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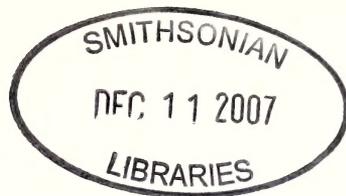
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NOTA

LEPIDOPTEROLOGICA

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Editors

Dr Bernard Landry (Genève, CH), e-mail: bernard.landry@ville-ge.ch
Dr Matthias Nuss (Dresden, D), e-mail: matthias.nuss@snsd.smwk.sachsen.de

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Description of androconia in the Palaearctic Asian *Pseudochazara baldiva* (Moore, 1865) butterfly species-group (Nymphalidae: Satyrinae) with designation of two lectotypes and reference to type and other material in the Natural History Museum, London

ANDREW WAKEHAM-DAWSON¹, OTAKAR KUDRNA² & ROGER L. H. DENNIS³

¹ Mill Laine Farm, Offham, Lewes, East Sussex, BN7 3QB, UK;
e-mail: andrew@wakeham-dawson.orangehome.co.uk

² Naturmuseum Südtirol, Bindergasse 1, 39100 Bozen, Italy;
e-mail: Kudrna.MEB@t-online.de

³ Institute for Environment, Sustainability and Regeneration, Room s122, Mellor Building, Staffordshire University, College Road, Stoke on Trent, ST4 2DE, UK;
e-mail: RLHDennis@aol.com

Abstract. Sakai's (1981) hypothesis (made in relation to material from Afghanistan) that the *Pseudochazara baldiva*-complex includes three species: *P. baldiva* (Moore, 1865), *P. lehana* (Moore, 1878), and *P. droshica* (Tytler, 1926) is tested by visual and statistical comparison of androconia scales from type and other specimens. The hypothesis is modified for a wider Central Asian study area to include *P. baldiva*, *P. droshica*, and *P. gilgitica* (Tytler, 1926) as the names that have priority to represent three species-groups, each of which exhibits distinctively shaped androconia. Evans' (1932a) misidentifications are resolved by designation of lectotypes for *Eumenis mniszeczii balucha* Evans, 1932a and *Eumenis mniszeczii balucha* f. *pallida* Evans, 1932a, and these two names are sunk in new synonymy as junior subjective synonyms of *P. gilgitica* and *P. baldiva* respectively. The findings of this study present a hypothesis of relationships for future testing against molecular and ecological data.

Introduction

The *Pseudochazara* de Lesse, 1951 butterflies of Afghanistan have been reviewed by Sakai (1981) as have those of Pamir, Turkmenistan, Uzbekistan, Tajikistan, Ladak and Kyrgyzstan (Tshikolovets 1997, 1998, 2000, 2003, 2005a, 2005b). Within this genus and endemic to Central Asia is a closely related group of mountain *Pseudochazara* taxa allied to *P. baldiva* (Moore, 1865). This is probably a natural complex of species artificially complicated by lepidopterists' enthusiasm for naming taxa on the basis of location and differences in wing colour and pattern. Wing colour, in particular, is an unreliable taxonomic character in this genus (Wakeham-Dawson & Dennis 2001). Building on the work of Gross (1978) and Sakai (1981), we are presenting a rigorous approach to taxon determination by looking at the androconia: male scent scales used in courtship of satyrine butterflies (Tinbergen 1972) and thus probably more closely linked to reproductive isolation between biological species than wing colour.

The present study is based on type and other specimens held in the Natural History Museum, London (BMNH). Androconia shape is compared visually and by statistical analysis of measurements made on the scales. We test Sakai's (1981) hypothesis (made in relation to material from Afghanistan) that the *P. baldiva*-complex includes three species: *P. baldiva*, *P. lehana*, and *P. droshica* and propose a modified hypothesis based on a wider range of material from Central Asia. Synonymies are suggested based on these

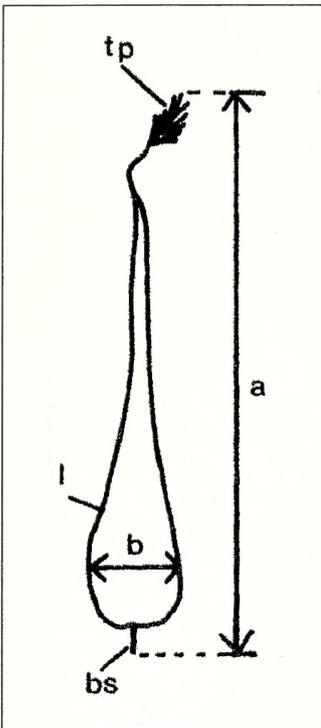


Fig. 1. Measurements of androconia from *Pseudochazara* type specimens held in the Natural History Museum, London. (a) androconium length (AL) from basal stalk (bs) to terminal points above apex (tp); (b) androconium breadth (AB) across the widest part of lamina (l). Terminology after Kudrna (1977).

results and a taxonomic/nomenclatural complication is resolved by designation of two lectotypes. The findings of this study present a hypothesis of relationships for future testing against molecular and ecological data.

Methods

Biometrics: androconia were prepared and measured using the methods described in Wakeham-Dawson (2006), Wakeham-Dawson & Kudrna (2000, 2005, 2006) and Wakeham-Dawson et al. (2003). In summary, androconia are removed from the forewing sex brands of male specimens and fixed on microscope slides. These slides are deposited in the BMNH and cross-referenced to specimens by authors' and museum reference numbers. Measurements of androconium length (AL) and breadth (AB) are made using an eyepiece graticule (Fig. 1) from between five and ten androconia per specimen (where possible). The shape of the androconia is expressed as a ratio A (length/breadth) and the androconia are drawn to scale. Where possible type or topotype material has been used and specimens determined by comparison to original taxonomic descriptions.

Statistical analysis: to test Sakai's (1981) three-group hypothesis measurements and ratios were subjected to k -means clustering (Legendre & Legendre 1998). The analysis was 'seeded' with three 'type' specimens as cluster centre points. These were specimens AWD628 to represent *P. baldiva* (a syntype), 631 for *P. droshica* (a syntype), and 618 for *P. lehana* (a topotype). The k -means

clustering technique starts with k random clusters and then moves objects between clusters until (1) variability is minimized within clusters and (2) variability is maximized between clusters. The method is related to Analysis of Variance (ANOVA), and the success of the operation is determined from the F statistics associated with each variable (or dimension). It is a suitable technique for situations where a certain number of groups is suspected to exist in a dataset and allows testing *a priori* classifications by 'seeding' the analysis with 'type' specimens (see Wakeham-Dawson et al. 2004 for another example of the use of this technique). The k -means clustering was carried out on standardized variables (each value taken from the mean and divided by the standard deviation to give zero mean, unit variance) to ensure comparability among the three variables. As it was not possible to normalise variable AB, results from this technique were compared with those using Kruskal-Wallis ANOVA by ranks. These results were then compared with an ANOVA test on more limited material ($n = 15$) where all three variables were standardized (each normal) on wing lengths.

Material studied

Unless otherwise stated, all specimens are male. B. M. Rhopalocera Type Nos can be compared against Riley & Gabriel's (1924) catalogue. AWD = A. Wakeham-Dawson; OK = Otakar Kudrna. These names are written out in full on data labels, but are abbreviated in the following list.

1. *Pseudochazara baldiva* (Moore, 1865: 499, pl. 30, fig. 4). Originally named as '*Lasiommata baldiva*'. Sakai (1981) figures *P. baldiva* syntypes (male: pl. 24 figs 15–18; female: pl. 24 figs 19–20). Type locality: 'Spiti and Tibet'. Syntype in Type Collection drawer 1–58: '[N. W. Himalaya], Upper Kuna-wur, Spiti, Lang 84', 'B. M. Type | No. Rh. 3724', 'Syntype | Lasiommata | baldiva Moore | det[ermined by] P. Ackery 1977', 'Coll. Moore 94–67', 'AWD | Androconia | preparation | 649'. Specimen 649 is accompanied by a female syntype ('B. M. Type | No. Rh. 3725') with similar data. Syntype in Main Collection drawer 3–22A: same data but 'AWD Androconia slide 628', 'BM(N.H.) | Rhopalocera | Slide No. | 30610'. Non type specimen in Main Collection drawer 3–22A: 'Skardo, July, 2000 ft', 'Leech Coll. 1901–173', 'AWD Androconia slide 629', 'BM(N.H.) | Rhopalocera | Slide No. | 30608'. Specimen 629 is probably *P. gilgitica* (see below in Results).
2. *Pseudochazara lehana* (Moore, 1878: 227). Originally named as '*Hipparchia lehana*'. Syntype figured by Tshikolovets (2005a, pl. 23 fig.8). Type locality: 'Leh [34.10N, 77.35E], Kharbu [34.33N, 75.58E], 13000 ft, Ladakh'. Topotype in Main Collection drawer 3–23: '**Himalayas**, K[h]ardong [34.16N, 77.38E], 14000 ft, Aug. 1889', 'McArthur Coll. (Leech Coll. 1901–173)', 'AWD Androconia slide 618', 'BM(N.H.) | Rhopalocera | Slide No. | 30604'.
3. *Pseudochazara turkestanica* (Grum-Grshimailo, 1893: 384). Originally named as '*Satyrus lehana turkestanica*'. Type locality: 'Mts of Turkestan and Thian Schan (west)'. Topotype (syntype?) in Main Collection drawer 3–23: '**Boro Chozo** <difficult to read: this could be Boro Khoro Mts, E. Turkestan, 44.20N, 83.00 E; further location data is illegible>, 1.vii.[18]89', 'Elwes Coll.', 'Coll. Gr[um]-Gr[shimailo]', 'AWD Androconia slide 620', 'BM(N.H.) | Rhopalocera | Slide No. | 30606'.
4. *Pseudochazara clarissima* (Seitz, 1908: 128). Originally named as '*Satyrus mniszechii clarissima*'. Seitz (1908, pl. 43 figs f & g) figures this taxon. Type locality: 'West China'. Topotype? (see Tshikolovets, 2005a: 105) in Main Collection drawer 3–23: '**N. Kashmir**, Hunza, 9450 ft, 21.viii.[19]13', 'No. 60', 'R. W. Hingston 1914–161', 'AWD Androconia slide 619', 'BM(N.H.) | Rhopalocera | Slide No. | 30605'.
5. *Pseudochazara esquelinus* (Fruhstorfer, 1911: 308). Originally named as '*Eumenis mniszechii* [sic] *esquelinus*'. Type locality: 'Alai'. 'Type' in Type Collection drawer 1–17: '**Alai Mont**[.] 1905[.] Korb', 'Fruhstorfer Coll. B.M. 1937–285', 'AWD | Androconia | preparation | 644'. Specimen 644 is accompanied by a female with the same data.
6. *Pseudochazara droshica* (Tytler, 1926: 256). Originally named as '*Eumenis lehana droshica*'. Sakai (1981) figures *P. droshica* syntypes (male: pl. 26 figs 5–6; female: pl. 26 figs 7–8). Type locality: 'Drosh and Shandur, Chitral'. Cotype in Type Collection drawer 1–58: '**Chitral**, Jhela Drosh', 'B. M. Type | No. Rh. 10762', 'Capt. S. W. Harris 98–182', 'AWD | Androconia | preparation | 654'. The distinctively torn female syntype illustrated by Sakai (1981) appears to be no longer present in drawer 1–58. Syntype in Main Collection drawer 3–22A: '**Chitral**, 20.vi.[19]10, [on] wall', 'Syntype (det. P. Ackery 1979)', 'H. C. Tytler Coll. Brit. Mus. 1941–92', 'AWD Androconia slide 631', 'BM (N.H.) | Rhopalocera | Slide No. | 30612'.
7. *Pseudochazara gilgitica* (Tytler, 1926: 256). Originally named as '*Eumenis lehana gilgitica*'. Type locality: 'Ghizer, Gilgit'. Syntype in Type Collection drawer 1–58: '**Chitral** | Shandur Pass | vii. 1901 | el[evaluation] 11000 ft | Coll. G. A. Leslie | & W. H. Evans | 1903–284', 'B. M. Type | No. Rh. 110764', 'AWD | Androconia | preparation | 653'. Specimen 653 is accompanied by a female syntype ('B. M. Type | No. Rh. 10765') with the following data: '**Chitral** | Shandur Pass | 11–14000 ft | 10.viii.[19]03 | A. R. C. Saunders | 1904–237'. Syntype in Main Collection drawer 3–22A: same data as specimen

- 653, but 'AWD Androconia slide 630a', 'BM(N.H.) | Rhopalocera | Slide No. | 30613'. Syntype in Main Collection drawer 3–22A: '**Gilgit**, Ghizer', '9. 23 [= ix.1923?]', 'H. C. Tytler Coll. Brit. Mus. 1941–92', 'AWD Androconia slide 630b', 'BM(N.H.) | Rhopalocera | Slide No. | 30614'.
8. *Pseudochazara balucha* (Evans, 1932a: 113). Originally named as '*Eumenis mniszecchii balucha*'. Type locality: 'Urak, Baluchistan'. Evans' (1932b) inclusion of 'Ziarat, Kojak and Bogra' in the type locality is no longer relevant with the designation of a lectotype for this taxon. Lectotype in Type Collection drawer 1–58: '**Baluchistan** | Urak | 10.vi.[19]28', 'W. H. Evans | B.M. 1932–274', <dry genitalia preparation glued to card>, 'AWD | Syntype | det[ermined] 24.xi.2006', 'AWD & OK | Lectotype | [designated] 24.xi.2006' (see below in Results and Discussion), 'AWD | Androconia | preparation | 655'. Specimen 655 is accompanied by a female specimen with the following data: '**Baluchistan** | Ziarat | 17.vi.[19]28', 'W. H. Evans | B.M. 1932–274'. Three specimens (formerly topotypes) in Main Collection drawer 3–23: 1- '**Baluchistan** | Ziarat | 26.vi.1928', 'W. H. Evans | B.M. 1929–98', 'AWD | Androconia | preparation | 657'; 2- same data, but '21.vi.1928', 'AWD Androconia slide 624a', 'BM(N.H.) | Rhopalocera | Slide No. | 30619'; 3- same data, but '9.vii.1931', 'W. H. Evans | BM 1935–7', 'AWD Androconia slide 624b', 'BM(N.H.) | Rhopalocera | Slide No. | 30620'.
 9. *Pseudochazara balucha* f. *pallida* (Evans, 1932a: 113). Originally named as '*Eumenis mniszecchii balucha* f. *pallida*'. Type locality: 'Ziarat, Baluchistan'. Lectotype in Main Collection drawer 3–23: '**Baluchistan** | Ziarat | 17.vi.[19]28', 'W. H. Evans | BM 1932–274', <dry genitalia preparation glued to card>, 'Syntype male | *Eumenis mniszecchii* | *balucha* f. *pallida* | Evans | det[ermined by] P. Ackery 1979', 'AWD & OK | Lectotype | [designated] 24.xi.2006' (see below in Results and Discussion), 'AWD | Androconia | slide 625 | 10.xii.2004', 'BM(N.H.) | Rhopalocera | Slide No. | 30621'. Specimen 625 has been misidentified and unnecessarily named by Evans. It is probably *P. baldiva* or *P. lehana* (see below in Results and Discussion). Sakai (1981) figures specimen 625 (pl. 28 figs 17–18) and a female syntype (pl. 28 figs 19–20). Topotype: same data, but '1.vi.1930', 'W. H. Evans | B.M. 1934–491', 'AWD | Androconia | preparation | 656'. Specimen 656, like specimen 625, is probably *P. baldiva* or *P. lehana* (see below in Results and Discussion). Mislabeled specimen: same data, but '30.vii.1930', 'W. H. Evans | B.M. 1934–491', 'AWD | [slide] 643 | 6.v.2005 | Androconia', 'BM (N.H.) | Rhopalocera | Slide No. | 30624'. Specimen 643 is most probably a worn and faded specimen of *P. balucha* (see below in Results and Discussion).
 10. *Pseudochazara watsoni* Clench & Shoumatoff (1956: 148). Originally named as '*Pseudochazara mniszecchii watsoni*'. Type locality: 'Kotal Pass, 3800 m, Afghanistan'. Paratype in Main Collection drawer 3–23: '**Afghanistan**, Kotal Pass, August [17, 19]17', 'Paratype [Series] No. 279, Carn. Mus. Ent. Avinoff Coll. CM Acc. 14608', '3rd Danish Exp. Cent. Asia 148, N. Harlov, #127', 'Brit. Mus. 1974–415', 'AWD Androconia slide 621', 'BM(N.H.) | Rhopalocera | Slide No. | 30607'.
 11. *Pseudochazara atambegi* Wyatt & Omoto (1966: 161). Originally named as '*Satyrus (Pseudochazara) baldiva atambegi*'. Type locality: 'Bala Quran, Anjuman, Badachshan'. Topotype in Main Collection drawer 3–22A: '**Hindu Kush**, Bala Quran, 17.vii.1971, Y. Ishikawa', 'AWD Androconia slide 627', 'BM(N.H.) | Rhopalocera | Slide No. | 30609'.
 12. *Pseudochazara wakhilkhani* Wyatt & Omoto (1966: 164). Originally named as '*Satyrus (Pseudochazara) watsoni wakhilkhani*'. Type locality: 'Bala Quran, Anjuman Valley, Badachshan'. Topotype in Main Collection drawer 3–23: '**Afghanistan**, NE Hindu Kush Mts, Bala-Quran, 3000–3400 m, 7–22.vii.1971, Anjuman V[alley], S. Sakai leg.', 'Brit. Mus. 1977–372', 'AWD Androconia slide 622', 'BM(N.H.) | Rhopalocera | Slide No. | 30617'. Non type specimen in Main Collection drawer 3–23: '**Afghanistan**, Kho-i-baba Mts, Mt Shah Fuladi, 3300 m, 8–12.viii.1974', 'Brit.-Mus. 1977–415', 'AWD Androconia slide 623', 'BM(N.H.) | Rhopalocera | Slide No. | 30618'.

Results

Measurements from the androconia are given in Table 1 (together with the nomenclatural type status of each specimen) and representatives of androconia are illustrated in Figs 2–5. These neomorphic (see Warren 1963) androconia can be grouped by visual

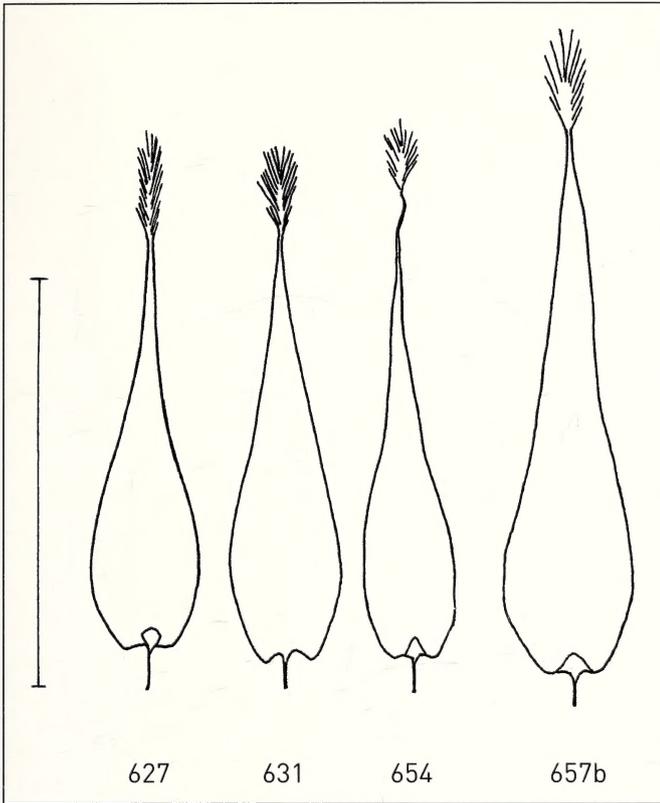


Fig. 2. Androconia (drawn to scale, with scale bar representing 0.25 mm) from specimens in Cluster 1: *P. atambegi* (AWD627), *P. droshica* (631 & 654), and aberrant *P. balucha* scale (657b).

comparison into three main shapes: (1) very bulbous at the base (*P. droshica* and *P. atambegi*; Fig. 2), (2) relatively tall and thin with lamina widest near base giving a triangular appearance (*P. gilgitica* and *P. balucha*; Fig. 3), and (3) relatively shorter and thinner with lamina widest further up from base than in (2) giving a cigar-shaped appearance (*P. baldiva*, *P. lehana*, etc.; Figs 4 & 5). Group (1) also includes aberrant scales from specimen 657, which have similar length to normal *P. balucha* scales, group (2) above, but are extremely bulbous at the base like *P. droshica* scales.

The *k*-means clustering analysis produced three significantly differentiated clusters based on significant differences in the measurements (Androconium length,

AL: $F_{2,21} = 23.0$, $P < 0.001$; Androconium breadth, AB: $F_{2,21} = 46.5$, $P < 0.001$; Shape ratio, A: $F_{2,21} = 41.2$, $P < 0.001$). However, two of the 'type' specimens: 618 (*P. lehana*) and 628 (*P. baldiva*) are placed in the same cluster. This is not a surprising outcome when we consider our findings from visual comparison of androconia in Figs 2–5.

There are certainly three androconium shapes here as indicated by the three clusters, but from this analysis we have to reject Sakai's (1981) hypothesis that *P. lehana*, *P. droshica*, and *P. baldiva* are the three names that have nomenclatural priority to represent the clusters of type specimens before us. From our analysis we can see that *P. lehana* (Moore, 1878) is a junior subjective synonym of *P. baldiva* (Moore, 1865). Re-visiting our androconia drawings in Figs 2–5 indicates that *P. gilgitica* (Tytler, 1926) is the name that has priority to represent the cluster of relatively tall, thin androconia in our data set. So we reran the *k*-means analysis 'seeding' with 628 to represent *P. baldiva*, 631 for *P. droshica*, and 653 for *P. gilgitica* (all these specimens are syntypes).

This second analysis produces the same Euclidean distances between clusters and similar *F*-statistics (Androconium length, AL: $F_{2,21} = 21.8$, $P < 0.001$; Androconium breadth, AB: $F_{2,21} = 44.2$, $P < 0.001$; Shape ratio, A: $F_{2,21} = 40.2$, $P < 0.001$) as the first run and is represented in Fig. 6 as a non-metric multidimensional (NMMS) plot

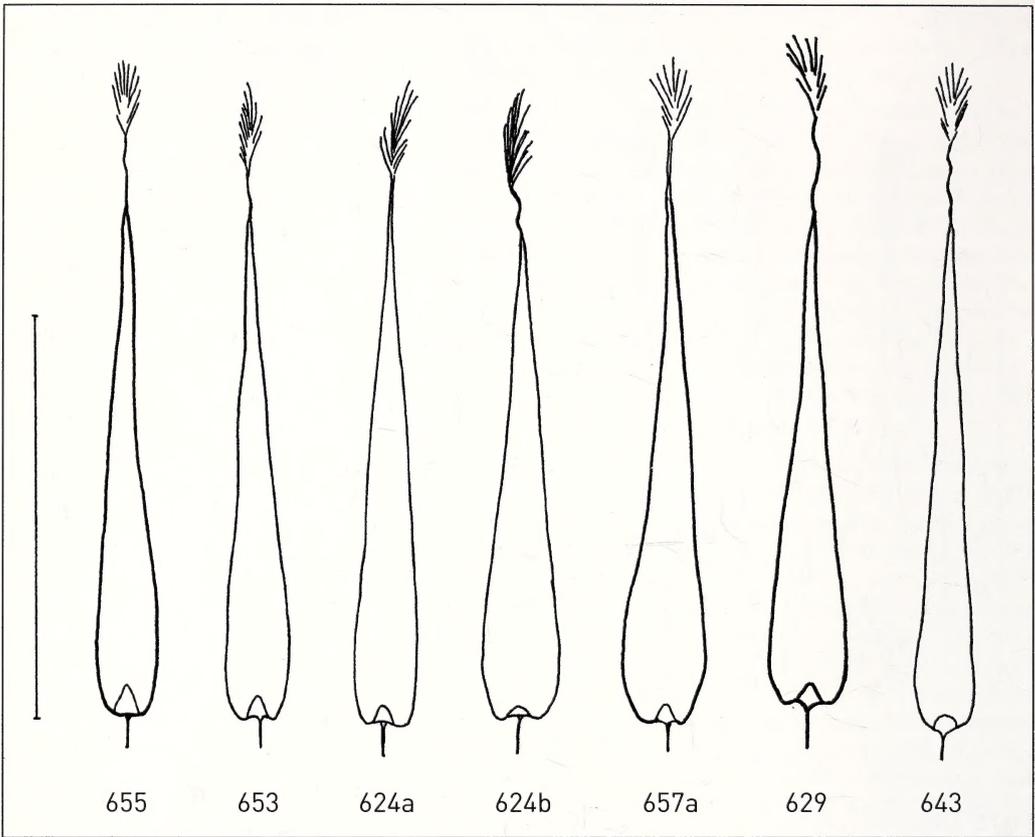


Fig. 3. Androconia (drawn to scale, with scale bar representing 0.25 mm) from specimens in Cluster 2: *P. balucha* (AWD655, 624a, 624b & 657a), a specimen (643) labeled as *P. balucha* f. *pallida*, which is probably *P. balucha*, and a specimen (629) labeled as *P. baldiva*, which is probably *P. gilgitica*. Specimen 653 is *P. gilgitica*.

of Euclidean distances. In Cluster 1 (four specimens represented by circles in Fig. 6): *P. droshica* (631 & 654) clusters with *P. atambegi* (627) and specimen 657b (aberrant scales from a *P. balucha* specimen) also clusters with this group. In Cluster 2 (seven specimens represented by triangles in Fig. 6): *P. gilgitica* (653) clusters with *P. balucha* (624a, 624b, 655 & 657a (normal scales)) and a specimen (643) labeled as *P. balucha* f. *pallida*. Specimen 629 (labeled as *P. baldiva*) also clusters with *P. gilgitica*, but 629 is not a type specimen and may therefore be *P. gilgitica*. In Cluster 3 (13 specimens represented by squares in Fig. 6): *P. baldiva* (628 & 649) clusters with *P. watsoni* (621), *P. wakhilkhani* (622 & 623), *P. esquelinus* (644), *P. clarissima* (619), *P. lehana* (618) and *P. turkestanica* (620). Specimens 625 (syntype) and 656 that are labeled as *P. balucha* f. *pallida* in the BMNH collection also cluster with *P. baldiva*. Specimens 630a and 630b (syntypes) labeled as *P. gilgitica* in the BMNH collection also cluster with *P. baldiva*, but are at the edge of the cluster closest to the *P. gilgitica* cluster. The androconia from specimens 630a and 630b are not cigar-shaped and are widest relatively close to their base.

