overview of the equipment necessary for the entire preparation process. One may work through the programme step by step or use the “Navigator” window to choose which part of the programme to access directly. At any moment the user may look for terms via the “Find” window. In this way, the entire programme is easy to use and understand, even for beginners of genitalia preparation or computing (or both).

Unfortunately, less is explained about requirements for the stereo-microscope. This is the most expensive of all the tools necessary for genitalia preparation. The microscope should have a magnification from about 7 to 70 times and there should be enough distance (c. 8cm) between the microscope stage and the object lens for handling instruments during the preparation process. Also, transmitted light is indispensable to facilitate discovery and removal of minute soiling. Without transmitted light it is nearly impossible to produce a clean genitalia slide good enough to photograph for publication.

The advanced user will notice the absence of a comprehensive list of literature or explanations of certain preparation techniques such as eversion of the vesica of the male aedeagus, or how to preserve the original shape of the female bursa copulatrix or the spermatophore(-s), but it might be not the intention of the authors to produce this tutorial for professionals. This CD-ROM reflects the main standard for the preparation of the genitalia of Lepidoptera. It is without any doubt a comprehensive and ‘personal’ teaching course about the preparation technique of the genitalia of the smaller Lepidoptera. It can be recommended for professional scientists and amateurs, and its usefulness is not restricted to research on “Microlepidoptera”. Never before everybody could have his personal teacher for the technique of genitalia preparation available at any time. The programme is adapted to both Microsoft Windows and Macintosh computer systems. Information is also available at [www.eti.uva.nl](http://www.eti.uva.nl).

MATTHIAS NUSS

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<sup>1</sup> Somebody who have difficulties in obtaining snipe-feathers may try to replace them by penguin-feathers which may be obtained from Zoological Gardens.

# The Distribution Atlas of European Butterflies

OTAKAR KUDRNA

**Publication spring 2002. 29 x 21 cm. Approx. 400 pages. Distribution maps to all species. (Oedippus No. 20.) ISBN 87-88757-56-0. Hardback. DKK 390,00**

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**The author:** *Dr. Otakar Kudrna* (63, British, but Czech born) has devoted most of his life to the scientific study of butterflies, concentrating mostly on those of Europe. He is the author of about 80 original papers and books on systematics, biogeography, ecology and conservation of butterflies published in English and German. Early retirement relieved him of his university duties and enabled him to conceive and conduct the *Mapping European Butterflies* project, his long-held dream. Nonetheless, without the support of Naturschutzbund Deutschlands e.V. (NABU) and the Gesellschaft für Schmetterlingsschutz e. V. (GfS), *Mapping European Butterflies* could never have been started, and without the co-operation of the 250 recorders, the project would never have been successfully accomplished.

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A journal devoted to the study of Lepidoptera

Published by the Societas Europaea Lepidopterologica e. V.

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**Halle / Saale, 01. 03. 2002**

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