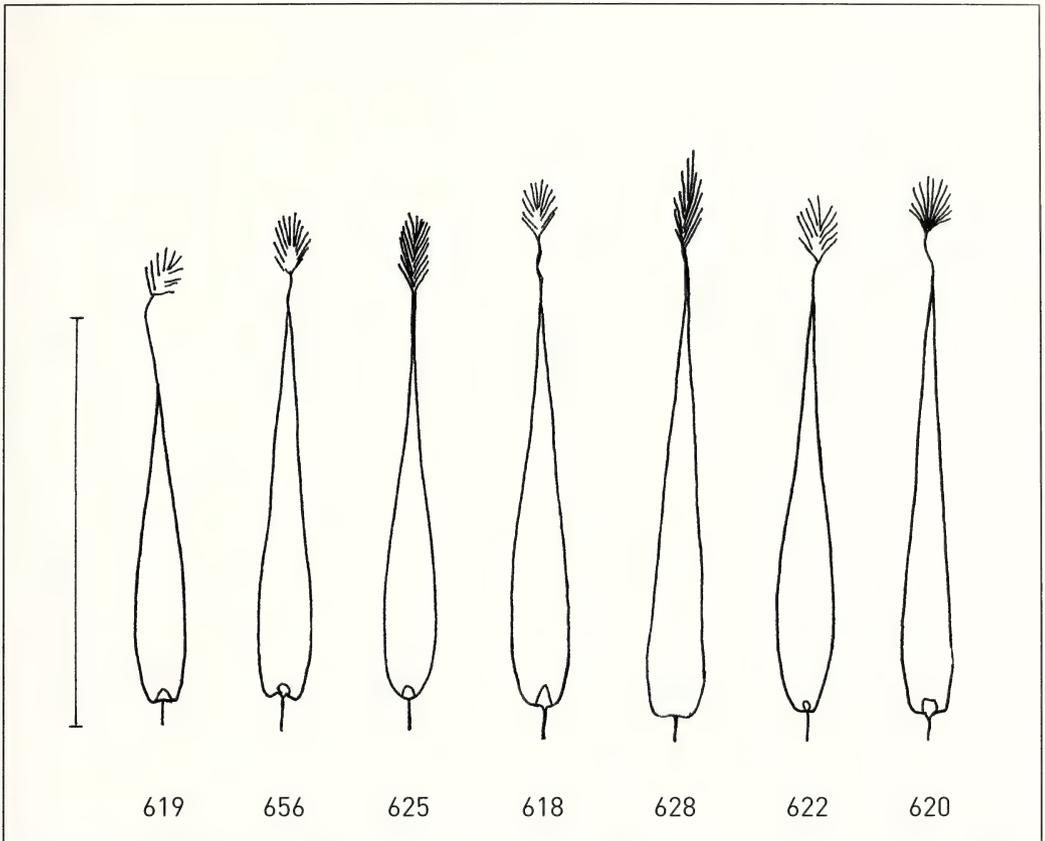


Fig. 4. Androconia (drawn to scale, with scale bar representing 0.25 mm) from specimens in Cluster 3: *P. clarissima* (AWD619), *P. balucha* f. *pallida* (656 & 625), *P. lehana* (618), *P. baldiva* (628), *P. wakhilkhani* (622), and *P. turkestanica* (620).

Kruskal-Wallis ANOVA by ranks supported these contrasts ($H_{2, n=24}$): AL = 13.2, $P = 0.0013$; AB = 16.1, $P = 0.0003$; A = 9.7, $P = 0.008$); all groups were separated using multiple comparisons: Clusters 1 and 2 by variables AB and A, Clusters 2 and 3 by variables AL and AB, and Clusters 1 and 3 by variable A. Using data standardized on wing lengths for a limited sample of 15 individuals (for which wing measurements were available), a one-way ANOVA confirmed inter-group (cluster) heterogeneity ($F_{6,20} = 16.0$, $P < 0.001$) despite small sample size, to which AB and A contributed to heterogeneity.

Discussion

The use of visual and quantitative comparison of specimens in the current study suggests that Sakai's (1981) nomenclature for the three androconia-shape groups based on material from Afghanistan should be replaced with the synonymy given below. This synonymy is based on material that includes more type specimens and covers a wider

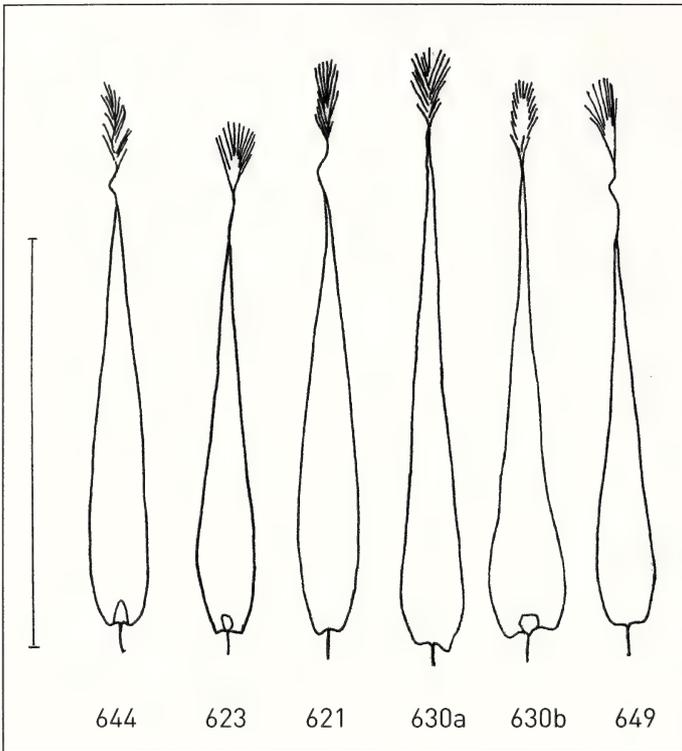


Fig. 5. Androconia (drawn to scale, with scale bar representing 0.25 mm) from specimens in Cluster 3: *P. esquelinus* (AWD 644), *P. wakhilkhani* (623), *P. watsoni* (621), *P. gilgitica* (630a & 630b), and *P. baldiva* (649). See text in relation to the placing of specimens 630a and 630b.

Central Asian study area. Additional probable synonymies of nominal taxa, for which material was not available to us in this study (but whose androconia have been reliably illustrated in other studies), are given in square brackets with references. These names have been used in so many combinations in the literature (e.g. see Gross 1978; Tuzov 1997; Tshikolovets 2005a, b) that, with two exceptions (see text below), we do not attempt to identify which of these are new synonymies.

***Pseudochazara baldiva* (Moore, 1865: 499)**

Hipparchia lehana Moore (1878: 227)

Satyrus lehana var. *turkestanica* Grun-Grshimailo (1893: 384)

[*Satyrus lehana* var. *sagina* Heyne (1894: 542) (ref: Gross, 1978)]

[*Satyrus baldiva* var. *tarbagata* Staudinger (1901: 57) (ref: Wakeham-Dawson & Kudrna, 2005)]

Satyrus mniszechii clarissima Seitz (1908: 128)

Eumenis mniszechii [sic] *esquelinus* Fruhstorfer (1911: 308)

Eumenis mniszechii balucha f. *pallida* Evans (1932a: 113), syn. n.

Pseudochazara mniszechii watsoni Clench & Shoumatoff (1956: 148)

Satyrus (*Pseudochazara*) *watsoni wakhilkhani* Wyatt & Omoto (1966: 164)

[*Satyrus* (*Pseudochazara*) *watsoni dargaga* Wyatt & Omoto (1966: 165) (ref: Gross, 1978)]

[*Pseudochazara pseudobaldiva* Gross (1978: 62) (ref: Gross, 1978)]

[*Pseudochazara pakistana* Gross (1978: 63) (ref: Gross, 1978)]

***Pseudochazara droshica* (Tytler, 1926: 256)**

[*Pseudochazara porphyritica* Clench & Shoumatoff (1956: 150) (refs: Gross, 1978; Sakai, 1981)]

[*Satyrus (Pseudochazara) baldiva panjshira* Wyatt & Omoto (1966: 160) (ref: Gross, 1978)]

Satyrus (Pseudochazara) baldiva atambegi Wyatt & Omoto (1966: 161)

[*Satyrus (Pseudochazara) turkeстана badachshana* Wyatt & Omoto (1966: 162) (ref: Sakai, 1981)]

[*Pseudochazara kopetdaghi* Dubatolov, 1989: 138 (ref: Dubatolov, 1989)]

***Pseudochazara gilgitica* (Tytler, 1926: 256)**

Eumenis mniszechii balucha Evans (1932a: 113), syn. n.

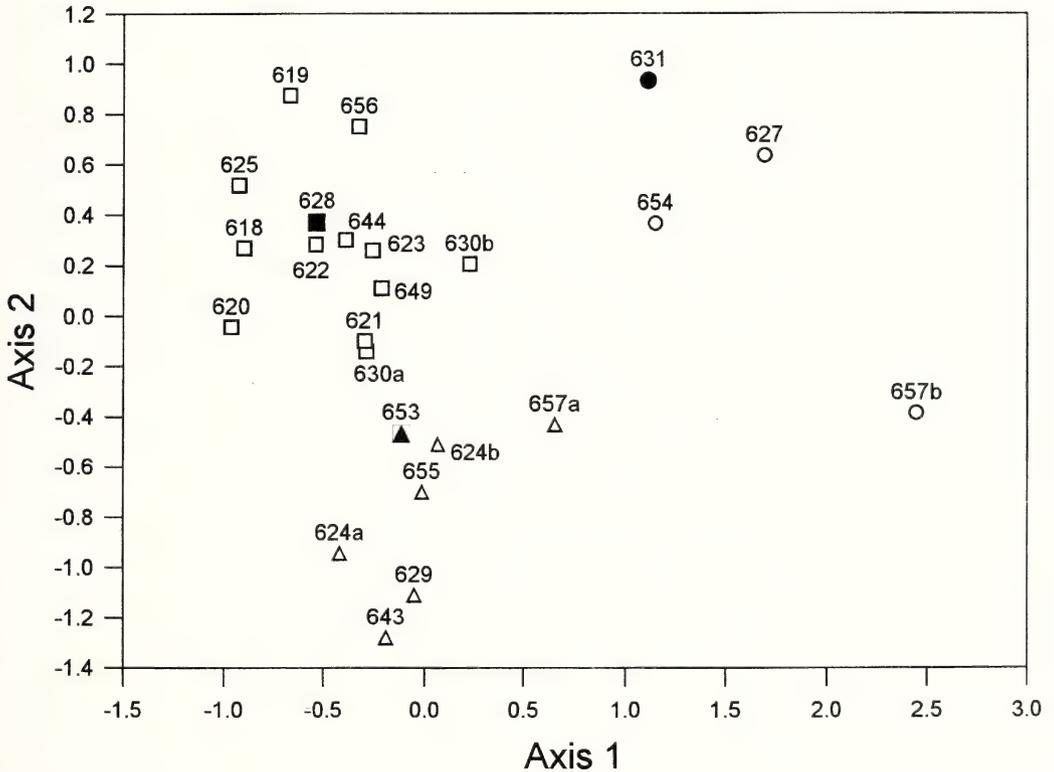


Fig. 6. A non-metric multidimensional (NMMS) plot of Euclidean distances between specimens (Alienation = 0.005 and Stress = 0.0003 indicating that the clusters are accurately represented); see text for explanation. Cluster 1 (circles): *P. droshica* (631 & 654), *P. atambegi* (627), and specimen 657b (aberrant scales from a *P. balucha* specimen). Cluster 2 (triangles): *P. gilgitica* (653), *P. balucha* (624a, 624b, 655 & 657a (normal scales)), specimen 643 labeled as *P. balucha* f. *pallida* and specimen 629 labeled as *P. baldiva*. Cluster 3 (squares): *P. baldiva* (628 & 649), *P. watsoni* (621), *P. wakhilkhani* (622 & 623), *P. esquelinus* (644), *P. clarissima* (619), *P. lehana* (618), *P. turkeстана* (620), *P. balucha* f. *pallida* (625 & 656) and *P. gilgitica* (630a & 630b, see text in relation to the placing of these specimens). The three 'type' specimens used to seed the *k*-means analysis are indicated by filled symbols.

Tab. 1. Androconium length (AL) from basal stem to terminal points and androconium breadth (AB) across the widest point of the lamina (mm) (means \pm sd), and ratio A (AL/AB; no units) (mean \pm sd) that represents overall shape of androconia from 23 specimens among 12 nominal taxa of *Pseudochazara* butterflies. **Spec. No.** = Authors' numbers allocated to specimens and androconia slides. **BMNH No.** = BMNH Rhopalocera Slide Number; * = No. not yet allocated at time of publication. **N** = number of androconia measured. Status: **C** = cotype, **P** = paratype, **S** = syntype, **L** = lectotype, **T** = type, **TT** = topotype, **TT*** = topotype status removed by designation of lectotype, **NOT** = not type material, **+** = mislabeled in BMNH (this is probably *P. gilgitica*), **++** = mislabeled in BMNH (this is probably *P. balucha*).

Taxon	Status	Spec. No.	BMNH No.	AL	AB	A	N
<i>P. atambegi</i>	TT	AWD627	30609	0.344 \pm 0.004	0.066 \pm 0.002	5.19 \pm 0.16	5
<i>P. baldiva</i>	NOT+	AWD629	30608	0.440 \pm 0.011	0.041 \pm 0.004	10.94 \pm 0.79	5
<i>P. baldiva</i>	S	AWD628	30610	0.332 \pm 0.012	0.032 \pm 0.002	10.45 \pm 0.75	10
<i>P. baldiva</i>	S	AWD649	*	0.356 \pm 0.006	0.036 \pm 0.002	9.85 \pm 0.62	6
<i>P. f. pallida</i>	L	AWD625	30621	0.314 \pm 0.010	0.028 \pm 0.002	11.41 \pm 0.69	10
<i>P. f. pallida</i>	NOT++	AWD643	30624	0.450 \pm 0.015	0.039 \pm 0.002	11.43 \pm 0.31	6
<i>P. f. pallida</i>	TT	AWD656	*	0.311 \pm 0.010	0.033 \pm 0.002	9.35 \pm 0.28	5
<i>P. balucha</i>	L	AWD655	*	0.414 \pm 0.023	0.040 \pm 0.002	10.28 \pm 0.57	5
<i>P. balucha</i>	TT*	AWD657b	*(aberrant scales)	0.419 \pm 0.005	0.082 \pm 0.005	5.15 \pm 0.31	3
<i>P. balucha</i>	TT*	AWD657a	*(normal scales)	0.406 \pm 0.009	0.049 \pm 0.002	8.34 \pm 0.37	5
<i>P. balucha</i>	TT*	AWD624a	30619	0.423 \pm 0.004	0.036 \pm 0.002	11.70 \pm 0.81	10
<i>P. balucha</i>	TT*	AWD624b	30620	0.402 \pm 0.014	0.041 \pm 0.003	9.89 \pm 0.63	10
<i>P. clarissima</i>	TT?	AWD619	30605	0.296 \pm 0.005	0.029 \pm 0.002	10.21 \pm 0.62	5
<i>P. droshica</i>	C	AWD654	*	0.358 \pm 0.000	0.056 \pm 0.000	6.36 \pm 0.00	1
<i>P. droshica</i>	S	AWD631	30612	0.317 \pm 0.011	0.056 \pm 0.011	6.00 \pm 1.48	10
<i>P. esquelinus</i>	T	AWD644	*	0.339 \pm 0.015	0.034 \pm 0.003	10.15 \pm 1.19	5
<i>P. gilgitica</i>	S	AWD630a	30613	0.371 \pm 0.011	0.036 \pm 0.004	10.38 \pm 0.99	10
<i>P. gilgitica</i>	S	AWD630b	30614	0.356 \pm 0.009	0.042 \pm 0.004	8.67 \pm 1.04	10
<i>P. gilgitica</i>	S	AWD653	*	0.396 \pm 0.011	0.039 \pm 0.003	10.35 \pm 0.90	5
<i>P. lehana</i>	TT	AWD618	30604	0.331 \pm 0.011	0.029 \pm 0.004	11.67 \pm 1.81	5
<i>P. turkeстана</i>	S?	AWD620	30606	0.351 \pm 0.008	0.029 \pm 0.001	12.20 \pm 0.34	5
<i>P. wakhilkhani</i>	NOT	AWD623	30618	0.345 \pm 0.008	0.035 \pm 0.002	9.78 \pm 0.52	5
<i>P. wakhilkhani</i>	TT	AWD622	30617	0.338 \pm 0.013	0.032 \pm 0.002	10.56 \pm 0.74	10
<i>P. watsoni</i>	P	AWD621	30607	0.368 \pm 0.008	0.036 \pm 0.003	10.38 \pm 0.98	10

Our comparison of androconia shows that specimen AWD625 (which has been identified as a syntype of *Eumenis mniszechii balucha* f. *pallida* Evans 1932 by P. R. Ackery) is clearly a different taxon from *Eumenis mniszechii balucha* and not just a pale form. This difference has been noted previously by Sakai (1981) and Wakeham-Dawson (2006). Evans (1932a: 113) describes his taxa as follows within a key of satyrid taxa that he includes in the genus *Eumenis*: ‘WSF [Wet Season Form] band dark; on upf [upper-surface of fore-wing] decreasing to dorsum, lower ocellus always present and usually 2 white dots between the ocelli: unf [under-surface of fore-wing] discal line clear, submarginal line zigzag. DSF [Dry Season Form] band very pale, on upf of even width, lower ocellus rarely present and white dots absent; unf discal line clear, submarginal line sinuous. [*Eumenis*] *mniszechii balucha*, nov. (58-65). The Tawny Rockbrown. Baluchistan. NR. (DSF *pallida*, nov).’

Evans (1932b: 201-202) gives the following additional descriptions for his two taxa: ‘45. ‘*Eumenis mniszechii balucha*’, Evans and ‘*pallida*’, Evans. The Tawny Rockbrown. A large dark brown species with a broad tawny band across both wings. It flies from the Caucasus and Asia Minor to Central Asia, the N.-W. Frontier to Ladak and W. China. It is common from June to August at Urak, Ziarat, the Kojak and Bogra, and at Ziarat in May and June (perhaps elsewhere) there is to be met a very pale form. The ordinary local form differs from its allies in the following respects: on the forewing above the band decreases posteriorly, there is always a lower ocellus and usually two white dots between the ocelli: on the underside of the forewing the central line is clearly marked and the submarginal line is zigzag. The form *pallida*, probably an early brood, has the band very pale brown; forewing below the central line is distinct and the submarginal line is sinuous.’ In addition (p. 197) he states: ‘All the types will be placed in the British Museum’.

Evans had a mixed series of specimens before him and misidentified his ‘f. *pallida*’ specimens. Androconia shape indicates that specimen 625 (labeled as *balucha* f. *pallida*) is probably a member of our *P. baldiva* group. Specimen 656 (placed in the *balucha* f. *pallida* series) is probably also a member of our *P. baldiva* group. However, specimen 643 (also placed in the *balucha* f. *pallida* series) has *P. balucha*-shaped androconia (when compared with syntype specimen 655; see Fig. 3) and has been mis-placed as *P. balucha* f. *pallida* in the BMNH collection because it is worn and faded. In addition, the shape of the orange band on the forewings is like that of syntype *P. balucha* rather than syntype *P. balucha* f. *pallida*. Furthermore specimen 643 is labeled as having been captured in late July, while true *P. balucha* f. *pallida* specimens are labeled as having been captured in early to mid June.

To resolve any confusion of identity or nomenclature identified above, we hereby designate specimen AWD625 as Lectotype of *Eumenis mniszechii balucha* f. *pallida* Evans 1932a and synonymize this name with *Lasiommata baldiva* Moore 1865 (New Synonymy). In addition, we designate specimen AWD655 as Lectotype of *Eumenis mniszechii balucha* Evans 1932a and synonymize this name with *Eumenis lehana gilgitica* Tytler, 1926 (New Synonymy).

Our three-group synonymy is fairly bold and there is a danger that our nomenclature fails to acknowledge genetic variation between isolated populations of these butterflies.

The relationships between these taxa may be much more subtle with clines of variation and/or the effects of periodic isolation and recombination of mountain populations during ice ages. So the next stage in this research will be to test our hypothesis with additional material, molecular data and ecological field observations. Currently we do not know to what extent or even whether different androconia shape is associated with different pheromone production and how in turn this may be related to isolation between taxa. One of our *P. balucha* specimens (AWD657) merits special discussion in this respect. Two shapes of androconia are present on this specimen. The majority are typical *P. balucha* scales, but three scales on the microscope slide are shaped like large *P. droshica* scales. We are confident that these scales are not contamination from another specimen as colour, location and size all indicate that they belong to specimen 657. What has caused this 'mutation', and is it the same mechanism that has given rise to androconia shape differences between populations and taxa? Can we assume that both shapes of scale on this specimen produce the same chemicals? If so, this again raises the question as to whether shape differences correspond to chemical differences between taxa. Or is the presence of two scale types the result of hybridization between taxa?

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With 118,000 inhabitants Innsbruck is the fifth largest city of Austria. Situated in the Inn river valley, it is protected by high mountain chains to the north as well as to the south. It comprises an area of 105 square kilometers and altitudes range from 565 to 2,641 meters. During the last decades, urbanisation increased seriously, causing an alarming decline of butterflies and moths, a characteristic situation in all of Central Europe. In spring 2004 a team of lepidopterists started to record the current butterfly and moth fauna of Innsbruck. Until 2006, recording took place from March to October every year using nets, artificial lights, sugar baits, and pheromones. An astonishing number of nearly 1,200 species was recorded. However, analyzing the historical data dating back 150 years, 920 species formerly known from Innsbruck could not be found again. Though there are several species difficult to record, like Nepticulidae, the decline is also obvious in butterflies. Their number of species decreased from 138 to 87, or a third the species, since lepidopterological research started in Innsbruck 150 years ago. The largest decline happened in the period of 1950 to 1979. Altogether, 437 species have been recorded for the last time during that period. More details are given and analyzed in the excellent book on the butterflies and moths of Innsbruck by Huemer and Erlebach. Written in German and in a popular science style it will be understandable for entomologists as well as amateurs in this field. It is illustrated with 255 color figures, mostly photographs of Lepidoptera and their habitats, but also maps and graphs. The book is divided into nine chapters, an (1) introduction, (2) a chapter on nomenclature, characters, the metamorphosis and lifespan of Lepidoptera, (3) diversity of species in Innsbruck and their systematics, (4) history of lepidopterological research in Innsbruck (5) a description of the areas of unspoiled nature and the habitats of Lepidoptera, (6) threats, local losses of Lepidoptera and their conservation, (7) experiencing nature, (8) literature, and (9) an appendix with the list of species known from Innsbruck for the periods before 1878, 1879–1914, 1915–1949, 1950–1979, 1980–1999, and since 1999. Altogether, the reader can learn about Lepidoptera in general, the history of their study in Innsbruck, changes to their habitats and reasons for their decline, and he can get an introduction to the literature and an idea of the current composition of the lepidopteran fauna of Innsbruck. Thus, the book summarizes the knowledge on Lepidoptera in Innsbruck for professionals, amateurs, and those who are just interested in nature, and it might be a starting point to study or just to enjoy butterflies and moths. This book is not just written by lepidopterists for lepidopterists. It has the potential to interest non-lepidopterists to enjoy butterflies and moths, to respect them, and to care for them in the future.

MATTHIAS NUSS

High level of genetic variation in *Aricia artaxerxes issekutzi* (Lycaenidae) populations in Northern Hungary

KATALIN PECSENYE¹, JUDIT BERECZKI¹, MARIANN SZILÁGYI¹ & ZOLTÁN VARGA^{1,2}

¹ Department of Evolutionary Zoology and Human Biology, University of Debrecen, Debrecen, Egyetem tér 1., Hungary; e-mail: pecskati@tigris.unideb.hu

² HAS-DU Research Group for Evolutionary Genetics and Conservation Biology

Abstract. *Aricia artaxerxes issekutzi* imagos were collected from eight localities in two regions in Northern Hungary (Bükk Mountains and Aggtelek Karst region) in 1999 and 2000. Enzyme polymorphism was analysed at 16 enzyme loci using polyacrylamide gel electrophoresis. In the analysis of the data, F-statistics was computed and the total genetic variation was partitioned into within and between population components. Nei's genetic distances were calculated and UPGMA dendrogram was constructed on the basis of the distance matrix. Hierarchical F-statistics and AMOVA were computed to study the pattern of genetic differentiation among the samples. PCA analysis was also carried out using the allele frequencies of the samples. The Hungarian populations of *A. artaxerxes issekutzi* exhibited a high level of enzyme polymorphism. Both the dendrogram and the results of PCA indicated a clear differentiation between the Bükk and Karst regions. Most parameters of polymorphism and also the level of differentiation among the local populations were similar in the two regions. Nevertheless the average number of alleles per locus was significantly lower in the samples of the Bükk Mts than those of the Karst ones. In addition, the Bükk populations possessed a significantly lower portion of the species allele pool compared to the Karst ones. It was mostly the consequence of genetic drift due to the small population sizes in the Bükk Mts.

Introduction

Survival of natural populations in fragmented landscapes is an increasingly important topic in conservation biology (Ricketts 2001; Ries & Debinski 2001; Baguette & Schtickzelle 2001). Habitat fragmentation results in population subdivision and isolation. Consequently, it has grave influence on the genetic structure of populations resulting in decreasing effective population size and loss of genetic variation (Thomas et al. 1998). Nevertheless, different species may experience the same fragmented habitat in a different way (Thomas & Harrison 1992). Thus, surveys of genetic differentiation among local populations within a species have become more and more embedded in conservation studies (Schmitt & Hewitt 2004). Butterflies have been considered as sensitive indicators of changes in cultural landscapes. As a consequence, studies applying population genetic techniques to butterfly conservation surveys have assumed increasing importance.

Aricia artaxerxes (Fabricius, 1793) is a widespread Eurasiatic species. It occurs from Northern Europe to Central Asia and East Siberia (Obraztsov 1935, 1936). In the north-western periphery of the range and also in the mountainous parts of southern Europe, it is subdivided into several subspecies (Beuret 1954; Kaaber & Hoegh-Guldberg 1961; Urbahn 1964; Hoegh-Guldberg 1966, 1968; Hoegh-Guldberg & Jarvis 1969; Kames 1969). One of these subspecies occurs in calcareous areas of the Carpathian basin such as the Bükk Mountains and the Aggtelek Karst region in Northern Hungary, described as *A. artaxerxes issekutzi* Balogh, 1956 (Varga 1961, 1968). The documented food plants of *A. artaxerxes issekutzi* are *Helianthemum ovatum* and *Geranium sanguineum*. However, the caterpillars of *A. artaxerxes* (different subspecies) have been

reared under artificial conditions on different *Geranium* species and *Erodium cicutarium* (Hoegh-Guldberg & Jarvis 1969; Varga pers. obs.). The favoured habitats of this subspecies are dry or semi-dry swards rich in flowers. *Aricia artaxerxes issekutzi* is a monovoltine species. Females lay their eggs usually singly on the lower surface of the leaves or on the flower buds of the food plant (Malicky 1969, Varga 1968). They have about 100 eggs but only 3–5 eggs will be laid on a plant. In this way, the eggs of a female are distributed fairly evenly within the habitat. Larvae develop first on the food plant. Later they are taken to ant nests. *Aricia artaxerxes*, however, is only a facultative myrmecophilous species (Malicky 1969).

The Brown Argus butterflies are known to be highly variable Lycaenid species (Aagard et al. 2002). They are, therefore, appropriate to analyze the genetic consequences of habitat degradation and fragmentation. The aim of the present study was to compare the level and structure of genetic variation in strong and declining populations of *A. artaxerxes issekutzi* in Northern Hungary.

Materials and Methods

Samples. *Aricia artaxerxes issekutzi* samples were collected from two subregions of northern Hungary: Aggteleki Karst region (strong populations) and Bükk Mountains (declining populations). Altogether 12 samples were collected from 8 populations in 1999 and 2000 (Fig. 1). In this way, the samples exhibited two types of hierarchy: geographic regions and populations within the regions (spatial pattern); years and populations collected in the same year (temporal pattern). Imagos were collected mostly in July, after the main egg-laying period and stored at -80°C until electrophoresis. Sample sizes varied between 12 and 40, according to the size of the populations.

Enzyme studies. Allozyme polymorphism was studied at 16 different loci by vertical polyacrylamide gel electrophoresis: aconitase (*Acon*), alcohol dehydrogenase (*Adh*), aldehyde oxidase (*Aox*), esterase (*Est*), glutamate dehydrogenase (*Gdh*), glutamate oxalacetate transaminase (*Got*), glucose-6-phosphate dehydrogenase (*G6pdh*), α -glycerophosphate dehydrogenase (*α Gpdh*), hexokinase (*Hk*), isocitrate dehydrogenase (*Idh*), lactate dehydrogenase (*Ldh*), malate dehydrogenase (*Mdh*), malic enzyme (*Me*), phosphoglucose isomerase (*Pgi*), phosphoglucomutase (*Pgm*), and superoxid dismutase (*Sod*). Thoraxes were homogenized in 300 μl extraction buffer and these samples were used to study *Got*, *α Gpdh*, *G6pdh*, *Hk*, *Idh*, *Ldh*, *Mdh*, *Me*, *Pgi*, *Pgm*, and *Sod*. Abdomens were homogenized in 150 μl extraction buffer and these extracts were used to analyse *Acon*, *Adh*, *Aox*, *Est*, and *Gdh*. The extraction buffer, the electrophoresis buffer systems and running conditions, together with the staining solutions used for each enzyme are described in Bereczki et al. (2005). Genotypes of the different individuals were scored according to their enzyme pattern.

Statistical analyses. Genotype and allele frequencies were calculated on the basis of banding patterns. Measures of genetic variation (average number of alleles, % proportion of polymorphic loci, average observed heterozygosity) were calculated for each sample. The distribution of alleles with different frequencies between the two geographic regions was compared using generalised linear models. The computation was

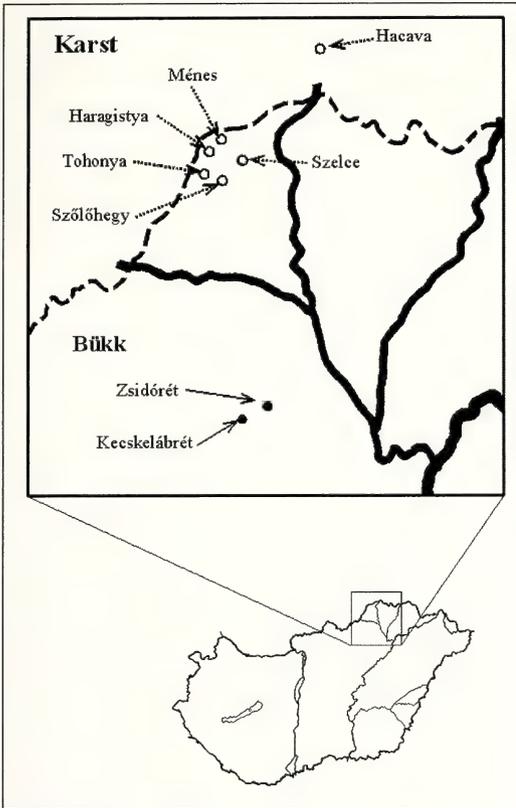


Fig. 1. Sample sites of *A. artaxerxes issekutzi* in northern Hungary.

carried out with GLIM 4 (Francis et al. 1994). Genetic differentiation among the populations was first analysed by Wright's F-statistics (Wright 1978; Weir 1996). In this analysis, the total genetic variation of the samples (F_{IT}) was partitioned into within (F_{IS}) and between population components (F_{ST}). The analyses were conducted by FSTAT version 1.2 (Goudet 1995). An exact test for population differentiation (Raymond & Rousset 1995a) was also conducted to test for independence of the allelic composition of the populations. Genepop, version 1.0 (Raymond & Rousset 1995b) was used to perform this test. Allele frequencies were used to estimate Nei's genetic distances (Nei 1972) and an UPGMA dendrogram (Sneath & Sokal 1973) was constructed on the basis of these data. The computation of genetic distances was performed by Biosys-1, Release 1.7 (Swofford & Selander 1981). The distribution of the total genetic variation at various levels of the hierarchy was also studied by AMOVA (Excoffier et al. 1992; Weir

1996). In this analysis, the total genetic variation is partitioned into three components: among groups, among populations within a group and within population. AMOVA was carried out by Arlequin, version 2.000 (Schneider et al. 2000). In the last part of the study, we carried out a principal component analysis (PCA) using the genotypic composition of the individuals to show the size of overlap in the genetic variation of the populations in a reduced space of variables. PCA analyses were performed running R Package Version 4.0 (Casgrain & Legendre 2001).

Results

Level of enzyme polymorphism. Three of the 16 loci analysed (*Hk*, *αGpdh*, *Sod*) did not have an alternative allele in any of the investigated sample. The samples exhibited a very high level of polymorphism. As a whole, the portion of polymorphic loci was 57.3% and the average frequency of heterozygotes was 24.6% (Tab. 1). Heterozygote deficiency was observed in all samples, which proved to be significant in 8 cases out of the total 12 (Tab. 1). The total number of alleles was 71 at the 16 loci investigated. We have calculated the portion of alleles the samples actually possessed of the total 71 (Tab. 1: A). In general, populations contained 64% of the species gene pool. The

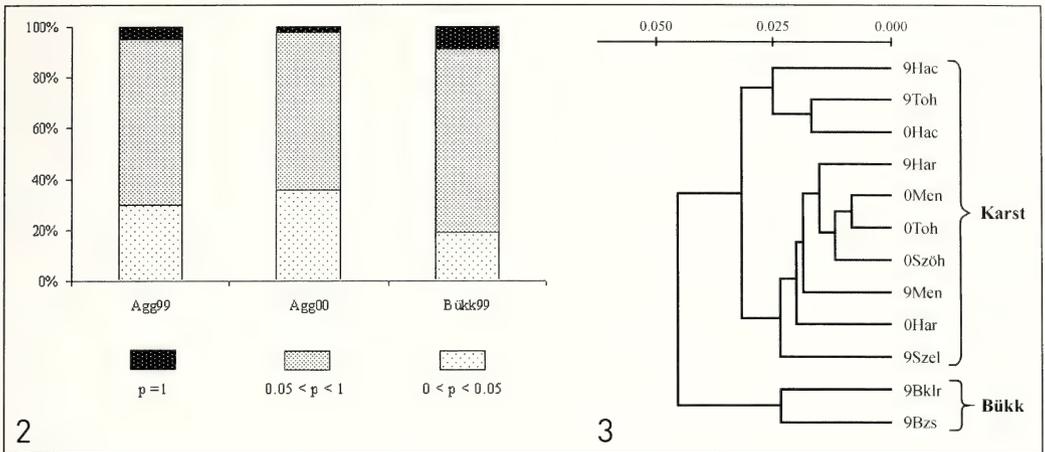
Tab. 1. Parameters of enzyme polymorphism in the *Aricia artaxerxes issekutzi* samples. **N**: sample size; **n_A**: average number of alleles per locus; **A**: average portion of the allele pool of the species; **P**: portion of the polymorphic loci; **F_{IS}**: index representing the within population component of genetic variation. *: significant at 0.05 level; **: significant at 0.01 level; ***: significant at 0.001 level.

		N	n_A	A	P	H	F_{IS}
Bükk 99	Kecskelr.	22.5	2.19	49.3	56.3	0.214	0,139***
	Zsidórét	15.8	2.63	59.2	56.3	0.265	0.043
	Subtotal	19.2	2.41	54.3	56.3	0.240	0.098*
Karst 99	Hacava	23.8	3.13	70.4	68.8	0.274	0.185***
	Haragistya	31.5	2.75	62.0	50.0	0.227	0.137**
	Ménes	26.6	3.13	70.4	56.3	0.244	0.147**
	Szelce	12.0	2.44	54.9	50.0	0.234	0.071
	Tohonya	14.8	2.63	59.2	56.3	0.250	0.107
	Subtotal	21.7	2.82	63.4	56.28	0.246	0.141**
Karst 00	Hacava	32.5	3.31	77.5	68.8	0.258	0.122**
	Haragistya	35.1	3.06	69.0	56.3	0.249	0.029
	Ménes	21.8	2.88	64.8	50.0	0.239	0.132*
	Szőlőh.	25.8	2.88	69.0	56.3	0.255	0.093*
	Tohonya	39.4	2.88	64.8	62.5	0.242	0.137**
Subtotal	30.9	3.00	69.0	58.8	0.249	0.103**	
Total			2.66	64.2	57.3	0.246	0.117**

Tab. 2. Results of F-statistics for the *A. artaxerxes issekutzi* samples. **F_{IT}**: index indicating the total genetic variation of the samples; **F_{IS}**: index representing the within population component; **F_{ST}**: fixation index. *: significant at 0.05 level; **: significant at 0.01 level.

Loci	F_{IT}	F_{IS}	F_{ST}
<i>Acon</i>	0.210**	0.154**	0.066**
<i>Adh</i>	0,211**	0.202**	0.011*
<i>Aox</i>	0.173**	0.127*	0.053**
<i>Est</i>	0,226**	0.205**	0.026**
<i>Gdh</i>	0.232**	0.217*	0.019
<i>Got</i>	0.072	-0.010	0.081**
<i>G6pdh</i>	-0.005	-0.004	-0.001
<i>Idh</i>	-0.010	-0.011	0.001
<i>Ldh</i>	0.288**	0.289**	-0.001
<i>Mdh</i>	0.014	-0.005	0.019
<i>Me</i>	0.216**	0.191**	0.032**
<i>Pgi</i>	0.033	0.026	0.007*
<i>Pgm</i>	0.078*	0,060	0.019**
Total	0.146**	0.117**	0.033**

samples were grouped in two ways. First, the samples collected in 1999 were split according to their geographic origin (Bükk vs. Karst populations). Except for the parameters indicating allelic richness, there was no significant difference in the level of polymorphisms between the samples collected in the two geographic regions. Both the average number of alleles per locus ($F_{1,10}=8.09$; $0.05>P>0.01$) and the portion of the species gene pool the population possessed ($\chi^2_1=7.73$ $0.01>P>0.001$) were, however, significantly higher in the populations collected in the Karst region compared to those of the Bükk Mts. The next step was to sort the samples of the Karst region according to the years (generations) they were collected. Although the samples collected in 2000 exhibited a slightly higher polymorphism these differences were not significant for any of the parameters (Tab. 1). We also compared the distribution of alleles with different frequencies between



Figs 2–3. 2. Distribution of alleles with different frequencies in the populations of the two regions in the two years of collection. Agg99: Karst samples collected in 1999; Agg00: Karst samples collected in 2000; Bück99: samples collected in the Bück plateau in 1999. 3. UPGMA dendrogram of the *A. artaxerxes issekutzi* samples constructed on the basis of Nei's distances.

the two regions and between the two years. Three frequency categories were set: rare alleles ($p < 0.05$), common alleles with a frequency of $0.05 < p < 1$ and fixed alleles ($p = 1$). The differences between the two regions in their allele distribution were significant ($\chi^2 = 8.04$; $0.05 > P > 0.01$). The Bück populations carried less rare alleles but were fixed for more alleles than the Karst populations (Fig. 2). At the same time, the two samples collected in the Karst region proved to be similar ($\chi^2 = 4.04$; $P > 0.05$).

Structure of the genetic variation. The results of F-statistics indicated that a substantial portion of this variation was observed within the samples. The average F_{IS} value suggested significant heterozygote deficiency within the samples (Tab. 2), which was attributable to 7 of the 13 loci. At the same time, the samples exhibited a relatively low level of genetic differentiation (Tab. 2: F_{ST}). Yet, 8 of the total 13 loci proved to be significantly differentiating (Tab. 2).

Nei's (1972) genetic distances were calculated and a UPGMA dendrogram was constructed on the basis of the distance matrix. The dendrogram showed an obvious geographic pattern (Fig. 3). The samples originating from the two regions were clustered in two well differentiated branches. Moreover, the two samples collected in Hacava, which is situated in the Slovakian part of the Karst region were separated from the other Karst samples. At the same time, the samples of the other Karst populations (except for the '99 sample from the Tohonya ridge) collected in the two consecutive years (generations) were scattered randomly in the middle branch (Fig. 3). This indicates a fairly high level of random changes in their allele frequencies.

In the analysis of the structure of genetic differentiation, we contrasted the spatial and temporal components of the between sample variation. Accordingly, we computed AMOVA using Arlequin. In this analysis, the total genetic variation can be analysed involving the within sample component as well. However, we could not include all levels of the hierarchy above the sample in a single run. We, therefore, conducted the analy-

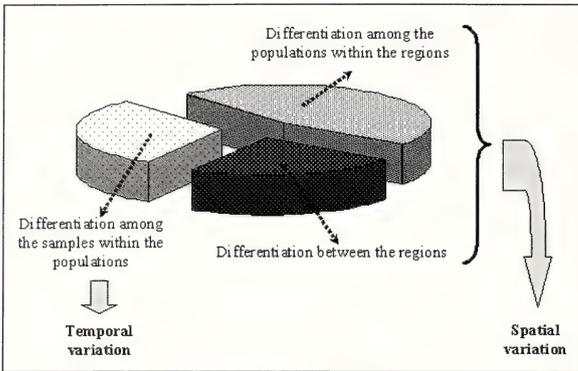


Fig. 4. Distribution of the total between sample variation in *A. artaxerxes issekutzi*.

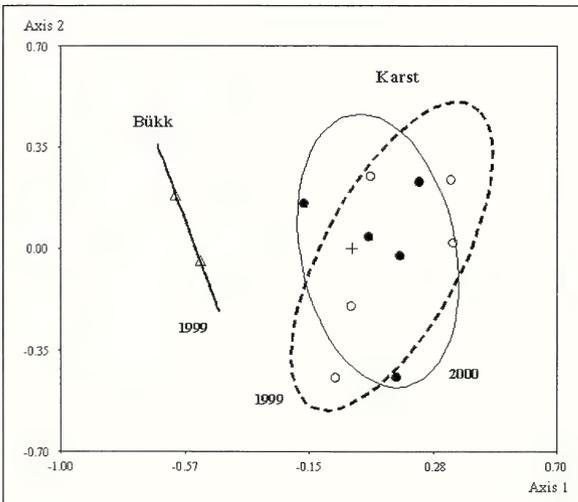


Fig. 5. Results of the PCA analysis for the *A. artaxerxes issekutzi* samples. Δ : Bükk samples; \bullet : Karst samples collected in 1999; \circ : Karst samples collected in 2000.

ses in two series. In the first run, the levels of the hierarchy were: regions (group of samples) and samples. In the second run, the following levels of the hierarchy were considered: populations (group of samples) and samples. The results suggested that most of the total genetic variation was attributable to the within sample component (95.08%). The distribution of the between sample variation revealed that a much higher portion of variation was explained by the differences among the populations (Fig. 4: spatial variation) than by those within them, i.e. between the samples collected in different generations from the same population (Fig. 4: temporal variation). The indices of differentiation also indicated that the spatial component of variation was far larger than the temporal one. F_{PT} , the index representing the level of differentiation among the populations was highly significant ($F_{PT} = 0.034$, $P < 0.001$) while F_{SP} , the index representing the level of differentiation among the samples within the populations was not ($F_{SP} = 0.011$, $P > 0.05$).

Similarly to the dendrogram, the results of the PCA analysis also indicated a clear geographic pattern of differentiation. The samples exhibited two large clouds of points

Region	Year	F_{ST}	Exact test
Karst	1999	0.024** (6)	*** (3)
	2000	0.020** (6)	*** (6)
	Total	0.024** (6)	*** (6)
Bükk	1999	0.022* (3)	* (2)
Total		0.033** (8)	*** (7)

Tab. 3. F_{ST} values and the results of exact test at different levels of the hierarchy in the *A. artaxerxes issekutzi* samples. The numbers in brackets indicate the significantly differentiating loci. *: significant at 0.05 level; **: significant at 0.01 level; ***: significant at 0.001 level.

Tab. 4. Results of AMOVA for the *A. artaxerxes issekutzi* samples. **BR**: between region variation; **WRBP**: between population variation within a region; **WPBS**: between sample (year/generation) variation within a population; **WS**: within sample (year/generation) variation. Indices of differentiation were determined in two analyses with different levels of hierarchy: **Analysis 1** – region and sample; **Analysis 2** – population and sample. F_{RT} : index of differentiation among the regions; F_{PT} : index of differentiation among the populations; F_{SR} : index of differentiation among the samples (year/generation) within a region; F_{SP} : index of differentiation among the samples (year/generation) within a population; F_{ST} : index of total differentiation among the samples (year/generation).

% of variation		Indices of differentiation		
			Analysis 1	Analysis 2
BR	1.14	F_{RT}	0.034***	-
WRBP	2.29	F_{PT}	-	0.024***
WPBS	1.49	F_{SR}	0.026***	-
WS	95.08	F_{SP}	-	0.011
Total	100	F_{ST}	0.059***	0.035***

in the reduced space of variables (Fig. 5). The two axes explained 56.7% of the genetic variation of the samples. The 95% ellipses drawn according to the geographic regions and the years the samples were collected indicated an evident separation between the Karst and Bükk populations along the first axis. The allele frequency distribution at the *Got* and *Aox* loci contributed most to this axis. In accordance with the results of the hierarchical F-statistics the samples collected in two consecutive years/generations in the Karst populations comprised largely overlapping clouds.

Discussion

In line with other European lycaenid butterflies studied we found a high level of polymorphism in *Aricia artaxerxes issekutzi* populations. *Polyommatus coridon*, *P. bellargus* and *P. icarus* has been surveyed in many Western and Central European populations (Schmitt & Seitz 2001a, b; Schmitt et al. 2003). Those results revealed a high level of polymorphism e.g. the proportion of polymorphic loci ranged from 0.42 to 0.85. The mean number of alleles per locus has been especially high (3.0–3.5) in the southern European *P. coridon* populations (Schmitt & Seitz 2001a; Schmitt et al. 2002). Aagaard et al. (2002) have reported a high level of genetic variation in the northern European populations of *Aricia artaxerxes* and *A. agestis*. They found 1.84 alleles per locus on average with some loci having 6 or even 8 alleles. Our data indicated an even higher polymorphism than those of Aagaard et al. (2002). In the Hungarian *Aricia* populations, the average number of alleles ranges between 2.2 and 3.3. Moreover, we detected 17, 11 and 9 alleles at the *Est*, *Pgi* and *Pgm* loci respectively. As a consequence of the high number of alleles per locus, we also observed an exceptionally high frequency of heterozygotes (average $H_o=0.246$). As far as known, in butterfly populations enzyme studies has only revealed such a high level of heterozygosity in *P. hispana* populations (Schmitt et al. 2005).

Although most parameters of polymorphism were similar in the two regions studied, the average number of alleles per locus and the average portion of the species gene

pool each population possessed were significantly lower in the Bükk samples than in the Karst ones. Moreover, the distribution of alleles among the three frequency categories (rare, common and fixed alleles) was also different in the two regions. Namely, the fixed alleles were more frequent in the Bükk populations, whereas the rare alleles were more common in the Karst ones. It thus appears that populations living in the Bükk plateau have a lower allelic richness than those of the Karst region. A possible explanation of this situation is that *Aricia* populations are smaller and more isolated in the Bükk plateau than in the Karst region. *Aricia artaxerxes* prefers short-grass habitats at moderately high altitudes, which are rich in flowering dicotyledonous plants. The main nectar sources of this species are small Fabaceae species with yellow flowers like *Lotus corniculatus*, *Melilotus* spp. (Varga pers. obs.). Moreover, females should find the small larval food plants in the lower vegetation.

These circumstances can only be maintained under suitable edaphic-microclimatic conditions, e.g. at the rupicolous margin of karstic dolinas and/or by appropriate management. In general, mountain grasslands, however, are prone to succession process without appropriate management. The structure will change due to overgrowth by tall grasses and by the extension of shrubby vegetation. This process has been quite rapid on the higher (about 800–850 m) and more humid (over 800 mm precipitation pro year) Bükk plateau as a consequence of abandoned mowing. Accordingly, *Aricia artaxerxes issekutzi*, which was fairly common in the sixties (Varga pers. obs.) became rare and more localised during the last two decades. Management has started in the last 2–3 years in order to save these populations.

The situation is quite different in the Aggtelek Karst region. Lower precipitation (about 600 mm per year) and the shallow, karstic substrate is associated with an essentially slower succession. As a consequence, a more favourable structure and diversity of vegetation has been maintained in the Karst region than on the Bükk plateau. Both short-grass swards with abundant *Helianthemum ovatum* and xerothermic forest-steppe fringes with *Geranium sanguineum* remained widely distributed. Moreover, these habitat patches compose a kind of network on the Karst plateaus facilitating migration. Thus, *Aricia* populations have remained rather strong there. In contrast, the suitable habitat patches have become much smaller and relatively isolated in the Bükk Mts. The consequence of small population size and isolation is the enhanced effect of genetic drift, which results in an increased probability of allele fixation and loss of rare alleles (Frankham et al. 2002; Allendorf & Luikart 2006 and references therein). We detected both of these symptoms in the Bükk populations.

The level of differentiation was significant among the Hungarian *A. artaxerxes issekutzi* samples. Aagard et al. (2002) also detected significant inhomogeneity among the *A. artaxerxes* populations in the UK and Scandinavia. Assuming the relatively strong effect of genetic drift in the Bükk populations we expected a higher level of differentiation in this region than in the Karst one. Contrary to our presumption, the F_{ST} values indicated a fairly similar level of genetic differentiation in the two regions. This suggests that the size of the Bükk populations has decreased recently, i.e. they have been exposed to the effect of genetic drift for a short period. Though they have lost several rare alleles and a number of loci have become fixed this time period has not been long enough to enhance genetic differentiation among the local populations.

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A review of *Micropterix* Hübner, 1825 from northern and central Europe (Micropterigidae)

H. CHRISTOF ZELLER-LUKASHORT¹, MARION E. KURZ², DAVID C. LEES³ & MICHAEL A. KURZ⁴

¹ Forsthufeld 14, 5303 Thalgau, Austria; e-mail: christof.zeller@gmx.net

² Sportplatzstraße 23, 5303 Thalgau, Austria; e-mail: marion.kurz@gmx.at

³ Department of Entomology, Natural History Museum, Cromwell Road, London SW7 5BD, U.K.; e-mail: dcl@nhm.ac.uk

⁴ Reischenbachweg 2, 5400 Hallein-Rif, Austria; e-mail: michael.kurz@gmx.at

Abstract. All known species of the Palearctic genus *Micropterix* Hübner, 1825 (Micropterigidae) from northern, north-western, central and north-eastern Europe including the Alps are reviewed. The purpose of this review is to permit reliable identification of the genus in this region. Adults, male and female genitalia are illustrated for eighteen species. For these, taxonomy, adult life history (preferred biotopes, phenology and pollination records) and variability is detailed. Distribution is summarized for each species. Treated species are fully diagnosed and also compared with extralimital taxa. The presently known species diversity of *Micropterix* is assessed and a brief synopsis of diagnostic characters for the genus is given in the context of what is known for the family worldwide. A checklist is provided and a key is presented based on adult wing pattern and characters of the male and female genitalia. Advice on genitalic preparation and information about suitable collection sites is also provided.

Introduction

The genus *Micropterix* Hübner, 1825 is distributed in the temperate and subtropical zones of Eurasia, as well as of Northern Africa (Kristensen 1984a). Up to now, 83 species are known (72 have been described), taking into account probable synonymy, of which 49 occur in Europe, 16 additional species in Asia (very few of which reach the eastern Palearctic), and about 17 additional in northern Africa. This makes *Micropterix* by far the most species rich genus of Micropterigidae, a family numbering about 132 described and about 93 undescribed species up to end of 2006 (Kristensen 1999; Hashimoto 2006; Gibbs in litt.). Most of the described species occur in the Mediterranean region, and several undescribed species are to be expected in the mountains of Asia.

It is the purpose of this paper to review eighteen species of the Palearctic genus *Micropterix*. We treat all species known from northern, north-western, central and north-eastern Europe, including Fennoscandia, Great Britain and Ireland, France (including the northern slopes of the Pyrenees), the entire Alps, Hungary, Romania, Slovakia, Poland, Belarus and the Baltic States (Fig. 122). All species are figured in colour, and their genitalia are illustrated. Our focus in this paper is on the aspects of the species most useful for identification, namely wing colour patterns and abdominal morphology, for which we present a key. We also summarise what is known of adult life history and emphasise how little is known of the evolutionary relationships even of European species. We present for now a largely phenetic arrangement of species. In this paper we build on the previous important identification treatments by Heath (1987), Kozlov (1989, 1990a, b) and Whitebread (1992).

Material and methods

For many years the authors have collected specimens of *Micropterix* throughout the western Palaearctic region. These specimens form the basis of the presented study. Furthermore many other specimens, including type specimens from the following museum and private collections have been investigated:

BMNH	British Museum of Natural History, London
CZ	Collection Christof Zeller
HNSA	Museum Haus der Natur, Salzburg
IEUP	Istituto di Entomologia, Università degli Studi, Pavia, Italy
LSUK	Linnean Society, London
MK	Collection Michael Kurz
MNHN	Museum National Histoire Naturel, Paris
MSNM	Museo Civico di Storia Naturale, Milano
MSNV	Museo Civico di Storia Naturale, Verona
NHMK	Landesmuseum für Kärnten, Klagenfurt
NHRS	Naturhistoriska Riksmuseet, Stockholm
NMW	Naturhistorisches Museum, Wien
OLML	Oberösterreichisches Landesmuseum, Biologiezentrum, Linz
SMNK	Staatliches Museum für Naturkunde, Karlsruhe
TLMF	Tiroler Landesmuseum Ferdinandeum, Innsbruck
USNM	Smithsonian National Museum of Natural History, Washington
ZMHB	Museum für Naturkunde, Humboldt-Universität zu Berlin
ZMUC	Zoological Museum, Copenhagen
ZSM	Zoologische Sammlung des Bayerischen Staates, München

Collection sites. Best collection sites are boundaries of shrub vegetation and woodland, where the adults gather on flowering vegetation often very locally, but often also in great abundance. The specimens fly only short distances, but can frequently be found crawling around pollinating many different blossoms. Some species prefer herbaceous plants, others shrubs or trees. In the southern latitude or lower elevation areas *Micropterix* were more usually found in shaded areas than areas exposed to full sunshine; in more northern latitudes, they often occur in open sunny areas. At a given locality, adults aggregate usually on a limited range or even only a single plant species. At higher elevations some species can often be found around elfin woodland, feeding on the pollen of *Pinus mugo* Turra. Ecologically more specialized species inhabit marshes, dwarf vegetation, open grassland or alpine meadows. In the Mediterranean, specimens often rest on the underside of leaves or in shady places during the hottest hours of the day, being active mainly in the morning and in the evening. In woodland, specimens may be active throughout daytime.

The adults are attracted to flowers of the following gymnosperm and angiosperm (monocot and dicot) plant families and genera or species (Adler et al. 1994; Kozlov 2006; Pankhurst 1999; Schwartz-Tzachor 2004; Zeller-Lukashort, Kurz & Kurz 2006; Helmut Deutsch, Markus Fluri, Peter Huemer, Utsugi Jinbo, all pers. comm.; this work): Pinaceae (*Pinus mugo* Turra), Ranunculaceae (*Caltha palustris* L., *Actaea spicata* L., *Ranunculus* spp.), Caryophyllaceae (*Lychnis flos-cuculi* L., *Stellaria holostea* L.), Fagaceae (*Fagus sylvatica* L. (pollen on leaves, not flowers), *Quercus* spp.), Urticaceae

(*Urtica dioica* L.), Brassicaceae (*Cardamine pratensis* L.), Sapindaceae (*Acer pseudo-platanus* L.), Rosaceae (*Aruncus dioicus* (Walter) Fernald, *Crataegus* sp., *Filipendula ulmaria* (L.) Maxim., *Rosa pendulina* L., *Rosa canina* L. agg), Fabaceae (*Spartium junceum* L., *Vicia* sp.), Euphorbiaceae (*Mercurialis perennis* L.), Apiaceae (*Heracleum* sp.), Cistaceae (*Helianthemum* sp., *Cistus salvifolius* L.), Ericaceae (*Rhododendron ferrugineum* L., *Vaccinium* sp.), Pyrolaceae (*Pyrola* sp.), Primulaceae (*Cyclamen persicum* Mill.), Rubiaceae (*Galium* sp.), Scrophulariaceae (*Veronica chamaedrys* L.), Plantaginaceae (*Plantago media* L.), Oleaceae (*Fraxinus ornus* L., *Olea europaea* L., *Syringa vulgaris* L.), Caprifoliaceae (*Sambucus nigra* L., *Lonicera xylosteum* L.), Liliaceae (*Paris quadrifolia* L.), Orchidaceae (*Dactylorhiza romana* (Sebast & Mauri) Soó), Cyperaceae (*Carex* spp.) and Poaceae.

External characters used for identification. Forewing markings and the colour of the scales of the head are the external characters used for the identification of the *Micropterix* species dealt within this paper. The colouration of the wings is solely due to the physical properties of the wing scales (which are of the ‘fused’ type and on the upper surface as in other lower grade Lepidoptera). Wing pattern is dominated by a combination of metallic golden, silvery and purplish elements. The basic marking scheme on the forewing seems to be a purplish ground colour with three transverse golden fasciae. This basic scheme is modified in many ways, such as by additional spots and fasciae, or by shifting the purplish ground colour to a golden one and the colour of the fasciae varying to a whitish or silvery one. Although of great importance for identification, forewing markings do vary to a significant degree. This variation seems to be not only genetically determined, but may be influenced by local habitat conditions, as discussed below under Life history, and on a geographic basis according to metapopulation structuring (Kozlov 1995). We include several instances here of local, geographically distinct colour morphs (see e.g. *Micropterix paykullella* (Fabricius, 1794), *Micropterix aruncella* (Scopoli, 1763)). Schematic wing drawings used in the identification key are encoded as given in Fig. 1.

	brownish golden - purple - bluish violet
	reddish golden - coppery
	bronzy golden - greenish golden
	golden
	whitish golden - silvery

Fig. 1. Code of schematic wing drawings.

Anatomical characters used for identification. Several anatomical details, presenting valuable characters in some other lepidopterous families, like wing venation or number and size of spurs on the legs, are not useful for species identification in the genus *Micropterix*. Male genitalia are very characteristic in this genus and always present sufficient details for a reliable specific identification. Female genitalia, although less useful, sometimes yield useful exoskeletal characters on segments IX and X, and to some extent from the shape and length of the receptaculum seminis. Nevertheless, in

some cases, the geographical distribution has also to be considered, since many similar species are allopatric or endemic to a relatively small area. The main features of male and female abdominal characters are explained in Figs 2 and 3.

Preparation techniques (genitalia preparation). The whole of the abdomen is removed and then transferred to a 10%-solution of caustic potash. By gentle shaking, the solution is heated until the abdomen becomes transparent and the 'soft tissues' have been completely dissolved. After rinsing the abdomen with water, it can be transferred to a drop of a 7:3 mixture of water and glycerol on a micro slide. The preparation should be as clean and devoid of scales as possible when inspecting it under 20–30 fold magnification. Most drawings and many photos of the female genitalia have been made in this stage of preparation, since the receptaculum seminis may be recognized very well now. Details of sclerotized parts have been added to the drawings using permanent preparations.

For determination purposes only, it is normally not necessary to remove the sclerotized parts or the phallus from the male genitalia. Also it is not necessary to stain the preparation, since all diagnostically important characters are strongly sclerotized. Therefore the preparation can be transferred to 96% ethanol for at least 15 minutes and afterwards mounted in Euparal in lateral position. For this purpose, the genitalia are first fixed in a drop of Euparal overnight before the cover slip is brought into position with a second drop of Euparal. With this technique, squeezing the genitalia can be avoided best. For taxonomical studies it may be necessary to remove the sclerotized parts and the phallus, to choose another position than the lateral one or to squeeze the genitalia (especially when investigating the spinoid (thickened) setae of the accessory claspers).

When preparing female genitalia, it is important to know that the inner structures of the abdomen are not sclerotized at all. Removing the pregenital exoskeleton and staining the preparation is therefore not advisable, because dehydration during the process strongly deforms the receptaculum seminis. Furthermore sternum IX may be damaged, which is important for some species identifications. After rinsing the preparation with water, the following procedure can therefore be used for the mounting of the female genitalia. Firstly, the last two segments of the abdomen, forming a short, retractable ovipositor, are expanded carefully. These segments must not be damaged. A micro-pipette, that has been drawn above a flame to a very fine tip is connected to a rubber tube with a mouth-part and filled with a dispersion of chlorazol black in water. Then the tip of the pipette is inserted into the abdomen up to segment VI or VII, beginning at the proximal end. A tiny amount of the stain suspension is now injected by gentle pressure. In this way the receptaculum seminis may be stained blue without opening the exoskeleton. This also helps to avoid distortion of the membranous receptaculum seminis when dehydrating the preparation with 96% ethanol. Finally the preparation is transferred to Euparal and mounted in the usual way. A lateral position fits the natural flattening of the abdomen, although for investigation of sternite IX a dorso-ventral mounting is to be preferred.

Data archives. The data of all investigated specimens have been archived in a database, which is accessible via internet: <http://www.nkis.info/nkis/auscollabfrage.cgi?uid=guest&lang=e> (Kurz et al. 2000–2007). To create a list, just input "Micropterix" into field "Scientific name" and click on Button "Search". Each specimen has been labelled with a unique identification (ID) number representing the record number of the

database. With this ID-number, the data of each specimen can be checked individually on www.nkis.info, menu “DATA ANALYSIS”. Furthermore, these records, together with original life observations, contribute to dynamically generated distribution maps. Analyses concerning phenology, vertical distribution, biotope preferences, interactions with other organisms and many others can be generated in a similar way. All these statistics are generated from original data and do not present literature compilations, although reliable literature records may to a small extent contribute to the original data. In any case, data are tagged as to whether they originate from investigated specimens, from living observations or from literature records.

Results

Micropterix Hübner, 1825

Micropterix Hübner, 1825 b: 426. Type species: *Tinea podevinella* Hübner, 1813, by original designation. *Micropteryx* Zeller, 1839: 185 (unjustified emendation).

Eriocephala Curtis, 1839: pl. 751. Type species: *Phalaena (Tinea) calthella* Linnaeus, 1761, by monotypy.

Microptericina Zagulajev, 1983: 113. Type species: *Micropteryx amasiella* Staudinger, 1880, by original designation.

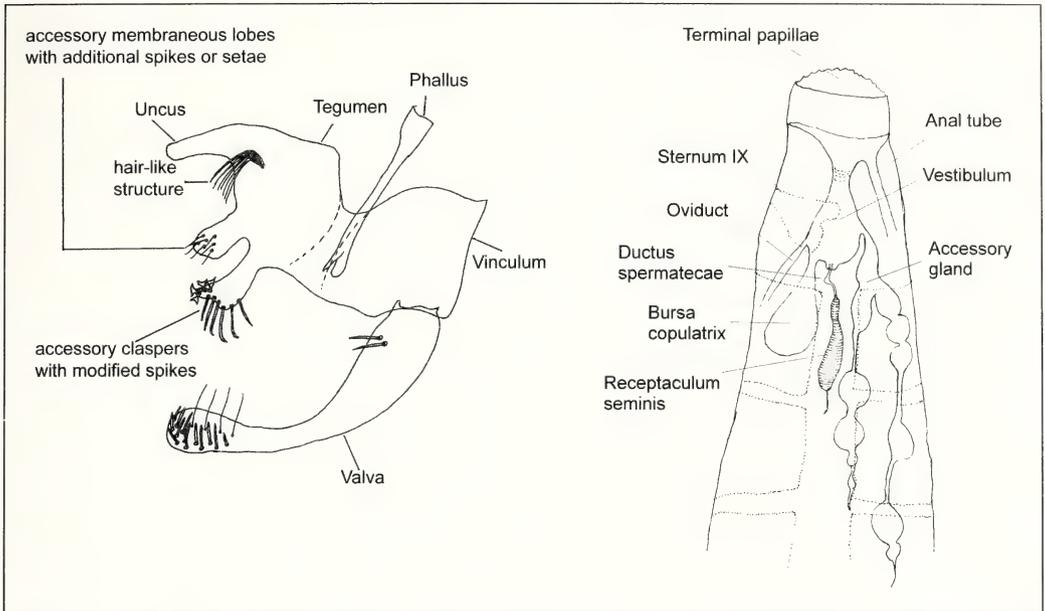
The genus *Micropterix* has been suggested to represent the sister group of all other members of the basalmost group of extant Lepidoptera (e.g. Kristensen 1984a; Kristensen & Nielsen 1979), the Zeugloptera [= Micropterigidae Herrich-Schäffer, 1855] notably on the basis of its complete lack of a hindwing vein R and retention of minute remnants of the eighth abdominal sternite in males (Kristensen 1998: 43; Hashimoto 2006: 58). However, the support for this placement was soon questioned (Kristensen & Nielsen 1982) and is now definitely known to be spurious (Skalski 1995; Davis et al., unpubl.), as is also strongly indicated by preliminary analyses of 16S_rRNA molecular data (Kobayashi et al. 2002; Gibbs et al. 2004; Hashimoto 2006). The phylogenetic position of this genus within the family Micropterigidae is still quite unclear, but while it is subordinate within the hierarchy of extant taxa, it is at least clearly external to the group comprising the other Northern Hemisphere members. There are 11 currently recognized genera in the family (including those recently described by Hashimoto (2006), but disregarding undescribed genera of which a number will be needed to render *Sabatinca* Walker, 1863 monophyletic). *Micropterix* shares with most or all of these genera the presence of fully functional, asymmetrical mandibles (with apical incisor cusps only on the left mandible), and presence of antennal ascoid type sensilla (see Kristensen, 1984a: 154 for a list of another eight characters synapomorphic for Micropterigidae). Movable mandibles are not, however, unique to Micropterigidae, also occurring in the primitive genera *Agathiphaga* and *Heterobathmia*. The use of mandibles for crushing pollen or fern spores, combined with the presence of filtering structures in the mouth cavity, appears thus to have been lost independently in ancestors of *Agathiphaga* (where the mandibles are functional only in the pharate adult) and Glossata (Kristensen & Skalski 1998). There is little doubt also that all the taxa currently placed within *Micropterix*

constitute a natural group (excluding for now fossil taxa, notably *Micropterix anglica* Jarzembowski, 1980, whose fragmentary forewing venation but not probable palaeoenvironment is consistent with extant members of this genus, or any Baltic amber material that require reassessment).

The genus *Micropterix* has at least three derived traits: (1) in the wing venation all Rs branches run to the costa; (2) the male tergum I has a special muscle set inserting on an anteromedial longitudinal costa; and (3) the male abdominal segment IX has specialized dorsomedian and dorsolateral processes (Kristensen & Nielsen 1979). Also, more weakly (4) forewing R is unforked, but this trait occurs in other Northern hemisphere genera; (5) the dorsal part of the female abdominal sternite IX ring is unsclerotized (Kristensen & Nielsen 1982: 514); (6) *Micropterix* has lost the basal trait attributed to the Amphiesmenoptera of sternal V glands, although this loss has also happened elsewhere among the Micropterigidae (Kristensen 1984: 128) and (7) apyrene type of sperm is absent (so far checked in just a single species, Kristensen 1999).

Diagnosis. A number of features are plesiomorphies widespread in other homoneurous moths: head rough scaled, densely covered; ocelli prominent (as in all extant micropterigid genera); maxillary palpi long, with 5 segments, folded (as e.g. in eriocraniids). Other characters are more or less characteristic of Micropterigidae: full complement of sulci present on head; lacinia present, cardo irregular, longish; labial palpi shortened (2-segmented in *Micropterix* as in most micropterigids), with a sensory concavity (Von Rath's organ) on the basal segment; antennal sensillae (including branched 'ascoid' basiconic type as also in Opostegidae) on all segments except the two basalmost ones and the distalmost one; mandibles present and fully functional in both pupa and adult; fore tibia with epiphysis; spur formula 0-0-2 as in other micropterigids (absence of mesotibial spurs shared uniquely with Heterobathmiidae); forewing with jugum, hindwing with a row of non-coupling subcostal frenulum bristles. The *Micropterix* species of northern and central Europe, considered in this paper, have a wingspan of 5–12 mm; antennae are filiform or sub-moniliform, from 1/2 to almost forewing length, wing colouration is metallic shining, with two principal colour patterns only: golden with or without silvery spots and fasciae, or more or less purplish with golden spots and fasciae (Heath 1983; Scoble 1995; Kristensen 1999). The radial vein is unbranched in forewing as in "*Micropterix*" *anglica*, "*Sabatınca*" *porphyrodes*, and most E. Asian micropterigids (Hashimoto 2006) and the abdominal sternal V glands are absent, inferred lost, as occasional in a few tropical taxa such as *Hypomartyria* (Kristensen 1984b).

Morphology of adults. The exoskeletal and internal adult morphology of the species *Micropterix calthella* (Linnaeus, 1761) has been more or less intensively studied and readers are referred here to a few principal works. Very little is known of the detailed morphology of other species in the genus. For characteristics in wing venation, see for example Hashimoto (2006). Internal thoracic musculature of *Micropterix aureatella shikotanica* Kozlov, 1988 was treated by Kozlov (1986), whilst Kristensen (1984b) treated in detail the abdominal musculature and chordotonal organs of *M. calthella*, whose head musculature is described by Hannemann (1956). Kristensen (1984c) also treated the respiratory system of *M. calthella*. Sensillae of antennae and palps were described by Le Cerf (1926). Mouthpart sensillal ultrastructure of



Figs 2–3. Characters of genitalia referred to in the descriptions. 2. ♂. 3. ♀ (according to Kristensen in litt.).

M. calthella was described in more detail by Chauvin & Faucheux (1981). In this paper, we focus on wing pattern and comparative features of abdominal sclerites and genitalia of Palearctic species.

Adult *Micropterix* have a forewing length of about 1.5–7 mm. On the head they bear a vestiture of hair-like scales, which, in most cases, are more or less yellow coloured, but sometimes may be dark brown or even black. The antennae of males are significantly longer in males, reaching $2/3$ – $7/8$ of the forewing length, whereas in females their length is only $1/2$ – $2/3$ of the forewing length. The forewings show a pattern of golden and usually, also purple to violet markings, which are often very species-specific. The hindwings are devoid of any markings, more or less bronzy golden with the apex tinged purple.

Pregenital abdomen. The pregenital abdomen consists of eight well developed segments. In both genders, the sclerites of segments I and II are heavily modified in shape, but the intraspecific variation of these characters is too great to be used for species-identifications. Also not useable for that purpose are all other segments including segment VIII, although sternites III–VI, as well as tergites VI–VIII often bear heavily sclerotized cross-ridges, or, seldom, a reticulate structure. In males, sternite VIII is always reduced to two tiny sclerotized platelets.

Male genitalia. Segments IX and X form the core of the genitalia, which are not retractable into the abdomen. In a few species like *Micropterix mansuetella* Zeller, 1844, the two complexes consisting of vinculum and valvae on the one hand and uncus, tegumen and two pairs of accessory claspers on the other hand, are clearly separated from each other. In most species however, the two parts are fused. Besides uncus and valvae, which are common in most other Lepidoptera, two additional clasping structures can be developed on the posterior margin of the tegumen. In *Micropterix aureatella* (Scopoli,

1763) and its relatives, both clasping structures (Fig. 2) are developed and bear normal, hair-like (hereafter “unmodified”) or bristle-like/stout (hereafter “spinoid”) setae (Fig. 123). In *Micropterix aruncella* (Scopoli, 1763) and its relatives the upper pair is developed prominently, whereas the lower pair (called accessory claspers) is more or less atrophied. In most other species of *Micropterix*, the upper pair is reduced or completely obsolete, whereas the accessory claspers are well developed.

The accessory claspers normally bear up to 3 groups of thickened setae (Fig. 124) which may be on the inner surface. Often these setae are highly modified into T- or Y-shapes (Fig. 125).

The valvae also bear spinoid setae, but these are not modified.

The phallus, describe in detail by Hannemann 1957, is somewhat enlarged at its base and shows a delicate inner structure at the posterior end. Nevertheless, these structures are not informative at species level.

Female genitalia. Segments IX and X are normally retracted into the abdomen in order to form a short ovipositor. Tergite IX is obsolete with the exception of *M. mansuetella*, where a minute fragment is left. In all other cases so far investigated only a group of setae is left instead of the tergite. Sternite IX is also reduced and modified in shape in females and, despite a reasonable intraspecific variability, often of shape informative at species-level (for example this more or less strongly sclerotized plate may show concavities at its proximal margin, or form a complete ring fused at the dorsum). Two lateral setose sclerites constituting the discrete segment X of Micropterigidae, form the terminal papillae, and form a more or less an evenly wide ring. In some cases, they also can contribute to species identification. The diagnostic features of segments IX and X are discussed in the species descriptions. The internal parts of the female genitalia are not sclerotized at all. Therefore most structures are of no value for recognizing species. Only the receptaculum seminis is distinctly cross-striated and in many cases its shape and length can contribute to species identification (Fig. 3).

Morphology of preimaginal stages (Heath 1983; Hashimoto 2006).

E g g . The eggs are oval, about 0.38×0.24 mm to about 0.53×0.43 mm (Heath 1962), translucent white with rod like structures of variable length. The eggs are deposited between the vegetation on the soil.

L a r v a . The body is elongate or barrel-shaped, whitish grey to dark grey, body length 2.5–4.5 mm; the head is almost twice as long as broad; the antennae are well developed, 3-segmented and bear a seta on their ends; they are almost as long as the width of the head; head and prothorax can be retracted into meso- and metathorax; the thoracic legs have only three free segments; the abdominal legs consist of a pair of conical appendages, bearing claws similar to the thoracic legs; the anal sucker is trilobed; each segment bears four longitudinal ridges with eight rows of paired, scale-like setae.

The larvae have been assumed to feed on small pieces of rotten leaves or perhaps fungal hyphae although observations such as collections of larvae from tussocks of *Dactylis glomerata* (Poaceae) have been tenuous (Scoble 1995: 194), but *M. calthella* and *M. aruncella* have been recorded to eat *Stellaria* spp. (Caryophyllaceae) or other angiosperm tissue in captivity although they refused mosses or liverworts (Carter & Dugdale 1982). They have been found in the soil at a depth of 10 cm in stony woodland

soil (Heath 1983) and those of *M. aureatella* have been found in a range of leaf litter where they could feed on fungal mycorrhizae (Carter & Dugdale 1982). There would appear to be only three instars (Heath 1983).

Pupa. Body length is about 2.5mm; the mandibles usually conspicuous and functional (Mosher 1916); the head and thorax with long bifurcate setae; the first seven abdominal segments are movable and the appendages are not fused to the body (Scoble 1995); the pupa rests within a tough silken cocoon. There is a nice drawing of the pupa of *M. calthella* in Lorenz (1961).

Life history. The adult moths feed on the pollen of many different plants (already detailed), and they cluster gregariously on flowers, especially on easily accessible blossoms, rather than searching for pollen grains on leaves as for example some syrphid flies. It has been demonstrated that in some cases the pollination is successful (Schwartz-Tzachor et al., 2004): e.g. in Israel, *Micropterix berytella* de Joannis, 1886 and *Micropterix elegans* Stainton, 1867 are, besides species of thrips, bees and flies, the most important pollinators of *Cyclamen persicum* Miller. For *Micropterix*, blossoms are also mating sites (Kozlov & Zvereva 2006). We have observed that copulation often lasts only a few seconds. No *Micropterix* are known to feed on fern spores as do some other micropterigid lineages in North America (Tuskes & Smith 1984) and in the Southern Hemisphere (e.g. '*Sabatinca*' *porphyrodes*; Gibbs, pers. comm.), but pollen is also known as a food source for New Caledonian *Sabatinca* sensu stricto (Thien et al. 1985) and for some Australian micropterigids (Common 1990: 130).

The biotope preferences of most species have been insufficiently studied so far, but a certain constancy of soil humidity seems to be necessary for the development of the larvae, which are apparently usually detritus-living or subterranean. Therefore, the genus inhabits biotopes with higher humidity like woods and scrubland, but also moors and moist meadows, especially places where the soil is moist, whereas only few species are able to live in dryer regions. Furthermore, some correlation between the colouration of the forewing and the biotope seems to exist. Species, inhabiting wood- and bushland, i.e. places with less solar insolation, are primarily purplish to violet with golden markings, whereas species living in open habitats are more reddish golden to golden coloured without darker wing markings. Due to the higher reflection rate, such golden animals are less susceptible to overheating in direct sunlight. It is also suggested (Kozlov 1985) that visual cues are important in the absence of sternal V glands and lack of apparent pheromonal communication (despite suggestion to this effect by Pringruber (1944)) and so this could explain the bright shiny scale colours that could be the cues for conspecific aggregation irrespective of sex.

The adults of *Micropterix* are active in sunshine, although sometimes they may come to light. Depending on latitude and elevation, they swarm during a period of two or three weeks in a single generation any time from late January (southern Mediterranean area, e.g. Israel) to August (highest sites in the Alps). The actual flight period only lasts a few weeks in any locality, but the individual lifespan is poorly known. According to an experiment to prove the pollination of *Cyclamen persicum* Miller in Israel, *M. elegans* and *M. berytella* were kept in captivity for four or five days before they died (Schwartz-Tzachor, pers. comm.).

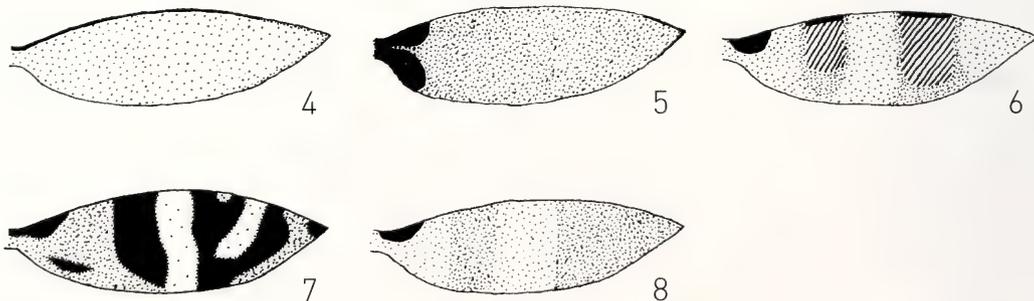
Micropterix is one of two genera of Micropterigidae (Gibbs, unpublished) with a larva that typically lives in the leaf litter zone where it may even feed on fungal hyphae as well as a probably wide range of plant material that includes living angiosperm leaf tissue and are the only micropterigids known to do so (Lorenz 1961; Carter & Dugdale 1982). Despite the diversity of species in Europe, it is remarkable that almost nothing still is known about the early stage life history, and apart from descriptions of eggs laid by females, there is knowledge only about the larva and pupa of *M. aruncella* and *M. calthella* (and larva of *M. aureatella*), for which remarks below apply.

Phylogenetic relationships. Up to now no consensus hypothesis has emerged as to the phylogenetic relationship of species within the genus *Micropterix*. The authors have identified several morphological characters, which are assumed to be autapomorphies of recognized species groups (unpublished results). This has led to an ordered arrangement of species that has been used in this paper, although for the time being this arrangement must be regarded as provisional and partly phenetic. Further studies, including DNA investigations performed by the authors will hopefully improve the presented picture.

Key to the species

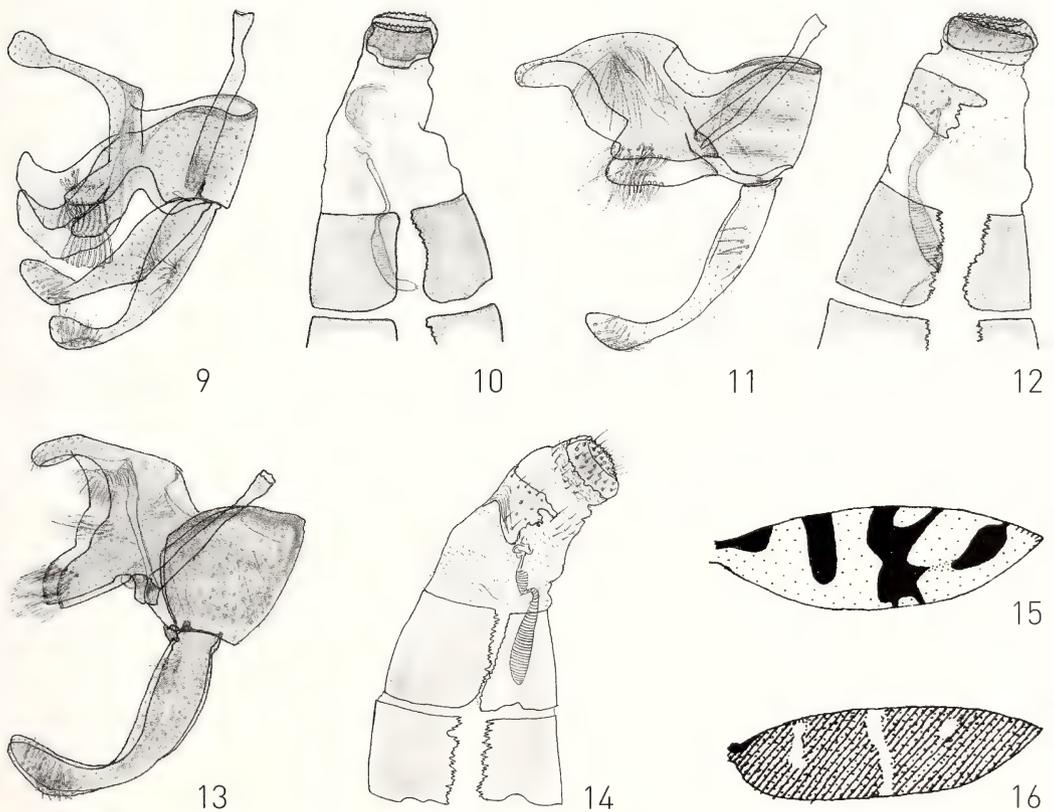
The key is based on characters observable without dissection, as far as possible.

- | | | |
|-----|---|-----------------------|
| 1 a | Forewings uniformly golden (Fig. 4), or with only minute reddish to violet markings (Fig. 5, 8) | 2 |
| 1 b | Forewings different (Figs 6, 7) | 6 |
| 2 a | Hair-like scales of head black, forwing markings see Figs 6, 8 | <i>M. mansuetella</i> |
| 2 b | Hair-like scales of head yellow to dark brown | 3 |
| 3 a | Base of forewing purple from costa to inner margin (Fig. 5) | <i>M. calthella</i> |
| 3 b | Only base of costa slightly purple; three taxa distinguishable only by genitalia examination (Fig. 4) | 4 |



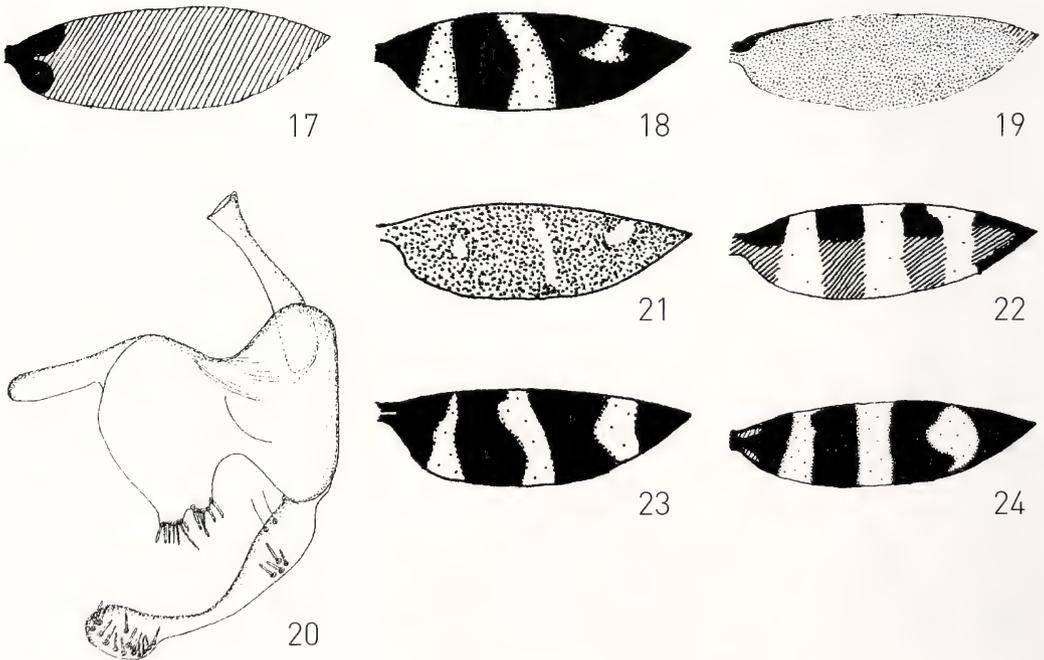
Figs 4–8. Illustrations for the “Key to the species”: Schemes of forewing drawing, ♂ genitalia and ♀ abdomen of *Micropterix*. **4.** *M. isobasella*. **5.** *M. calthella*. **6.** *M. mansuetella*. **7.** *M. osthelderi*. **8.** *M. mansuetella*.

- 4a male genitalia: membranous lobe between accessory claspers and uncus prominent (Fig. 9); female genitalia: sternite IX much reduced, almost interrupted in the middle (Fig. 10); males without silvery markings known from Sardinia ***M. aruncella***
- 4b male or female genitalia different **5**
- 5a male genitalia: segments IX (tegumen) and X (uncus, accessory claspers) completely fused, accessory claspers with sickle-shaped spines (Fig. 11); female genitalia: not distinguishable from *M. isobasella* with certainty (Fig. 12); normally the species is deep purple violet, a golden form without markings is known only from high altitudes in the south western Alps (Marguareis), flying together with more or less marked specimens ***M. paykullella***
- 5b male genitalia: segments IX and X distinctly separated from each other (Fig. 13); female genitalia: not distinguishable from *M. paykullella* (Fig. 14); distribution confined to southern Switzerland (Simplon) and adjacent regions of northern Italy at high altitudes ***M. isobasella***
- 6a Forewings golden with extended purple markings, often more or less diffuse (Figs 6, 15) **7**
- 6b Forewings reddish, coppery (Fig. 16), purple or deep violet with silvery or golden markings (Fig. 7) **9**
- 7a Hair-like scales of head black, forewing markings see Figs 6, 8 ***M. mansuetella***
- 7b Hair-like scales of head yellow to brownish **8**



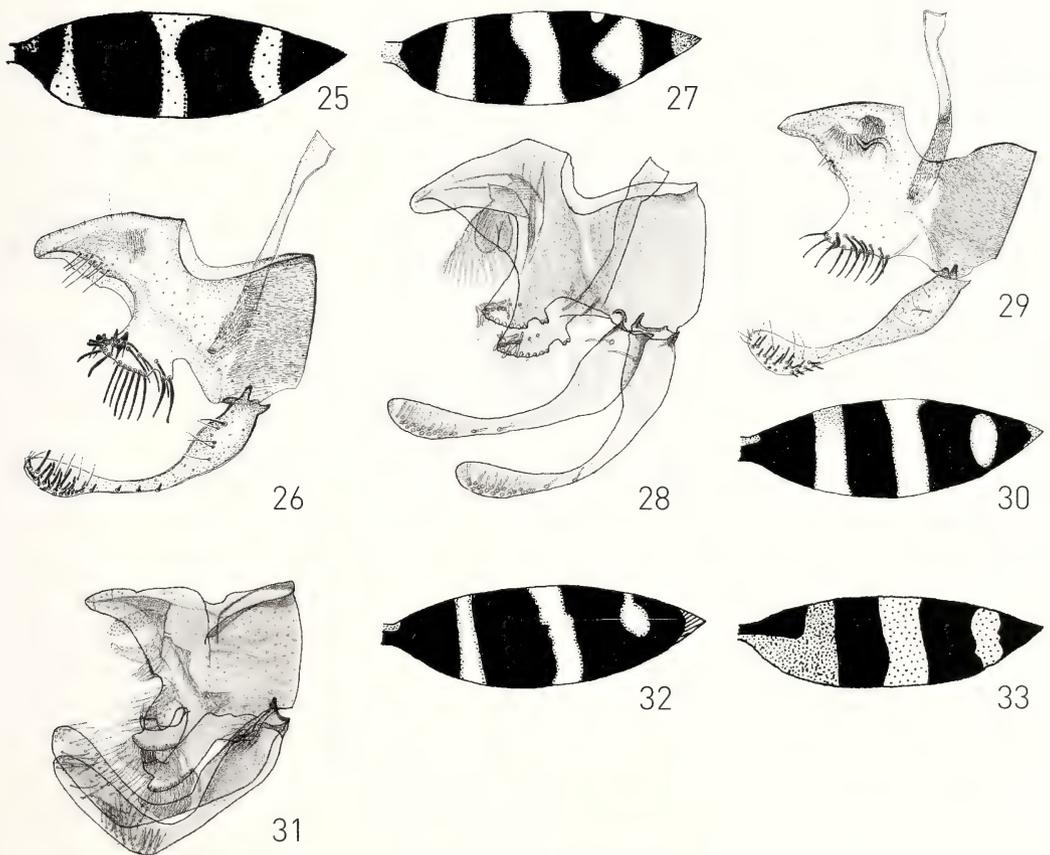
Figs 9–16. 9–10. *M. aruncella*. 11–12. *M. paykullella*. 13–14. *M. isobasella*. 15. *M. tunbergella*. 16. *M. aruncella*.

- 8a Base of forewing purple from costa to inner margin, other markings more or less diffuse (Fig. 17) *M. calthella*
- 8b Base of forewing not extensive purple; purple fascia in the centre of the wing distinctly forked at costa, embedding a small golden costal spot (Fig. 15) *M. tunbergella*
- 9a Forewings bronzy golden or coppery with more or less distinct silvery markings (Figs 16, 21); two taxa distinguishable in the male sex only by genitalia examination **10**
- 9b Forewings reddish, brownish golden, purple to purple violet with more or less distinct light golden to bronzy golden wing markings (Figs 7, 18) **11**
- 10a Males: lobes between uncus and accessory claspers prominent, accessory claspers spatulate (Fig. 9); females: without silvery wing markings (Fig. 19) *M. aruncella*
- 10b Males: lobes between uncus and accessory claspers missing; accessory claspers very prominent (Fig. 20, after Heath & Kaltenbach 1984); Females: silvery wing markings distinct; distribution confined to Alpi Cozie (Fig. 21) *M. fenestrellensis*
- 11a Small species: wing expanse less than 6.5 mm **12**
- 11b Larger species **13**
- 12a Forewings with three broad transverse fasciae reaching from costa to inner margin (Figs 22, 23) *M. rablensis*
- 12b Forewings with two broad transverse fasciae reaching from costa to inner margin and an outer prominent costal spot, reaching only to the middle of the wing (Fig. 18) *M. myrtetella*
- 13a Forewings with three transverse fasciae reaching from costa to inner margin; a small costal spot may be present (Figs 24, 25) **14**
- 13b Forewings with additional or other wing markings (Fig. 7) **17**
- 14a Outer transverse fascia triangular and extremely broad (Fig. 24) **15**



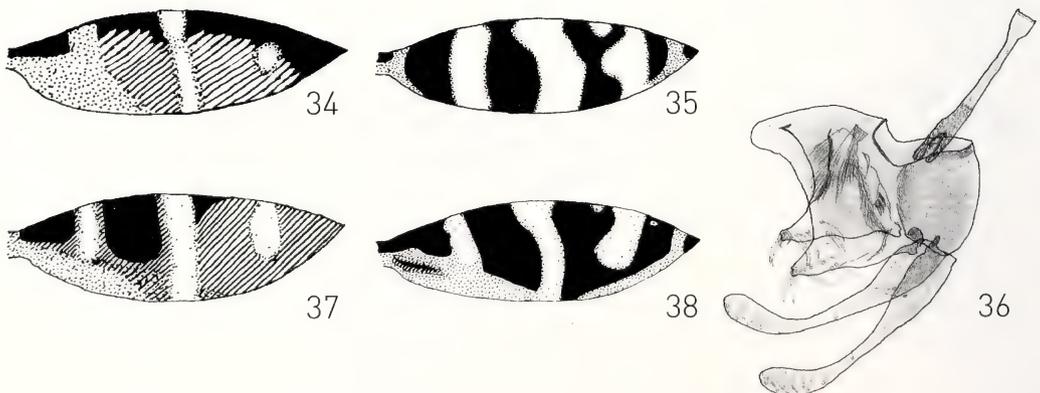
Figs 17–24. 17. *M. calthella*. 18. *M. myrtetella*. 19. *M. aruncella* ♀. 20–21. *M. fenestrellensis* (♂ genitalia after Heat & Kaltenbach 1984). 22–23. *M. rablensis*. 24. *M. trifasciella*.

- 14b Outer transverse fascia narrower, sometimes not completely reaching costa or inner margin (Fig. 25) 16
- 15a Small costal spot normally absent (Fig. 24); male genitalia: accessory claspers slightly shorter and broader; spines beyond uncus normally present (Fig. 26); female genitalia: not distinguishable from *M. allionella*; distribution confined to a small region in the French-Italian border area *M. trifasciella*
- 15b Small costal spot normally present, often remnants of a bronzy golden outer margin also present (Fig. 27); male genitalia: accessory claspers slightly longer and smaller (Fig. 28); female genitalia: not distinguishable from *M. trifasciella* *M. allionella*
- 16a Outer transverse fascia always reaching costa and inner margin (Fig. 25); male genitalia: lobes between uncus and accessory claspers completely atrophied (Fig. 29); female genitalia: unknown; distribution confined to high altitudes in the south western Alps (only known from type locality Marguareis) *M. huemeri*
- 16b Outer transverse fascia normally not reaching costa and inner margin (Fig. 30); male genitalia: lobes between uncus and accessory claspers distinctly developed (Fig. 31); female genitalia: receptaculum seminis moderately long) *M. aureatella*
- 17a Posterior margin not bronzy golden (Fig. 32), or if bronzy golden, this colouration not extending to fascia at 1/2 (Fig. 33) 18



Figs 25–33. 25. *M. huemeri*. 26. *M. trifasciella*. 27–28. *M. allionella*. 29. *M. huemeri*. 30–32. *M. aureatella*. 33. *M. aglaella*.

- 17b Posterior margin more or less distinctly bronzy golden from base to fascia at 1/2 (Fig. 7) **22**
- 18a Forewings markings: Two transverse fasciae at 1/4 and 1/2 and an outer spot, often almost reaching costa and posterior margin (see also 13) (Fig. 32) *M. aureatella*
- 18b Additional markings developed (Figs 33, 27) **19**
- 19a Posterior margin without any bronzy golden area; outer transverse fascia very broad and triangular, extending across the whole wing width (Fig. 27) **20**
- 19b Posterior margin with bronzy golden area (Fig. 33), sometimes almost reaching fascia at 1/2 (Fig. 34); outer transverse fascia narrower, often not extending across the whole wing width and normally not triangular **21**
- 20a Transverse fasciae extremely broad, sometimes fused with costal spot; outer bronzy golden margin well developed (Fig. 35); male genitalia: accessory claspers broad triangular, proximal spines not on a separate stylus (Fig. 36); female genitalia: not distinguishable from *M. allionella* *M. rothenbachii*
- 20b Transverse fasciae at 1/4 and 1/2 smaller; outer bronzy golden margin often reduced (especially males) (Fig. 27); male genitalia: accessory claspers not broad triangular, two proximal spines on a separate stylus (Fig. 28); female genitalia: not distinguishable from *M. rothenbachii*, *M. allionella*
- 21a Bronzy golden wing base almost extending to fascia at 1/2 at posterior margin; outer margin of the bronzy golden area and fascia at 1/2 therefore not parallel (Fig. 34) *M. paykullella*
- 21b Bronzy golden wing base not extending towards fascia at 1/2; outer margin of the bronzy golden area and fascia at 1/2 therefore parallel (Fig. 33) *M. aglaella*
- 22a Ground colour often more or less reddish, light golden markings often indistinct; small costal spot missing (Fig. 37) *M. aureoviridella*
- 22b Ground colour distinctly purple to bluish violet; markings distinctly golden; small costal spot always present) (Fig. 7) **23**
- 23a Inner transverse fascia light golden in its centre above bronzy golden inner margin (Fig. 38) *M. schaefferi*
- 23b Inner transverse fascia and inner margin completely bronzy golden (Fig. 7) *M. osthelderi*



Figs 34–38. 34. *M. paykullella*. 35–36. *M. rothenbachii*. 37. *M. aureoviridella*. 38. *M. schaefferi*.

Checklist of northern and central European species

- Micropterix mansuetella* Zeller, 1844
= *Lampronia ammanella* (Hübner, 1813) sensu Wood, 1839
- Micropterix calthella* (Linnaeus, 1761)
= *Tinea urticella* Costa, 1834
= *Eriocephala sulcatella* Bentley, 1845
= *Micropteryx silesiaca* Toll, 1942
- Micropterix isobasella* Staudinger, 1871
- Micropterix aglaella* (Duponchel, 1838)
- Micropterix aureatella* (Scopoli, 1763)
= *Tinea paykullella* Thunberg, 1794
= *Tinea ammanella* Hübner, 1813
- Micropterix aruncella* (Scopoli, 1763)
= *Tinea seppella* Fabricius, 1777
= *Tinea podevinella* Hübner, 1813
= *Lampronia concinnella* Stephens, 1834
= *Micropteryx eximiella* Zeller, 1850
= *Eriocephala atricapilla* Wocke, 1877
= *Micropteryx nuraghella* Amsel, 1936
- Micropterix tunbergella* (Fabricius, 1787)
= *Tinea helwigella* Hübner, 1805
= *Tinea rubrifasciella* Haworth, 1828
= *Micropteryx depictella* Herrich-Schäffer, 1851
- Micropterix aureoviridella* (Höfner, 1898)
= *Micropterix liogierella* Réal, 1987
- Micropterix paykullella* (Fabricius, 1794)
= *Tinea anderschella* Hübner, 1813
= *Micropterix paykullella* [sic!] f. *rosarum* Müller-Rutz, 1927
- Micropterix allionella* (Fabricius, 1794)
= *Tinea tricinctella* Costa, 1836
- Micropterix trifasciella* Heath, 1965
- Micropterix rothenbachii* (Frey, 1856)
= *Micropterix australis* Heath, 1981a
= *Micropterix vallebonnella* Réal, 1988
- Micropterix huemeri* Kurz, Kurz & Zeller, 2004
- Micropterix schaefferi* Heath, 1975
= *Micropteryx anderschella* (Hübner, 1813) sensu Herrich-Schäffer, 1851
- Micropterix osthelderi* Heath, 1975
- Micropterix fenestrellensis* Heath & Kaltenbach, 1984
- Micropterix rablensis* Zeller, 1868
- Micropterix myrtetella* Zeller, 1850

Micropterix mansuetella Zeller, 1844

Micropterix mansuetella Zeller, 1844: 16. Type locality: "Groß-Glogau" (now: Glogów, Poland).
Lectotype: in coll. BMNH.

Lampronia ammanella (Hübner, 1813) sensu Wood, 1839: 231, pl. 50.

Misidentification.

Description of adults. Examined: 9♂, 10♀. Forewing length: ♂ 3.4–3.9 mm; ♀ 3.8–4.2 mm. Head black; vestiture of hair-like scales on the head black-brown to black, golden fuscous; antennae 4/5 (♂), respectively, 1/2 (♀) of forewing length, dark brown at base, distal parts lighter brown, golden fuscous; thorax dark golden, prothorax posteriorly with purple and bluish scales; tegulae purple, posteriorly edged bluish; forewing golden with bronzy golden to reddish golden pattern, especially in the southern part of the species' geographic range the reddish golden markings often only faintly developed or, in males, almost oblique: a purple costal spot near the base; a broad, diffuse fascia at 1/3, narrowing towards inner margin, sometimes disrupted near the costa, sometimes purplish at the anterior margin and in the middle; a very broad, diffuse fascia at 3/4, purplish at costa, usually hardly distinguished from the bronzy golden apical part; cilia brightly golden; hindwings bronzy golden, especially at apex with purple tinge; cilia brightly bronzy golden with faint purple tinge; legs dark golden fuscous; abdomen golden brown.

♂ **Genitalia.** Uncus moderately long, broad, stout, distal with some short setae, forming a separate, clearly distinguishable unit with accessory claspers; accessory claspers moderately long, enlarged distally, anterior margin almost S-shaped, with short, stout thickened setae, which have spatulate bases and short, hook-like ends, pointing backwards; a row of shorter, unmodified setae near anterior margin; valvae rather short, stout, strongly narrowed near mid-length, with clearly distinguished ends; a small, basal group of short setae at inner surface, postbasally a larger, elongated group of short setae; several rows of very short to moderately long, spinoid setae at inner surface of distal ends.

♀ **Genitalia.** Sclerites of segment IX reduced, forming a complete sclerotized ring: ventral half of normal width, ventrolaterally the proximal part lobe-shaped and enlarged; dorsal third of normal width, laterally slightly constricted; distal margin of ring with straight, sharp border, proximal margin of ring dorsolaterally irregular, faintly sclerotized. Terminal papillae strongly sclerotized, distal margin straight, proximal margin irregular; ductus receptaculi short, sharply bent, very narrow at onset of receptaculum seminis; onset of receptaculum seminis slightly enlarged, upper third constricted and slightly bent; afterwards forming a curved and slender sac; lower end with characteristic, semicircular appendix.

Diagnosis. The species might be confused with worn specimens of *M. tunbergella* or with *M. calthella*. It differs, however, from all European species by the blackish scales on the head. Only *M. aruncella* from alpine locations has comparable dark scales. *M. aruncella* usually inhabits different biotopes (nutrient-poor meadows versus swamp-land) and is found at higher elevations (although sometimes syntopic). The wing colour is greener in *M. aruncella*, having a distinct purple base at the costa. Adults are

also usually smaller than *M. mansuetella*, with hair-like scales on the head less dark.

Distribution. According to Heath (1996) and Karsholt (2004) this species occurs in northern, eastern, central and western Europe (including Great Britain and Ireland). Heath (1983) reports this species local in northern Europe as far south as Bavaria (Germany). Meyrick (1912) depicts Europe, without further specification. Meeß (1910) reports the species from central, western (including England) and northern Europe. The records from Italy (Heath 1996; Hartig 1964) respectively seem to be doubtful and those from Portugal (Meeß 1910; Heath 1996) belong to the recently described *Micropterix herminiella* Corley, 2007.

The investigated specimens from the collection of Klimesch (now ZSM) are from the Austrian alpine regions: Edlbach-Moor (Upper Austrian) and Selzthal-Moor (Styria). Deutsch (pers. comm.) also collected the species in Eastern Tyrol (Austria), which is as far as we know the most southern occurrence of this species.

Life history. We collected specimens from flowering sedges (*Carex* spp.) in open woodland (*Fraxinus-Salix*-association) at the border of fens. Klimesch (pers. comm.) found the species favoured swamplands, feeding on sedges in birch-groves. Deutsch (pers. comm.) reports its occurrence in a ditch with *Alnus incana* L. next to a small woody moorland slope. The species seems to be absent from higher mountain regions.

Preimaginal stages. According to Heath (1962, 1983), the egg has an oval shape, a length of 360–490 μm and a width of 260–330 μm , with up to 140 μm long, rod-like structures. Immediately before hatching, the translucent white colour turns to grey. The larva and pupa are unknown.

Micropterix calthella (Linnaeus, 1761)

Phalaena (Tinea) calthella Linnaeus, 1761: 367. Type locality: Sweden. Lectotype: in coll. LSUK.

Tinea urticella Costa, 1834: 10–11, pl. 2 figs 1a–c. Type locality: Camaldoli (Capodimonte, Napoli, Italy).

Junior subjective synonym.

Eriocephala sulcatella Bentley, 1845: 1086–1087. Type locality: London (Great Britain). Junior subjective synonym.

Micropteryx silesiaca Toll, 1942: 171. Type locality: Ustron (Poland). Junior subjective synonym.

Description of adults. Examined: 13♂, 43♀. Forewing length: ♂ 3.1–3.7 mm; ♀ 3.6–4.6 mm. Head black-brown; vestiture of hair-like scales on the head dirty white to rusty yellow; antennae brown, golden shining, with reddish tinge, 4/5 (♂), respectively, nearly 3/5 (♀) of forewing length; thorax bronzy golden to coppery, posteriorly sometimes purple mixed; tegulae coppery to bluish violet; forewing bronzy golden, brownish golden to slightly greenish golden, usually without any markings; the basal area from costa to inner margin, more or less extended, purple to purplish violet, sometimes with single bluish scales; ground colour occasionally intensely tinged purple or with rudiments of vague purple markings present; these consist of a costal spot near 1/4 and a similar spot at 2/3, the latter extending almost across the whole width of the wing; fringe light bronzy golden to whitish golden, sometimes with a purple tinge; hindwing light bronzy golden, sometimes more or less purplish at the apex; fringe light bronzy

golden, brighter at the distal margin, sometimes with a purple tinge; legs and abdomen brown, golden shining, sometimes slightly purplish.

A great deal is known about the internal anatomy and exoskeletal ultrastructure of the adult of this species (see section: Morphology of adults). Below we describe the broad morphology of the abdomen only.

♂ **Genitalia**. Uncus moderately long and slender; ventrally beyond the uncus a tuft of long hair-like setae; accessory claspers well developed, nearly trapezoid; their rounded anterior margin with a row of seven or eight very short, thickened setae of spoon-like to spatulate shape; at the lower apex of the anterior margin a row of three similar but longer, straight thickened setae, which are partly hook-shaped at their ends; valvae moderately long, distinctly constricted medially, the distal fourth spatulately enlarged, bent upwards; at their inner surface postbasally two or three shorter, straight spinoid setae; the distal fourth at the inner surface with two to four irregular rows of moderately long to very short, straight spinoid setae.

♀ **Genitalia**. Tergite IX missing; sternite IX much reduced, moderately sclerotized, sometimes with indistinct margins, but of relatively characteristic shape. Segment X (terminal papillae) with sclerotized band; ductus receptaculi very thin; receptaculum seminis long and slender, at the beginning slightly thickened, the first half straight, very slender, without transverse striation; the second half enlarged into a curved, elongate sac with somewhat irregular transverse striation; a thin appendix at the end.

Diagnosis. *M. calthella* may be confused with other unicolorous golden species without markings like *M. isobasella*., unmarked forms of *Micropterix sicanella* Zeller, 1847 and *M. paykullella*, *Micropterix garganoensis* Heath, 1960 and the female of *M. aruncella*. From these, *M. calthella* is separated mostly by its darker (more greenish or brownish) bronzy golden ground colouration, as well as by its distinct purple colouration of the forewing base, reaching from costa to the inner margin. *M. mansuetella* with indistinct markings also may be very similar, but is readily distinguished by its black scalés on the head.

In the male genitalia, *M. calthella* is well characterized.

Distribution. According to Heath (1983) and Karsholt (2004), the species is distributed across Europe to central Siberia. *M. calthella* has not been recorded from Iceland, the Iberian Peninsula, southern Balkans and from the Mediterranean islands (Heath 1996).

Life history. *M. calthella* inhabits moist but not saturated locations such as marshy areas, forest tracks and outskirts of the forest. The adults feed on easily accessible pollen of a wide variety of different herbaceous plants (such as *Ajuga*, *Cardamine*, *Mercurialis*) and even occasionally trees (*Crataegus*, *Acer*), but they strongly favour sedges (*Carex* spp.), kingcup (*Caltha palustris*) and buttercups (*Ranunculus* spp.).

Preimaginal stages. According to Heath (1983), the egg has an oval shape, a length of 450–480 μm and a width of 350–370 μm , with up to 60 μm long, rod-like structures. Immediately before hatching, the translucent white colour is turns to grey. Chauvin & Chauvin (1980) also describe the egg.

The larva (see general description above, under Life history) is described by Martinova (1950) and Hamon & Chauvin (1995).

The pupa rests in a compact cocoon. More about the pupa can be found in Lorenz (1961) and Hamon & Chauvin (1995).

Remarks. We found this species near Siena (Tuscany, Italy), which is as far as we know the most southern occurrence of this species. The records from Napoli (Campania, Italy) (for *Tinea urticella* Costa, 1834) should be verified.

Micropteryx isobasella Staudinger, 1871

Micropteryx isobasella Staudinger, 1871: 289. Type locality: Italy, western Alps, Macugnaga. 6 syntypes in coll. ZMHB.

M. isobasella f. *weberi* Müller-Rutz, 1927; infrasubspecific.

Description. Examined: 2♂, 5♀. Forewing length: ♂ 3.5–3.8 mm; ♀ 3.0–4.4 mm. Head black-brown; vestiture of hair-like scales on the head rusty yellow; antennae dark brown, coppery shining, slightly more than 3/4 (♂), respectively, slightly more than 1/2 (♀) of forewing length; thorax bronzy golden; tegulae bronzy golden, posteriorly with single purple scales; forewing golden with a greenish tinge; costal margin purplish up to 3/4; almost invisible bronzy golden transverse fasciae or spots at 1/3 and 2/3, seldom of diffuse reddish colour (f. *weberi* Müller-Rutz); base slightly darker, the darker colouration extending from costa across 1/3 of forewing width; fringe light golden, with a purple tinge, especially at its base; hindwing bronzy golden, fringe golden, both with a purple tinge; legs and abdomen brown, golden shining.

♂ **Genitalia.** Uncus moderately long, somewhat stout, with a broad tip; a paired association of hair-like setae ventrally beyond the uncus; accessory claspers moderately long, nearly keel-shaped, with about 11–12 elongate, straight, unmodified setae at the rounded distal margin; another irregular row of five or six shorter, finer setae, which are more inwardly located (shape not characterised as mostly folded in the permanent preparation); an area of long, straight spinoid setae dorsal of the accessory claspers; valvae moderately long, stout, distal third enlarged and strongly bent upwards (constricted at the point of inflection); on the inner surface of the valvae three shorter setae postbasally; on the inner surface of the lower margin two to three irregular rows of shorter spinoid setae and some longer setae on the distal fourth.

♀ **Genitalia.** Tergite IX missing; sternite IX reduced, constricted medially, with strongly fringed lateral margins, without diagnostic features. Terminal papillae with two sclerotized plates forming an undiagnostic band; ductus receptaculi thin and strongly bent, at the beginning of the receptaculum seminis short and straight; receptaculum seminis long and slender, constricted in the first third, with typical transverse striation.

Diagnosis. *M. isobasella* can be separated from *M. calthella* and from females of *M. aruncella* by its almost complete lack of purple colouration at the forewing base. *M. calthella* has an extended purple basal area, whereas females of *M. aruncella* have only the base of the costa purplish coloured (males of *M. aruncella* are characterized by their silvery fasciae). *M. isobasella* has only a slight purple colouration along the costa. In the highly mountainous southwestern Alps, a form of *M. paykullella* has been found, more or less without any markings. This form can be distinguished from *M. isobasella*

only by examination of the male genitalia. Also very similar and therefore externally not distinguishable is a form without markings of *Micropterix sicanella* Zeller, 1847 (f. *obsoleta* Heath, 1963). All above-mentioned species can be easily identified by examination of the male genitalia. In the female genitalia, only *M. aruncella* can be recognized with some certainty by its reduced sternite IX and by the somewhat protruding terminal papillae. Females of the other three species cannot be identified with certainty due to their intraspecific variability.

Further species without wing markings do not occur in the distribution range of *M. isobasella*. These are restricted to central Italy and northern Africa.

Distribution. According to Heath (1996) this species is restricted to Italy and Switzerland, where it seems to be distributed only in southern Switzerland and the adjacent northern Italy (Meeß 1910; Meyrick 1912).

Records from Sicily probably belong to *Micropterix sicanella* Zeller, 1847 (f. *obsoleta* Heath, 1963), records from North Africa to *Micropterix constantinella* Heath, 1986 or to *Micropterix eatoniella* Heath, 1986.

The examined specimens were found in Switzerland (area of Simplon).

Life history. Two of the examined specimens were found swarming around *Lonicera* sp.. Further records are from tall herbaceous vegetation in a mixed larch-pine forest at 1650–1800 m elevation.

Preimaginal stages. The early stages are unknown.

Remarks. *M. isobasella* f. *weberi* Müller-Rutz, 1927 from Switzerland (Laquintal) has two slight reddish cross-fasciae on the forewing.

Micropterix aglaella (Duponchel, 1840)

Adela aglaella Duponchel, 1840: 627, pl. 312 fig. 14. Type locality: Central and Southern France (including 'Fonscolombe', north of Aix-en-Provence). Syntype in coll. MNHN (Minet in litt.).

Description. Examined: 5♂, 12♀. Forewing length: ♂ 3.3–3.6 mm; ♀ 3.5–4.3 mm. Head black brown, vestiture of hair-like scales on the head white to rusty yellow; antennae dark brown, golden shining with a purple tinge, nearly 4/5 (♂), respectively, nearly 3/5 (♀) of forewing length; thorax bronzy golden, posteriorly reddish to purple, tegulae coppery to purple violet; ground colour of forewing reddish golden to purple violet, distal half sometimes purplish brown, outer margin sometimes reddish golden again, apex rarely also of this colour; a bronzy golden colouration from the base to 1/4, leaving a purple violet basal spot at costa; markings light golden to golden, delicately bordered in bronzy gold: a broad fascia at 1/2, slightly bent outwards, extending across the whole width of the forewing; sometimes a small costal spot at 3/5 (found in 7 of 17 specimens); a larger, almost round to slightly oval spot at 3/4, extending from costa across more than half, sometime even across whole forewing width (in the latter case the posterior part of this fascia bronzy golden); fringe golden, basally purple coloured, outwards whitish; hindwing bronzy golden, with an intense purple tinge; fringe bronzy golden, outwards whitish; legs and abdomen brown, golden shining.

♂ **Genitalia.** Uncus moderately long, stout, with a broad, rounded tip; beyond the uncus a weak structure of hair-like setae; between uncus and accessory claspers are

situated weakly sclerotized, elongated, spatulate-like lobes, somewhat variable in the length, at the anterior margin of the tegumen; these lobes with very long hair-like setae at their ends, as well as on a small appendix at their lower margin; accessory claspers spoon-like, with a row of nearly 13 moderately long to long, mostly sickle-shaped thickened setae; near the dorsal margin anteriorly two shorter, straight spinoid setae anterior and basally a row of about 6 strongly modified, very broad T-shaped thickened setae; valvae moderately long, stout, strongly constricted medially; at their inner margin a very long and a shorter seta basally, on the distal part a group of very short to rather long spinoid setae, clustered proximally towards the constriction; a row of short spinoid setae along the rounded anterior margin.

♀ **Genitalia.** Tergite IX missing, only indicated by a group of setae; sternite IX strongly reduced, weakly sclerotized, constricted medially. Terminal papillae consisting of two somewhat weakly sclerotized plates forming a band; receptaculum seminis more or less short and stout, the second half like a sac, with typical striation; vestibulum a large sac, without any special characters.

Diagnosis. This species can be confused with *M. paykullella*, but in most cases it can be recognized by its less intense purple colouration. In contrast to *M. paykullella* and *M. aureoviridella*, the golden inner margin of *M. aglaella* does not reach the fascia in the middle (the border of the bronzy golden inner part of the wing and the fascia in the middle are often nearly parallel). The outer spot at 3/4 extends across the entire width of the forewing in many cases. *M. aglaella* can also be separated from *M. aureoviridella* by the normally more acute shape of its markings, the darker purple colouration and by its consistently bronzy golden forewing base.

The male genitalia resemble somewhat those of *M. aureatella*, but can be easily distinguished. Also the female genitalia can be recognized quite well. In particular, the degree of sclerotization of sternite IX and of the terminal papillae of *M. aglaella* is distinctly weaker than that of *M. paykullella*. The receptaculum seminis seems to be shorter and stouter, but these differences are too minor to be useful.

Distribution. According to Heath (1996) and Karsholt (2004) this species occurs in Spain, France, Italy, Germany and Switzerland.

The records from Portugal (Heath 1996; Karsholt 2004) seem to be doubtful (Corley 2007).

To our present knowledge, *M. aglaella* is distributed in southern France, western Switzerland, the southern Alps (eastwards as far as Mt. Baldo, Italy), as well as in the Pyrenees. The record for the Schwäbische Alb (Germany) (Pröse 1987) has also been confirmed.

Life history. We have no modern information so are unable to confirm Duponchel's (1840: 628) records of his species from flowers of 'troène' (= *Ligustrum vulgare*), 'sureau' (= *Sambucus*) and 'cornouiller sanguin' (= *Cornus sanguinea*).

Preimaginal stages. The early stages are unknown.

Remarks. According to Minet (in litt.) the year of description has to be corrected to 1840 (all types are labelled as *Micropterix aglaella* Duponchel, 1840 instead of 1838).

***Micropterix aureatella* (Scopoli, 1763)**

Phalaena aureatella Scopoli, 1763: 254. Type locality: Slovenia, Carniola. Type: Lost or destroyed in coll. IEUP (Evenhuis 1997).

Tinea paykullella Thunberg, 1794: 89. Type locality: "Vestrogothia" (Sweden). Homonym of *Alucita paykullella* Fabricius, 1794.

Tinea ammanella Hübner, 1813: pl. 57 fig. 388. Type locality: None given. Junior subjective synonym.

Description. Examined: 19♂, 32♀. Forewing length: ♂ 3.9–4.6 mm; ♀ 4.2–4.8 mm. Head black-brown; vestiture of hair-like scales on the head brownish yellow to light ochre; antennae dark brownish golden with a light purple tinge, 4/5 (♂), respectively, 4/7 (♀) of forewing length; thorax dark bronzy golden, posteriorly partly purplish, tegulae purplish violet, posteriorly sometimes with single bluish scales; forewing purplish violet, to some extent with single bluish scales, sometimes bronzy golden with a purplish violet tinge; markings golden, delicately bordered in bronzy gold and of variable width; an indistinct and minute bronzy golden spot at the base; a fascia near 1/4, slightly bent inwards and slightly narrowed at the costa or in the middle, sometimes not reaching the costa; a fascia at 1/2, equal in width, somewhat bent outwards and sometimes narrowed in the middle; at 3/4 a broad, more or less oval spot of irregular shape, mostly reaching costa but not inner margin; fringe whitish golden; hindwing bronzy golden, more or less with a purplish tinge; fringe bronzy golden, distally whitish; legs light brownish golden; abdomen golden brown.

♂ **Genitalia.** Uncus short, somewhat stout; ventrally beyond the uncus two unsclerotized small lobes bearing humps; between these and the accessory claspers two lobe-shaped appendices at the anterior margin with long hair-like setae, above them a row with shorter setae; accessory claspers long, narrow, spatulate, at the apex with a small dorsally oriented lobe with short spinoid setae; accessory clasper on the ventral margin with numerous, long, bent spinoid or sickle-shaped setae, which are ventrally oriented; valvae long, strong, constricted medially, with many setae postbasally; the last third bent upwards and distinctly enlarged with many spinoid setae (two clusters of spinoid setae, one at the point of inflection and one at the apex).

♀ **Genitalia.** Tergite IX missing, sternite IX reduced, distinctly constricted medially, laterally enlarged into a lobe, strongly sclerotized, usually making the margins distinct. Terminal papillae with sclerotization in a band; receptaculum seminis long, narrow, at the beginning of the ductus receptaculi somewhat enlarged, forming a sac in the second half with typical striation; receptaculum seminis with a short appendix at the end.

Diagnosis. *M. aureatella* can be separated from most other purple-violet and golden species of *Micropterix* by its lack of a golden inner margin of the forewing, the more regular golden fasciae as well as the lack of the small golden spot at the costa at about 3/5. *M. trifasciella*, also without this spot, usually has broader golden fasciae. In some cases *M. aureatella* and *M. trifasciella* can be separated only by examination of the genitalia. The type locality of *M. trifasciella* is in the area of Torino (Fenestrelle, Val Susa, the border region of Italy and France). Also *M. huemeri*, found in the Alpes Maritimes (France), has a similar wing pattern. *M. aureatella* can also be separated with certainty by the male genitalia from the somewhat smaller species *M. rablensis* and *M. croatica*.

Sometimes the costal spot of *M. allionella* can be missing and then it can be confused also with *M. aureatella*. *Micropterix wockei* Staudinger, 1870, occurring in Greece, also looks superficially very similar to *M. aureatella*.

The structures of the female abdomen (segment IX and X) of *M. aureatella* sometimes look similar to those of *M. aureoviridella*, but sternite IX of *M. aureatella* is normally more strongly sclerotized with thus more distinct lateral margins.

Distribution. According to Heath (1996) and Karsholt (2004), *M. aureatella* is distributed throughout Europe except Spain, Iceland, Luxembourg, Albania, Bulgaria, the European part of Turkey and the Mediterranean islands. Also Heath (1983) records this species throughout the Palaearctic region, except northern Africa (Heath 1983).

The records from Portugal (Heath 1996) seem to be doubtful (Corley 2007).

The typical subspecies is replaced by ssp. *shikotanica* Kozlov in the eastern part of the Palaearctic region. This subspecies seems to differ clearly from the typical ssp. *aureatella* and therefore may present a separate species (Kozlov 1988, 1989; Moriuti 1982). The presence of the species in Japan is remarkable considering its long geological separation; the two populations in Hokkaido and Honshu have slightly different wing pattern but have not been placed to any subspecies (Hashimoto, 2006).

Life history. This species occurs especially in high moorland, where the moths have been found swarming around flowering *Pinus mugo mugo* Turra, *Vaccinium myrtillus* L. and also *Carex* spp. in full sunshine. In Hokkaido, Japan, the species is recorded on flowers identified as *Heracleum lanatum* Michx. var. *lanatum* (Hashimoto 2006: Fig. 11 O; U. Jinbo, pers. comm.). In mountain areas, *M. aureatella* inhabits mainly in elfin woodland in similar biotopes. This species can sometimes be found at the edges of forest openings and forest tracks, on more or less acid soils.

Preimaginal stages. According to Heath (1962, 1983), the egg has an oval shape, a length of 470–530 μm and a width of 370–430 μm with rod-like structures. Immediately before hatching, the translucent white colour turns grey. The larvae have been found in the strongly mycorrhizal leaf litter of bilberry plants and of oak and beech woodland (Carter and Dugdale, 1982). The pupa is unknown.

Remarks. The male genitalia figured by Viette (1948) as *M. aureatella* probably belongs to *M. trifasciella*.

Micropterix aruncella (Scopoli, 1763)

Phalaena aruncella Scopoli, 1763: 254. Type locality: Slovenia, Carniola. Type: Lost or destroyed in coll. IEUP (Evenhuis 1997).

Tinea seppella Fabricius, 1777: 296. Type locality: England (Karsholt in litt.). Junior subjective synonym.

Tinea podevinella Hübner, 1813: pl.50, fig.342. Type locality: None given. Junior subjective synonym.

Lampronia concinnella Stephens: 361. Type locality: Darenth wood (Great Britain). Junior subjective synonym.

Micropterix eximiella Zeller, 1850: 62. Type locality: Montenero (near Livorno, Tuscany, Italy). Junior subjective synonym.

Eriocephala atricapilla Wocke, 1877: 52. Type locality: Stelvio (Italy). Junior subjective synonym.

Micropterix nuraghella Amsel, 1936: 364. Type locality: Tempio Pausanias (Sardinia, Italy). Junior subjective synonym.

Description of adults. Examined: 90 ♂, 71 ♀. Forewing length: ♂ 2.6–3.6 mm; ♀ 2.6–4.0 mm. Head black-brown, vestiture of hair-like scales on the head dirty white to rusty yellow, sometimes brownish golden to blackish (f. *atricapilla* Wocke); antennae dark brown, reddish golden shining, nearly 4/5 (♂), or somewhat over 1/2 (♀) of forewing length; thorax bronzy golden to coppery, posteriorly often purple; tegulae purple to bluish; forewing golden to bronzy golden (seldom light golden), with more or less reddish tinge, which is sometimes missing; in specimens from the northern and central Apennines ground colouration often reddish bronzy golden to coppery; basal area mostly distinct purple at the costa, to some extent with single bluish scales; this purple colouration sometimes extending to 1/4 along the costa, sometimes nearly completely missing; apex in most specimens slightly more reddish than ground colour; ♀ mostly without any other markings, but specimens from the northern and central Apennines similar to males; ♂ with silvery white, often diffusely, but in specimens from the northern and central Apennines markings very distinct (markings missing in f. *nuraghella* Amsel): a narrow fascia near 1/4, not reaching costa but extending across more than half of the forewing width (strongly bent inwards and sometimes reduced to a small spot); a narrow, quite straight fascia, mostly extending across the whole width of the forewing at 1/2; sometimes a small, round spot in the anterior half of the wing at 3/4 (f. *seppella* Fabricius), distinctly pronounced in specimens from the northern and central Apennines; fringe light golden, mostly with a slight purplish tinge; hindwing golden to bronzy golden, more or less purplish, especially at the apex; fringe light golden with a reddish tinge; legs and abdomen brown, golden shining.

♂ **Genitalia.** Uncus long and narrow, somewhat enlarged at the tip; tegumen narrow, ventrally with a long, broadly hatchet-shaped terminal appendix, weakly sclerotized especially at the anterior margin; this hatchet-shaped appendix with some short setae; accessory claspers small, slipper-shaped, inside the above mentioned appendices and ventrally beyond their beginnings; at the dorsal margin of the inner surface of the distal end of the accessory claspers four or five short, slightly bent spinoid setae, which are multiply split at their ends; mostly at the lower margin 10 long, straight spinoid setae, bent at their ends; in the middle of the accessory claspers some short setae; valvae stout, beyond the middle strongly constricted, the distal ends spoon-like and slightly bent dorsad; on their inner surface an elongated patch of setae postbasally, a row of longer setae at their distal end and two or three irregular rows of shorter, straight spinoid setae.

♀ **Genitalia.** Tergite IX missing; sternite IX only moderately sclerotized, reduced to two nearly halfmoon-shaped sclerotized plates with a narrow, weaker sclerotized junction. This sternite IX, the receptaculum seminis and also the terminal papillae are more or less characteristic for this species, although sternite IX is not so distinctive in specimens from central Italy. Terminal papillae sclerotized in a medially broader band; receptaculum seminis very long and narrow, narrowest above the middle; the last part somewhat enlarged; receptaculum seminis with a distinct striation along the whole length and a short appendix.

Diagnosis. Males with an intense, reddish colouration may be confused with *M. au-roviridella* in central Europe, but they can be separated by their lack of the golden

colouration of the inner margin and by their narrower and more silvery fasciae. Similar Mediterranean species, like *Micropterix corcyrella* Walsingham, 1919, *Micropterix erctella* Walsingham, 1919, *Micropterix italica* Heath, 1981 and *Micropterix renatae* Kurz, Kurz & Zeller, 1997, but also the alpine *M. fenestrellensis* can be recognized with certainty only by examination of the genitalia, although they are normally more reddish and show more distinct silvery whitish markings (except *M. fenestrellensis*). We also found *Micropterix myrtetella idae* Rebel, 1902 from Peloponnes with dark scales on head, which looks also very similar to *M. aruncella* f. *atricapilla*. Females can be separated from other species without wing markings by their purple colouration at the base of the forewing costa. In *M. calthella*, this colouration reaches the inner margin, whereas in *M. isobasella* and *Micropterix sicanella* Zeller, 1847 f. *obsoleta* Heath, 1963, it is almost missing. In the Alpes Maritimes we have found a form of *M. paykullella* that also lacks markings and with a less extended purple colouration of the base of the forewing. *M. mansuetella* has black scales on the head, similar to *M. aruncella* f. *atricapilla*, although the latter never has such an intense black colouration. Furthermore, these two species prefer different biotopes. *M. mansuetella* inhabits swampland, whereas *M. aruncella* is normally found on sunny, dry, nutrient-poor meadows. Nevertheless, both species can also be found more or less syntopically, where these biotopes intersect. There are further similar species in the Sierra Nevada in Spain and in northern Africa, but so far *M. aruncella* has not been found there. In all cases, males can be easily recognized by their characteristic genitalia, and also the female genitalia seem to be fairly diagnostic.

Distribution. Heath (1996) and Karsholt (2004) have reported this species throughout Europe except Portugal, Sicily, Malta, Iceland, Romania, Albania, Bulgaria, Crete and the European part of Turkey. According to Heath (1983) and Meeß (1910), *M. aruncella* is distributed throughout Europe except the Iberian Peninsula, northwards to Sweden and Finland, eastwards to Russia.

Life history. *M. aruncella* is found in meadows, in bushland, at grassy forest margins, but not inside taller forests, except within larger open clearings with grasses. This species prefers extensively used, more or less dry and bushy meadows, where the moths can be found feeding on flowering grass and also on blossoms of other plants (Heath 1960a; Meyer et. al. 2002). In the Alps *M. aruncella* occurs also in elfin woodland where we found it on flowering *Rosa pendulina* L. and *Pinus mugo mugo* Turra. In other habitats we found this species feeding on the flowers of *Crataegus* sp., *Sambucus* sp., *Urtica* sp., *Cytisus* spp., *Lychnis flos-cuculi*, *Veronica chamaedrys* and *Plantago media*. The moths are on the wing from May to August, depending on elevation. They occur from near sea level up to more than 2000 m.

Preimaginal stages. According to Heath (1962, 1983), the egg has an oval shape, a length of 400–430 μm and a width of 310–350 μm , with up to 60 μm long, rod-like structures. Immediately before hatching, the translucent white colour turns to grey. According to Klausnitzer (2002), the body length of the final larval stage is 4.0–4.5 mm. The larva was found on *Dactylis* sp., where it probably feeds on detritus (Luff 1964; Heath 1983).

The pupa rests in a robust cocoon.

Remarks. This species shows a distinctive sexual dichroism and is one of the most variable species of the genus. Besides f. *atricapilla* mentioned above, which is common in the mountainous regions of the Alps, and f. *seppella*, specimens are known from the northern and central Apennines with distinct silvery white markings on a coppery ground colour. Furthermore, from Sardinia f. *nuraghella* has been described, characterized by males without any wing markings. Nevertheless, considering the genitalia, all these forms have been proven to belong to *M. aruncella*. The forms *atricapilla* and *nuraghella*, as well as the specimens from the northern and central Apennines may therefore present distinct subspecies.

Micropterix tunbergella (Fabricius, 1787)

Tinea tunbergella (Fabricius, 1787): 253. Type locality: Denmark, Funen, Fåborg. Neotype ♂: Alléskov, Faaborg, 7.5.1926; coll. Larsen, genit. no. 842 Kristensen; in coll. ZMUC.

Tinea thunbergella auct. nec Fabricius, 1794.

Tinea helwigella Hübner, 1805: pl. 38 fig. 263. Type locality: None given. Junior subjective synonym.

Tinea rubrifasciella Haworth, 1828: 572. Type locality: Kent (Great Britain). Junior subjective synonym.

Micropterix depictella Herrich-Schäffer, 1851: fig. 7. Type locality: None given. Junior subjective synonym.

Description of adults. Examined: 9♂, 20♀. Forewing length: ♂ 3.7–4.1 mm; ♀ 3.9–4.9 mm. Head black-brown; vestiture of hair-like scales on the head yellow, rusty yellow at the base of the antennae; antennae light brownish, 3/4 (♂), respectively 1/2 (♀) of forewing length; thorax golden; tegulae bronzy golden to purple, posteriorly purple violet; forewing with golden ground colouration and coppery to purple markings: a basal spot, extending from costa across nearly half of the forewing width; at 1/3 an elongated spot, extending from costa across 2/3 of the forewing width; distal of 1/2, a more or less broad fascia extending across the whole forewing width broadly bifurcated and purple violet at the costa, often interrupted in the middle and sometimes also bifurcated at the inner margin; at the posterior third of this fascia, mostly connected with another fascia directed to, but not always reaching the apex, narrow at the junction and spoon-like, apically broadened, sometimes bifurcated; apex and outer margin with bronzy golden to purple scales; fringe bronzy golden, golden distally; hindwing bronzy golden, often with a purple tinge apically; fringe golden, whitish outwards; legs brownish, golden shining; abdomen brownish golden.

♂ **Genitalia.** Uncus stout, in the form of a broad beak; accessory claspers well developed, with pocket-like lobes at the ventral margin, which bear many, relatively long, slightly bent spinoid setae at the anterior part of the ventral margin; a group of shorter thickened setae at the anterior tip; a bunch of long hair-like setae at the posterior part of the accessory claspers; at the anterior margin of the accessory claspers a long, lobe-like appendix on both sides extending beyond the uncus ventrally with long, hair-like setae; valvae long, very slender, upwardly bent, slightly enlarged at the tip; on the inner surface two irregular rows of shorter spinoid setae anteriorly and some setae postbasally, as well as long hair-like setae medially.

♀ **Genitalia.** Tergite IX completely atrophied, leaving only a small remnant with a patch of setae, sternite IX typically reduced, 1/3 of the width of the other sclerites in the middle, laterally enlarged into a lobe and with indistinct border. Terminal papillae typically sclerotized; ductus receptaculi enlarged at the beginning of the receptaculum seminis and strongly bent; receptaculum seminis long and narrow, somewhat enlarged in the second half, with a longer, thin appendix at the end.

Diagnosis. *M. tunbergella* can be sometimes confused with *M. mansuetella*. Also similar is *Micropterix kardamylensis* Rebel, 1903 (from Peloponnes, Greece), but it has no golden spot at the costa at 2/3 (the outer purple fascia is not bifurcated).

There is an undescribed species in Greece, which is very similar to *M. tunbergella*, but can be separated with certainty only by examination of the male genitalia.

Distribution. According to Heath (1996, 1983) and Karsholt (2004), the species is distributed across Europe. *M. tunbergella* has not been recorded from Portugal, Italy, Bulgaria and Finland.

In the Balkans, we recorded this species with certainty from Macedonia, Bosnia and Greece.

Life history (Heath 1983). *M. tunbergella* mostly inhabits deciduous woodland. The adults feed on pollen of *Quercus*, *Acer* and *Crataegus* as well as on other plants. Sometimes *M. tunbergella* has been found swarming around tree-tops.

Preimaginal stages. According to Heath (1983), the egg has an oval shape, a length of 380–390 μm and a width of 240–250 μm , with up to 100 μm long, rod-like structures. Immediately before hatching, the translucent white colour turns grey.

The larva and pupa are unknown.

Remark. The identity of the species named *tunbergella* by Fabricius in 1787 was settled by Heath et al. (1979) who designated a neotype. The name *thunbergella* (Fabricius, 1794) is a synonym of *Caloptilia alchimiella* (Scopoli, 1763) (Gracillariidae).

Micropterix aureoviridella (Höfner, 1898)

Eriocephala aureoviridella Höfner, 1898: 73. Type locality: Austrian Alps, Carinthia, Petzen near Bleiburg. 4 syntypes (2 ♂ [1 destroyed, only 1 forewing and parts of body left], 2 ♀) in coll. NHMK [examined].

Micropterix liogierella Réal, 1987: 377–378. Type locality: Cret de la Neige (France, Jura Mountains). Junior subjective synonym.

Description of adults. Examined: 10 ♂, 27 ♀. Forewing length: ♂ 3.4–3.9 mm; ♀ 3.6–4.7 mm. Head black-brown; vestiture of hair-like scales on the head rusty yellow to dirty white; antennae golden brown, purple at the base, 4/5 (♂), respectively, 4/7 (♀) of the forewing length; thorax golden, posteriorly purple violet; tegulae bronzy golden to purple violet, bluish in the posterior part; forewing bronzy golden to reddish golden, a purple violet spot near the base at the costa, basally and between the fasciae mixed with purple scales, sometimes also completely purple to purple violet in the anterior half of the forewing; inner margin broad golden to bronzy golden from the base to the middle of the wing; markings more or less silvery golden to golden, indistinctly

bordered: a fascia extending from costa across more than half of the forewing width at 1/5, sometimes poorly developed; a narrower, bent fascia across the entire width of the wing at 1/2, often narrowed in the anterior third, sometimes nearly completely interrupted; an elongated, more or less large spot at 3/4, usually not reaching the costa and the inner margin; a small bronzy golden costal spot at 3/4, sometimes very ambiguous; fringe bronzy golden to whitish bronzy golden; hindwing bronzy golden, more or less with a purple tinge; fringe lightly bronzy golden; legs and abdomen brownish, golden shining.

♂ **Genitalia.** Uncus moderately long, distinctly separated and stout; at the lower margin convex, with an area of setae; accessory claspers well developed, nearly triangular, with a row of many moderately long, partly modified spinoid setae, as well as inwardly oriented, nearly Y-shaped setae at the ventral margin of the anterior half; valvae moderately long, broad, distinctly constricted medially, strongly bent dorsad at the distal end; some setae postbasally on the inner surface of the valvae, two irregular rows of many shorter spinoid setae at the lower margin of the inner surface distally and a row of longer setae medially.

♀ **Genitalia.** Tergite IX missing; sternite IX atrophied, only 1/3 of the normal width in the middle, laterally enlarged into a weak lobe, but variably, so poorly diagnostic; distal and proximal margin distinctly bordered; lateral margin inwardly bent, indistinctly bordered. Terminal papillae with well developed sclerotized band, weakly diagnostic: proximally straight or slightly sinuate; ductus receptaculi short; receptaculum seminis small, at the beginning of the ductus receptaculi somewhat enlarged, afterwards constricted; receptaculum seminis forming a sac in proximal half, with an inconspicuous, typical striation; a thin appendix at the end.

Diagnosis. *M. aureatella* is coloured more purple violet (not as reddish as *M. aureoviridella*) without golden inner margin and with distinctly bordered, more golden fasciae. *M. aureoviridella* can be separated from *Micropterix facetella* Zeller, 1850 (from Balkans) by its lack of the small costal spot near 3/5. Sometimes *M. aureoviridella* can be mixed up with males of *M. aruncella*. Very similar are furthermore *M. aglaella* and especially *M. paykullella*, which therefore they can be identified with certainty only by examination of the genitalia.

Distribution. According to Heath (1996) and Karsholt (2004) this species has been found in Italy, Switzerland, Germany, Austria, Poland, Slovenia and Slovakia.

The records from Greece (Heath 1996; Karsholt 2004) and from Romania (Karsholt 2004) seem to be doubtful.

To our present knowledge, this species occurs in the northern and southern calcareous Alps and other upland areas (Germany: Harz; Switzerland and France: Jura [*M. liogierella* Réal, 1987]). Furthermore a series of females from the Dinarian Mountains (Croatia) probably belong to *M. aureoviridella*, suggesting the occurrence of this species across the Balkans (Zeller-Lukashort, Kurz & Kurz 2002).

Life history. So far this species has been found on alkaline ground (carbonate substrate) at 900–2000 m elevation. *M. aureoviridella* prefers open and dry habitats on southwardly directed slopes, margins of light spruce forest with interspersed rocks (with ground vegetation: besides grasses, especially *Mercurialis perennis* L.), margins

of forest and scrubs in mountainous areas, as well as in elfin woodland (vegetation: *Pinus mugo* Turra, *Rhododendron hirsutum* L., *Vaccinium myrtillus* L., *Erica carnea* L., *Juniperus communis alpina* (Suter), etc.). *M. aureoviridella* has also been found in sub-alpine dwarf scrub. The adults feed on flowering shrubs including *P. mugo*. According to the elevation, the adults occur from end of May to July.

Preimaginal stages. The early stages are unknown.

Remarks. A series of females from the Dinarian Mountains (Croatia) remains of uncertain taxonomic status. Superficially they resemble *M. aureoviridella*, but their wing markings are overall dark bronzy golden and very diffuse. Their ground colouration is more reddish to purple.

M. aureoviridella has often been described as “golden green”, which is the translation of its Latin name. But the animals are mostly reddish golden and often show a more or less intense purple colouration, which is already stated in the original description by Höfner (1898).

Micropterix paykullella (Fabricius, 1794)

Alucita paykullella Fabricius, 1794: 340. Type locality: Southern Europe. Holotype ♀: in coll. ZMUC (Karsholt in litt.).

Tinea anderschella Hübner, 1813: pl. 51, fig. 352. Type locality: none given. [Synonymy suggested by Heath (1987), but not clear from Hübner's illustration].

Micropterix paykullella [sic] f. *rosarum* Müller-Rutz, 1927. 532-533. Type locality: Above Törbel, 1600 m (Valais, Switzerland). Junior subjective synonym.

Description of adults. Examined: 16 ♂, 27 ♀. Forewing length: ♂ 3.0–3.7 mm; ♀ 3.4–4.3 mm. Head black-brown; vestiture of hair-like scales on the head dirty white to rusty yellow; antennae dark brown, golden shining, 3/4 (♂), respectively, 4/7 (♀) of forewing length; thorax bronzy golden, tegulae reddish bronzy golden, partly mixed purple; inner margin of forewing broad with bronzy gold extending from the base nearly to the median fascia; a broad bronzy golden fascia nearly at 1/4, connected with the bronzy golden inner margin; the rest of the forewing reddish bronzy golden, more purple at the costa and at the apex, in some specimens completely purple to purple-violet; wing markings whitish golden to golden, delicately bordered in bronzy gold: a narrow, slightly outwardly bent fascia nearly at 1/2 across the whole width of the wing, sometimes narrowed anterior of the middle and more golden coloured; rarely a small costal spot at 3/5; a slightly ovate spot at 3/4, seldom reaching the outer margin but mostly reaching the costa, sometimes a broader, golden fascia across the entire width of the wing, whitish golden coloured in the anterior half of the wing, somewhat narrowed in the posterior third; fringe bronzy golden, somewhat purple shining, lighter distally; hindwing bronzy golden, apically with a purple tinge; fringe bronzy golden, lighter distally; legs and abdomen brown, golden shining.

♂ **Genitalia.** Uncus short, moderately broad, with a broadly rounded tip; ventrally beyond the uncus and inside the tegumen, a tuft of longer hair-like setae; accessory claspers relatively broad, rounded distally; a row of about 10 longer, straight to slightly bent spinoid setae on the inner surface of the anterior end of the accessory

claspers, which are partly hook-shaped at their ends; basally a second row of two longer, nearly straight spinoid setae and three to four sickle-shaped thickened setae; valvae moderately long, constricted beyond the middle, the last fourth enlarged, triangle-shaped and bent dorsad; a group of about five shorter spinoid setae and some setae on the inner surface postbasally; one or two rows of about 10 shorter, straight spinoid setae and a row of longer setae on the inner surface of the enlarged end of the valvae.

♀ **Genitalia.** Tergite IX missing; sternite IX reduced, weakly sclerotized, with indistinct lateral margins. The pregenital abdomen noticeably but weakly differs from other species. Terminal papillae with a sclerotized band, without any specific characteristics; ductus receptaculi very narrow at the beginning of the receptaculum seminis; receptaculum seminis relatively long and narrow, striated, somewhat enlarged in the second half.

Diagnosis. *M. paykullella* can be confused with *M. aureoviridella*, the typical form of *Micropterix sicanella* Zeller, 1847 (*M. sicanella* does not occur in the area of distribution of *M. paykullella* so far) and especially with *M. aglaella*. *M. paykullella* can be separated from *M. aureoviridella* by its broader, bronzy golden fascia at 1/4, by its mostly narrower fascia at 1/2 and by its mostly stronger purple colouration especially at the apex. It can be separated from the typical form of *M. sicanella* by its bronzy golden colouration at the costa, which does not reach the base, by its narrower fascia at 1/2 and the mostly more intense purple colouration of the forewing, but also by lacking a costal spot at 2/3. Nevertheless, both species are very variable, so they can be recognized with certainty only by examination of the genitalia. *M. aglaella* is also very similar; it shows a mostly more purple-violet colouration and sometimes a small costal spot at 2/3. The bronzy golden colouration at the base of the forewing nearly reaches the median fascia in *M. paykullella*, whereas in *M. aglaella* this colouration ends far before the median fascia. In *M. aglaella*, the outer border of the bronzy golden colouration at the base and the median fascia are nearly parallel. Since *M. paykullella* and *M. aglaella* may occur together in the western Alps, for proper identification genitalic examination is needed. All above-mentioned species can easily be distinguished by their male genitalia.

Females of *M. paykullella* can be separated genitally from *M. aureoviridella* and *M. sicanella* particularly by their distinctly slender and longer receptaculum seminis, and from *M. aglaella* by their distinctly stronger sclerotization of sternite IX and terminal papillae. Furthermore, *M. aglaella* has a slightly shorter and stouter receptaculum seminis. Females of *M. aruncella* can be easily identified by their characteristic sternite IX.

Distribution. *M. paykullella* seems to be distributed locally across the whole Alps. According to Heath (1996) and Karsholt (2004), this species occurs in France, Italy, Austria and Switzerland. Following Meeß (1910), *M. paykullella* occurs in southern France (also Viette 1948; Leraut 1980), in Switzerland (also Whitebread 1992), in Tyrol (Austria), in the Alps of Lower Austria and in Italy. Furthermore this species occurs in Vorarlberg (Austria) (Burmam & Huemer 1984) and Bavaria (Germany) (Osthelder 1951; Präse 1987).

The records from Dalmatia (Croatia/Montenegro) seem to be misidentifications probably of *Micropterix facetella* Zeller, 1851. According to Karsholt (2004) the records from Germany (Heath 1996) seem to be doubtful. Records from southern Italy and Sicily belong to *Micropterix sicanella* Zeller, 1847. In Italy, *M. paykullella* is restricted only to the Alps according to present knowledge.

Life history. Specimens without any markings were found above the timberline (2200 m) feeding on pollen of *Helianthemum* sp. Individuals with typical wing pattern were swarming around dwarf shrubs in clearings and on the outskirts of forest at lower montane level.

Preimaginal stages. The early stages are unknown.

Remarks. Individuals from the Alpes Maritimes (border between France and Italy, Marguareis, 2200 m) with golden colouration and fasciae at 1/2 and 3/4 absent or only weakly observable are confirmed genitally to belong to this species.

Micropterix allionella (Fabricius, 1794)

Tinea allionella Fabricius, 1794: 321. Type locality: Southern Europe. Type: Not designated, in coll. ZMUC (Karsholt in litt.).

Tinea tricinctella Costa, 1836: 223, pl. 2 fig. 2. Type locality: Napoli (Italy). Junior subjective synonym. *Micropteryx rothenbachii* auct. nec Frey, 1856.

Description of adults. Examined: 5♂, 3♀. Forewing length: ♂ 3.6–4.5 mm; ♀ 4.7–4.8 mm. Head black-brown; vestiture of hair-like scales on the head dirty white to rusty yellow; antennae somewhat longer than 3/4 (♂), or nearly 2/3 (♀) of the forewing length, sexually dichroic, with the ♂ brown, golden shining with more or less purple tinge, with the ♂ distinctly bi-coloured: light golden at the base to nearly 1/3, apically similar to the ♂; thorax golden, tegulae coppery bronzy golden to purple; forewing brown golden, especially at the costa mixed with purplish to purplish violet with a golden basal area and light golden to golden markings, bordered delicately in bronzy gold, broader in males, more slender in females: a broad fascia nearly at 1/4, narrowed at the costa; a broad fascia at nearly 1/2, somewhat narrower medially and more or less bent distad; mostly a small costal spot at 2/3; a fascia at 3/4, more or less triangle-shaped; wing often bronzy golden at the apex and sometimes partially so at the inner margin; tip of the apex purple; fringe whitish golden; hindwing greenish bronzy golden to bronzy golden, more or less with a purple tinge; fringe light golden, with a purple tinge at the basal half; legs and abdomen brown, golden shining.

♂ **Genitalia.** Uncus moderately long, somewhat stout, a long tuft of hair-like setae ventrally beyond the uncus; accessory claspers moderately long, about four nearly Y- or T-shaped and moderately long and thickened setae at the tip; the posterior margin of the accessory claspers slightly bent outwards (bearing some longer spinoid setae); at the lower end of the posterior margin a small separated lobe, also with one or two longer spinoid setae; another two longer spinoid setae in the middle of the accessory claspers, distinctly behind the inner margin and in line with the Y- or T-shaped thick-

ened setae; valvae moderately long, distally constricted medially, weakly bent; basally a longer spinoid seta on the inner surface as well as some setae postbasally; tip of valvae slightly spatulate with two or three irregular rows of shorter spinoid setae and a row of longer setae on the inner surface; another two shorter spinoid setae, displaced towards the constriction.

♀ **Genitalia.** Tergite IX missing; sternite IX strongly reduced, constricted medially, with a distinct border, although weakly sclerotized. Terminal papillae with a strong sclerotized band; ductus receptaculi starting broadly, then very narrow at the beginning of the receptaculum seminis; receptaculum seminis moderately long, the first third a sac that abruptly narrows; the last third an elongated sac; receptaculum seminis with distinct striation; a sac-like vestibulum.

Diagnosis. *M. allionella* can be separated from most similar species by its broad golden fasciae, its small costal spot at 2/3 and almost complete absence of a golden inner margin. Sometimes *M. trifasciella* has also a small costal spot at 2/3 and also sometimes this spot is missing in *M. allionella*, and therefore *M. allionella*, especially males with reduced golden outer margin, could be misidentified as *M. trifasciella*. *M. allionella* is also very similar to *M. rothenbachii* and cannot always be separated externally for sure. *M. rothenbachii* has a more distinct purple to purplish violet colouration, broader golden fasciae (fasciae of males of *M. allionella* are nearly as broad as the fasciae of females of *M. rothenbachii*) and a more intense bronzy golden colouration at the apex and at the outer margin. *M. allionella* without costal spot at 2/3 can also be confused with *M. aureatella* and *M. rablensis*. *Micropterix hartigi* Heath, 1981 (from southern Italy) is also usually very similar to reddish or brown-golden coloured forms of *M. allionella* (especially male), but can be distinguished by its genitalia.

M. allionella has a somewhat longer uncus than *M. rothenbachii* and also differently shaped accessory claspers. *M. allionella* has four Y- or T-shaped thickened setae at the tip of the accessory claspers (*M. rothenbachii* only three, but these are also more distinct). *M. allionella* has valvae which are only weakly bent dorsad (*M. rothenbachii* has more slender valvae and the distal third is distinctly bent dorsad). In the male genitalia, *M. trifasciella* is very similar to *M. allionella*, but can be separated as follows: The uncus is more distinctly separated and not as broad as in *M. allionella*, the accessory claspers are somewhat shorter and broader at the base. The distal third of the valvae of *M. trifasciella* is distinctly broader than in *M. allionella*, and somewhat triangle-shaped (in *M. allionella* narrow, spatulate). The differences in the genitalia to *M. trifasciella* are very small, since the kind of spinoid setae on the accessory claspers seems not to be a constant character.

The abdomen of the female of *M. allionella* is indistinguishable from *M. rothenbachii* and *M. trifasciella*.

Distribution. According to Heath (1996) and Karsholt (2004) this species occurs in France, Italy, Germany, Switzerland, Czech Republic, Slovakia, Bulgaria, Croatia, Slovenia, and Yugoslavia. Following Meeß (1910) and Meyrick (1912) *M. allionella* (noted as *M. rothenbachi(ii)*) occurs in Switzerland (see also Whitebread 1992), in northern and central Italy and in Austria. Furthermore, this species occurs in the

Bavarian Alps (Osthelder 1951; Pröse 1987), together with *M. rothenbachii* according to Pröse (1987).

Leraut (1980) has recorded this species from France, Belgium and Corsica. But these records seem partially to be misidentifications of *M. rothenbachii*. The records from Turkey (Heath 1996) seem to be doubtful.

This species has also been recorded from southern Italy (Zeller-Lukashort, Kurz & Kurz 2002; Whitebread 1995).

Life history. We found this species in clearings and on the outskirts of forest flying in tall herbaceous vegetation. The examined specimens were found at 250–1700 m elevation.

Preimaginal stages. The early stages are unknown.

Micropterix trifasciella Heath, 1965

Micropterix trifasciella Heath, 1965: 243–245. Type locality: Italy, Piemonte, Fenestrelle. Holotype: ♂ Alpi Cozie, Val Chisone, Fenestrelle, 1300 m, leg. Della Beffa, agosto 1923 (examination of genitalia Heath No. 368); in coll. MSNM.

Micropterix aureatella (Scopoli, 1763) *sensu* Viette 1948: 37, fig. 26. Misidentification.

Description of adults. Examined: 16♂, 13♀. Forewing length: ♂ 3.4–4.7 mm; ♀ 4.2–4.8 mm. Head black-brown, vestiture of hair-like scales on the head light to rusty yellow; antenna nearly 4/5 (♂), respectively 1/2 (♀) of forewing length, brown, golden shining with a slight purple tinge; thorax golden to bronzy golden, tegulae coppery bronzy golden to purple violet; forewing brownish golden to blue violet, at the base with little coppery to bronzy golden spots, forewing with three whitish golden to deep golden fasciae of variable width, delicately bordered with bronzy gold: a moderately broad and straight fascia at nearly 1/4, narrowing against the costa and slightly oriented distad; a moderately broad and more or less straight fascia at 1/2, sometimes bent distad; a fascia at 3/4 of variable shape, often more or less triangle-shaped, sometimes only slightly so, sometimes broadly reaching costa and inner margin; sometimes a small costal spot at 3/5; fringe purple bronzy golden, distally golden; hindwing bronzy golden, with a strong purple tinge and with bronzy golden fringe, which is purple at the base; legs and abdomen brown, golden shining.

♂ **Genitalia.** Uncus short, somewhat stout, with a moderately broad tip; ventrally beyond the uncus and inside the tegumen short tufts of hair-like setae; between the uncus and the accessory claspers an indistinctly bordered area of very long, flat setae, which are easily lost during preparation; accessory claspers short, enlarged at the tip; anterior margin slightly bent outwards, at the ventral margin a small, distinctly separated appendix; accessory claspers with 19–24 thickened setae on the inner surface: At the tip about 7–10 strongly modified, hatchet-shaped and spatulate-shaped thickened setae in an upper row, a row of very long, slightly bent spinoid setae (about 9–12, two or rarely only one of them on the aforementioned posterior appendix) on the anterior margin; three to five long, L-shaped thickened setae which extend the upper row; valvae moderately long, strongly constricted medially, the distal third spatulate or somewhat

triangle-shaped, with two or three irregular rows of shorter spinoid setae and some long setae on the inner surface; on the inner surface two or three short spinoid setae distally of the middle of the valve and one longer, straight spinoid seta basally.

♀ **Genitalia.** Tergite IX missing; sternite IX strongly reduced, constricted medially, not diagnostic. Terminal papillae with a sclerotized band; receptaculum seminis moderately long, very slender, somewhat enlarged in the second half, with typical striation.

Diagnosis. Due to the lack of the small costal spot at 2/3 this species can easily be confused with *M. huemeri* (separable with certainty only by examination of the genitalia), and also with *M. aureatella* (see Viette 1948). *M. aureatella* can be distinguished by its mostly distinctly smaller spot or fascia at 3/4 and by its mostly more slender fasciae at 1/4 and 1/2. *M. trifasciella* differs externally from *M. allionella* mostly by lack of the costal spot at 3/5. But this character is sometimes missing too in *M. allionella*, whereas it may seldom be present in *M. trifasciella*. Therefore both species can only be separated with certainty by genitalic examination. So far, they have not been found together syntopically.

There are no differences in the female genitalia between *M. trifasciella* and *M. allionella*.

Distribution. To present knowledge, *M. trifasciella* has been recorded with certainty only from the Italian and French Alps (Zeller-Lukashort, Kurz & Kurz 2002).

Life history. This species inhabits tall herbaceous vegetation around boulders between montane and sub-alpine elevations (1400–1900 m). At the type location (Fenestrelle, Piemonte, Italy) this species was found again in 2003 at the roadside, also in tall herbaceous vegetation.

Preimaginal stages. The early stages are unknown.

Remarks. Compared with the original description, the examined specimens show distinctly more slender fasciae and the shape of the fascia at 3/4 is variable.

The male genitalia figured by Viette (1948) as *M. aureatella* probably belongs to *M. trifasciella*.

Micropterix rothenbachii Frey, 1856

Micropterix rothenbachii Frey, 1856: 52. Type locality: Switzerland. 2 syntypes in coll. BMNH.

Micropterix australis Heath, 1981a: 99. Type locality: Maroggia (Switzerland, Ticino). Junior subjective synonym.

Micropterix rothenbachi auctt. (incorrect subsequent spelling).

Micropterix germanica Heath. Nomen nudum (see remarks).

Micropterix vallebonnella Réal, 1988: 3–9. Type locality: Bonnevaux (Doubs, France). Junior subjective synonym.

Description of adults. Examined: 27♂, 12♀. Forewing length: ♂ 3.6–4.6 mm; ♀ 4.5–5.0 mm. Head dark greyish brown, vestiture of hair-like scales on the head dirty white to rusty yellow; antennae 3/4 (♂), respectively, slightly more than 1/2 (♀) of the forewing length, distinctly bi-coloured: light golden at the base (in ♀ reaching nearly to 1/3), brownish, more or less with a distinctly purple tinge apically; thorax bronzy gold-

en; tegulae coppery to purple violet, sometimes with single bluish scales posteriorly; forewing brownish golden to purple violet with whitish golden to golden markings of variable width (distinctly broader in ♂ than in ♀), delicately bordered in bronzy gold: forewing bronzy golden at the base; a fascia at 1/4, sometimes slightly broadened medially or narrowed in the upper third; a broad fascia close to 1/2, strongly bent distad and often broadened at the proximad margin; a small costal spot at 3/5; opposite, sometimes a very indistinct, very small spot at the proximad margin; a broad, triangle-shaped fascia at 3/4; this fascia sometimes enlarged along the costa towards the base and reaching the costal spot at 3/5, merging into a very large rectangular spot; this confluence often only subcostally developed, leaving at the costal margin a very small purple area; bronzy golden at the apex and at the outer margin, the bronzy golden colouration forming a slender fascia; tip of the apex coppery to purple; fringe whitish golden, bronzy to purple basally; hindwing bronzy golden with a variable purple tinge, especially at the apex; fringe bronzy golden, tips whitish; legs light bronzy golden; abdomen brownish, golden shining.

♂ **Genitalia**. Uncus short, stout, with a broadly rounded tip; ventrally beyond the uncus a brush of hair-like setae; accessory claspers broad proximally, acuminate distally, with three approximately Y-shaped, shorter thickened setae at the tip (mostly folded in permanent preparation and therefore hardly visible) and with 9–11 rigid, longer spinoid setae, sometimes slightly bent (six to eight on the apical part, two more further inside at the ventral margin, one somewhat dorsad) (see Remark); valvae distinctly bent, constricted beyond the middle, spatulate-shaped at the tip, with two irregular rows of shorter spinoid setae distal of the constriction at the ventrad margin of the mesad surface; medially and postbasally a similar seta each.

♀ **Genitalia**. Tergite IX missing; sternite IX reduced, more constricted medially than laterally, strongly sclerotized with distinct margins; lateral margins irregular, maybe diagnostic for this species. Terminal papillae with distinctly bordered sclerotized band, not protruding; ductus receptaculi at the beginning of the receptaculum seminis very narrow, before enlarging into a sac; receptaculum seminis moderately long, the first third small, then elongated into an enlarged sac; receptaculum seminis with typical striation.

Diagnosis. *M. rothenbachii* can be recognized by lack of the broad golden colouration of the inner margin. *M. allionella* is however very similar.

Distribution. Following Heath (1996) and Karsholt (2004), this species has been recorded from Italy, Sicily, Austria, Switzerland and Germany. According to Heath (1981a), this species occurs in Germany (Schwarzwald), Switzerland, Austria (Klagenfurt) and Italy (incl. Sicily). Karsholt (2004) reports this species also from Croatia and Slovenia (see also Zeller-Lukashort, Kurz & Kurz 2002).

Life history. This species inhabits light, dry and somewhat rocky, mixed beech forests, where it occurs in open places, mainly with natural cover such as brambles, grasses, etc. In central Italy, *M. rothenbachii* occurs together with *Micropterix vulturensis* Heath, 1981, and in the northern Apennines is syntopic with *M. schaefferi* and *Micropterix zangheriella* Heath, 1963.

Preimaginal stages. The early stages are unknown.

Remarks. This species was recognized as *M. australis* until 1987, whereas *M. rothenbachii* Frey, 1856 was said to be a synonym to *M. allionella*. In the original description of *M. australis*, Heath described 13 setae on the accessory clasper: "...with a marginal series of eight fairly long, stout, more or less curved setae and an inner row of five similar, straight setae."

In 1987, *M. rothenbachii* was re-established as a good species by Heath based on the examination of the type by Whitebread (1992) and *M. australis* became synonymous to it.

Originally, Heath wanted to describe a *Micropterix germanica*, but he changed the name before printing to *M. australis*, since the holotype did not come from Germany (Sattler, pers. comm.). Therefore, there are specimens in collections labelled as "*Micropterix germanica* Heath".

Micropterix huemeri Kurz, Kurz & Zeller, 2004

Micropterix huemeri Kurz, Kurz & Zeller-Lukashort, 2004: 111–114. Type locality: France, Alpes Maritimes, Marguareis. Holotype ♂: France, Dep. Alpes Maritimes, Marguareis, west slope, Navela, 2100–2200 m; 18.7.1991, GU MIC2 ♂ P. Huemer, ID-Nummer HdN-2289, in coll. TMLF.

Description of adults. Examined: 3♂, 1♀. Forewing length: ♂ 3.9 mm; ♀ 4.4 mm. Head blackish, vestiture of hair-like scales on the head yellow; antennae approximately 3/4 (♂) or almost 1/2 (♀) of forewing length, golden fuscous; thorax coppery to bronzy golden, tegulae purple violet with bronzy golden edges; forewings purple violet to bluish violet; base of costa bronzy golden; wing markings golden, delicately bronzy golden bordered; a fascia at 1/4, slightly bent, moderately broad on inner margin, distinctly narrowed from centre of wing to costa; a fascia at 1/2, slightly bent outwards, moderately broad, sometimes narrowed medially, sometimes distinctly broadened at costa; a fascia at 3/4, slightly broader than the other ones with distinctly curved inner margin; sometimes a residual costal spot at 3/5; cilia bronzy golden, apically whitish; hindwing coppery to bronzy golden, apically distinctly tinged purple; cilia bronzy golden; legs and abdomen golden fuscous.

♂ **Genitalia.** Uncus short, slightly stout with moderately broad tip; ventrally beyond uncus a tuft of hair-like setae; a small area with several faint, straight setae at the posterior margin of tegumen between uncus and accessory claspers; accessory claspers proximally broad, distally tapered, on inner surface with an upper row of six sickle-shaped thickened setae and a lower row of nine more or less straight, moderately long spinoid setae, with the two proximal spinoid setae being slightly apart; valvae slightly bent, constricted beyond middle with a triangular distal end and two or three irregular rows of shorter spinoid setae on inner surface beyond the constricted part of the valve; post-basally a distinctly robust seta on inner surface.

♀ **Genitalia and pregenital abdominal exoskeleton.** No attempt has been made to prepare the genitalia of the single available female of this species.

Diagnosis. *M. huemeri* belongs to a group of closely related species which is characterized by the following characters: The accessory claspers, seen laterally, bear two rows of thickened setae. In the ventral row, the distal thickened setae are strongly modified (Y- or T-shaped), and the one or two proximal most ones are distinctly separated from the rest of the row. These characters are shared by *M. rothenbachii*, *M. allionella* and *M. trifasciella*.

Externally, *M. huemeri* is quite well separated from the other species of this group by its three complete golden fasciae on the forewing and the absence of any further markings. One exception is *M. trifasciella*, which has very similar wing pattern elements with only slightly broader fasciae on the forewing. However, the male genitalia of *M. huemeri* differ in the shape of the accessory clasper which is conspicuously narrower proximally and has a different arrangement of the thickened setae. Furthermore, on the inner surface of the valve, the row of the short and thickened setae extends further towards the base into the constricted part of the valve.

In *M. huemeri*, the structures of the male genitalia are most similar to those of *M. rothenbachii*. *M. huemeri* can be distinguished superficially from *M. rothenbachii* by both the lack of a small costal golden spot and the golden tinge on the outer margin of the forewing. Concerning the male genitalia, *M. rothenbachii* has a distally club-shaped uncus and longer, distally more spatulate valvae with only one stout spinoid seta in the middle of the constriction.

Distribution. *M. huemeri* seems to be an endemic of the geologically isolated region of the Marguareis (France).

Life history. This species was found in high alpine grassland (at elevations higher than 2000 m) in tall herbaceous vegetation around boulders in July (P. Huemer, pers. comm.).

Preimaginal stages. The early stages are unknown.

Micropterix schaefferi Heath, 1975

Micropterix schaefferi Heath, 1975: 253–254, figs 1–2. Type locality: Austria, Upper Austria, Linz.

Holotype: ♂ Oberösterreich, Linz, 25.iv.1934, Klimesch (genitalia preparation Heath no. 213); coll. Heath, in coll. BMNH.

Micropterix anderschella (Hübner, 1813) sensu Herrich-Schäffer, 1851: 392, pl. 1 fig. 4. Misidentification.

Micropterix ammanella auctt. nec Hübner, 1813.

Description of adults. Examined: 25♂, 27♀. Forewing length: ♂ 3.8–5.1 mm; ♀ 4.7–5.8 mm. Head black, vestiture of hair-like scales on the head brownish yellow, yellow, whitish yellow or pale greyish yellow; antennae 3/4 (♂), respectively slightly more than 1/2 (♀); thorax dark golden to bronzy golden, tegulae bronzy golden, purplish to purplish violet tinged; forewings purplish bronzy golden to deep bluish violet with whitish golden to golden, finely bronzy golden bordered markings: inner margin broad bronzy golden reaching to 1/2; its basal part with an oblong spot of ground colour; apex, with exception of the outermost tip of the wing, as well as outer margin light bronzy golden; at 3/4 a small, whitish golden, often indistinct spot at the inner margin,

which is embedded in the apical golden colouration; at 1/4 a transverse fascia, narrow at costa, then broadening and reaching the bronzy golden inner margin; a broad, posteriorly somewhat narrower transverse fascia at 1/2, slightly bent outwards; a very broad transverse fascia at 3/4 reaching from costa and somewhat oblique to the centre of the wing, but not reaching the bronzy golden colouration at the outer margin; a small costal spot at 2/3, often connected with the outer transverse fascia, seldom also with the fascia at 1/2; fringe whitish golden, bronzy golden to purplish at its base; hindwing dark bronzy golden, more or less suffused with purple; fringe light bronzy golden; legs light brownish golden; abdomen brown, golden shining.

♂ **Genitalia.** Uncus more or less long, slender and somewhat flattened; accessory claspers broad, with a row of quite long, partly bent spines at the lower margin as well as with a shorter row of strongly modified, more or less Y-shaped, short thickened setae; valvae long, somewhat spatulate, narrower medially, their ends distinctly bent upwards; at the inner surface with a greater group of basal setae as well as with an irregular row of shorter spines at the lower margin and a row of long, flexible setae in the centre of the distal third of the valvae.

♀ **Genitalia.** Tergite IX missing; sternite IX much reduced, constricted in its middle, with indistinct lateral margins, similar to *M. osthelderi*; all sclerites with slightly fringe-like lateral margins. Terminal papillae with centrally somewhat enlarged band of sclerotization, whose form is not diagnostic; ductus receptaculi at the onset of the receptaculum seminis straight and very narrow for a short distance; receptaculum seminis short and a little stout, the last part an enlarged sac, with a typical transverse striation and a very narrow appendix at the end.

Diagnosis. *M. schaefferi* is easily recognized by its golden inner margin and by the costal spot at 2/3; *M. osthelderi* has a much more extensive bronzy golden colouration at the base of the forewing (including the fascia at 1/4 which is also bronzy golden and not whitish golden); *Micropterix facetella* Zeller, 1851 (from Balkans) often lacks the golden colouration at the apex and at the outer margin. *Micropterix vulturensis* Heath, 1981 and *Micropterix zangheriella* Heath, 1963, being very similar superficially, can be distinguished from *M. schaefferi* with certainty only by investigating the male genitalia. The former of these two species seems to be allopatric from *M. schaefferi*, being distributed in central and southern Italy, whereas the latter has been found sympatrically in the northern Apennines.

Concerning the male genitalia, *M. facetella* is somewhat similar, but is distinguished by its longer uncus, the more distinctly pronounced and narrower accessory claspers and by having only three basal setae at the inner surface of the valvae (*M. schaefferi* having a group of more numerous setae).

Concerning the structures of the female genitalia, *M. osthelderi* and *M. schaefferi* can be separated quite easily by the characteristics described for *M. osthelderi*.

Distribution. According to Karsholt (2004) the species is recorded from France, Corsica, Italy, Belgium, the Netherlands, Germany, Switzerland, Austria, Hungary, Czech Republic, Bulgaria and Denmark. Heath (1996) reports this species also from Poland and former Yugoslavia. Following Heath (1975) this species occurs with certainty also in Hungary and Czech Republic.

Older records concerning Asia Minor (Meeß 1910; Meyrick 1912) are very doubtfully identified.

In Italy this species seems to reach the border between the regions of Emilia Romagna and Tuscany, whereas to the South the very similar species *Micropterix vulturensis* Heath, 1981 can be found.

Life history. The species inhabits open beech and coniferous mixed woodland, but also can be found in very wet situations in *Fraxinus*-dominated ravine forests as well as in dry situations in pine forests with *Erica*. Almost always the herbaceous layer in such woods is well developed, consisting in central Europe of different grasses, *Mercurialis perennis* L. and *Dentaria enneaphyllos* L., and in dry locations also *Erica carnea* L.. In elfin woodland in the mountains, the herbaceous layer is dominated by *Vaccinium* species. Furthermore, *M. schaefferi* can be found in cuttings rich in shrubs, in blackberry thickets and on sunny wood margins. The species is absent from dense woodland, especially spruce forests without herbaceous layer.

Preimaginal stages. The early stages are unknown.

Micropterix fenestrellensis Heath & Kaltenbach, 1984

Micropterix fenestrellensis Heath & Kaltenbach, 1984: 22–23, figs 3–4. Type locality: Italy, Piemonte, Val Chisone, Fenestrelle. Holotype: ♂ Alpi Cozie, Val Chisone, Fenestrelle, 1300 m, leg. Della Beffa, agosto 1923 (examination of genitalia Kaltenbach GU 204); in coll. MSNV.

Description of adults. Examined: 1♂, 5♀. Forewing length: ♂ 3.3 mm; ♀ 3.0–3.2 mm. Head black-brown, vestiture of hair-like scales on the head black; antennae dark-brown with a weak coppery tinge, about 3/4 (♂), respectively, 2/3 (♀) of forewing length; thorax anteriorly bronzy golden, posteriorly purple to purplish violet; tegulae purple-violet; forewing bronzy golden to reddish bronzy golden, purple at the base of the costa, sometimes reddish along the costa, with silvery white markings: an oval to longish, oblique spot near 1/4, not reaching costa and inner margin; a narrow fascia at 1/2, slightly bent outwards across the whole width of the wing; a round spot at 3/4 across the half width of the wing, near, but not quite reaching costa; fringe coppery bronzy golden, lighter outside; hindwing bronzy golden, with a purple tinge, especially at the apex; fringe coppery with lighter tip; legs and abdomen dark brown, golden shining.

♂ **Genitalia.** Uncus moderately long, club-shaped, rounded; tegumen and accessory claspers fused together; accessory claspers broad, trapezoid; at the anterior margin on the tip of the accessory claspers a group of short, acute, bent spinoid setae, along the anterior margin a row of five longer, acute spinoid setae, the one to two distalmost distinctly separated; at the end of this row another group of a few short, acute, bent spinoid setae; valvae moderately long, somewhat stout, constricted medially, enlarged and spatulate-like at the end; on the inner surface two longer, acute, straight spinoid setae postbasally, a very short spinoid seta medially and two or three rows of short, straight spinoid setae with some long setae at the end.

♀ **Genitalia.** Tergite IX missing; sternite IX reduced to two very characteristic, elongated sclerotized platelets, which fuse together ventrally. Terminal papillae sclero-

tized in a band, somewhat bent outwards proximally; receptaculum seminis very long and slender, the second half enlarged, with typical striation.

Diagnosis. *M. fenestrellensis* can only be confused with *M. aruncella* in its geographic range. The ground colouration of *M. aruncella* is generally less reddish, the silvery drawings are smaller and less distinct, and females do not show any markings.

The male genitalia of *M. fenestrellensis* cannot be confused with any other species, and the sternite IX of the female is very characteristic for this species.

Distribution. So far, this species has been recorded only from the type locality (Italy, Piemonte, Fenestrelle, 1300–1600 m) and from Monte Tanarello (Briga (fr.)) at 2000 m (French and Italian border area, south of Cuneo, Piemonte).

Life history. At the type locality, the species occurs together with *M. trifasciella* in tall herbaceous vegetation around bushes.

Preimaginal stages. The early stages are unknown.

Micropterix osthelderi Heath, 1975

Micropterix osthelderi Heath, 1975: 256–258., figs 5–6. Type locality: Bavaria, Fürstenrud [Fürstenried] near Munich. Holotype ♂: Bav.mer., Fürstenrud [Fürstenried] b. München, Daniel, 24.iv.26 (examination of genitalia Heath No. 261); in coll. ZSM [examined].

Description of adults. Examined: 1♂, 7♀. Forewing length: ♂ 4.7 mm; ♀ 5.0–5.6 mm. Head dark-brown; vestiture of hair-like scales on the head light to dirty yellow; antennae brownish, bronzy golden shining, 3/4 (♂), respectively, 1/2 (♀) of forewing length; thorax bronzy golden; tegulae bronzy golden, mixed with purple scales; forewing purplish violet to bluish violet: the basal fourth dark golden to bronzy golden, except small purplish violet streaks at the base of the costa and towards the dorsal margin lying within the basal bronzy golden colouration which reaches the median fascia, and a bronzy golden streak from the costa along the outer margin, just leaving the tip of the apex purplish violet; the rest of the markings whitish golden to golden, finely bordered in bronzy gold: a moderately broad fascia of equal width at 1/2, slightly bent outwards; a small costal spot at 2/3; a big costal spot at 3/4, bent inwards and sometimes enlarged towards the centre of the wing; fringe light bronzy golden; hindwing bronzy golden with a strong purple colouration, especially at the apex; fringe bronzy golden; legs and abdomen brown, bronzy golden shining.

♂ **Genitalia.** Uncus short, stout, with a small tip; accessory claspers with a lower row of shorter spinoid setae, partly bent at the end, and an upper row of strongly modified Y-shaped thickened setae; valvae long, constricted medially, with probably two longer and some shorter, basal setae at the inner surface; two irregular rows of shorter spinoid setae and a row of longer setae at the distal third of the inner surface and many small spinoid setae at the tip of the valvae.

♀ **Genitalia.** Tergite IX missing, sternite IX reduced and very similar to *M. schaefferi*, just somewhat enlarged medially. Terminal papillae with a very characteristic sclerotization: margin towards segment IX medially enlarged outwardly, with smooth margins; ductus receptaculi at the beginning of the receptaculum seminis very slender; receptaculum seminis long, constricted medially and strongly bent, only the

last part enlarged like a sac, with a typical striation; receptaculum seminis with three very small spinoid setae at the end, lying side by side (this character was found in no other species); the shape of the receptaculum seminis and the number of spinoid setae are diagnostic.

Diagnosis. *M. osthelderi* can easily be separated from all other similar species, including *M. schaefferi*, by its broad, dark golden colouration at the forewing base, and by its fascia at 1/4, which is not brightened in the middle but shows the same (bronzy) golden colouration as the inner margin. Poorly preserved specimens can easily be recognized by the very characteristic male and female genitalia.

Distribution. According to Heath (1996) and Karsholt (2004) this species occurs in Italy, Germany, Switzerland, Austria, Poland, Czech Republic and Denmark. Heath (1975) records this species from the Alps (Austria, Switzerland, Bavaria) and from the uplands (Germany: Rheingau; Poland: Sudeten).

Life history. This species seems to inhabit mixed coniferous forest especially at montane elevations.

Preimaginal stages. The early stages are unknown.

Remarks. The paratypes of *M. osthelderi* (deposited in ZSM) include also specimens of *M. schaefferi*.

***Micropterix rablensis* Zeller, 1868**

Micropterix rablensis Zeller, 1868: 133. Type locality: Italy, Alps, south of Tarviso, Raibl. Holotype ♂: in coll. BMNH.

Description of adults. Examined: 10♂, 4♀. Forewing length: ♂ 3.0–3.4 mm; ♀ 3.25–3.8 mm. Head black-brown, vestiture of hair-like scales on the head dirty white, light yellowish grey to yellow; antennae brown, light reddish golden shining, 3/4 (♂), respectively, 2/3 (♀) of forewing length; thorax bronzy golden, tegulae bronzy golden, posteriorly coppery to purple; forewing reddish bronzy golden to purple, with three whitish golden to light golden, sometimes diffusely bordered fasciae across the whole width of the wing: a fascia at 1/4, slightly bent inwards, narrow at the costa and constantly broadening towards the inner margin; a broad, more or less straight fascia at 1/2, sometimes slightly enlarged inwards at the anterior third; sometimes a small costal spot at 2/3, which can be joined with the median fascia or with the outer fascia; a broad fascia at 3/4, often enlarged inwards in the middle; fringe coppery proximally, distally whitish golden; hindwing bronzy golden, sometimes with a slightly reddish to purple tinge; fringe slightly reddish to purple proximally, distally light golden; legs and abdomen light brown, golden shining.

♂ **Genitalia.** Uncus very short; beyond the uncus and inside the tegumen tufts of long, very acute hair-like setae; tegumen and accessory claspers fused, strongly developed; accessory claspers with a row of short, isolated, straight spinoid setae at the anterior margin, starting near the uncus; a row of short, acute, proximally straight, distally increasingly curved spinoid setae inside the lower posterior margin; anteriorly a short row of small, strongly modified, broad T-shaped (or hatched-shaped) thickened setae (starting at the anterior margin of the accessory claspers); proximally of these some

very small, acute, straight spinoid setae; valvae moderately long, slender, strongly constricted medially, the distal part spatulate, slightly bent upwards; a row of longer setae and two to three rows of short to very short, straight spinoid setae (proximally intergrading to a row of spinoid setae reaching the constriction) at the distal part on the inner surface.

♀ **Genitalia.** Tergite IX missing, sternite IX strongly reduced, weakly sclerotized in the middle distally, here partly without sclerotization (maybe characteristic for this species), partly with only indistinctly lateral margins. Terminal papillae with a sclerotized band; receptaculum seminis very short, narrow, at the beginning of the ductus receptaculi enlarged like a knot, distinctly constricted before the middle, enlarged into a sac in the last part; receptaculum seminis with striation along the entire length, but not very regular; a longer appendix at the end.

Diagnosis. *Micropterix croatica* Heath & Kaltenbach, 1984 is externally very similar to *M. rablensis*, but can be separated by its darker purple-violet ground colouration of the forewing, as well as by its more distinct, sharper markings. *M. rablensis* could be confused with small specimens of *M. aureatella* or *M. aureoviridella*. *M. aureatella* is darker purple-violet with smaller and distincter fasciae, *M. aureoviridella* shows mostly a less reddish colouration than *M. rablensis*, with indistinct markings and a bronzy golden inner margin. *M. rablensis* can be separated from both species by its broad outer fascia, which is mostly only an oval spot in *M. aureatella* and *M. aureoviridella*. Sometimes, small *M. allionella* can be confused with *M. rablensis*, which is normally smaller.

The male genitalia of *M. croatica* are very similar to those of *M. rablensis*, but can be separated besides other characters by their row of spinoid setae on the valvae, which reach the basal third. *M. myrtetella* is also related to *M. rablensis* and shows also a row of spinoid setae on the valvae postbasally, but the outer fascia of the forewing is reduced to a spot.

Distribution. *M. rablensis* is most probably restricted to Carinthia (Austria) and to the adjacent areas of Styria (Austria), of Italy (type locality) and potentially of Slovenia. According to Heath (1996) and Karsholt (2004), this species occurs in Italy and Austria.

Records from Romania (Heath 1996; Karsholt 2004) and Croatia (Karsholt 2004) are doubtful and probably belong to *M. myrtetella*. Also records from France (Viette 1948) turned out to be a misidentification (Heath in litt. according to Leraut 1980). All examined animals from Trieste (Italy) belong to *Micropterix croatica* Heath & Kaltenbach, 1984. A record of *M. rablensis* from the Traunstein (Upper Austria) in the ZOOBODAT seems to be very doubtful too. Pröse (1987) probably also refers to this record. An examination of this record has not been possible so far, but probably this is a misidentification of *M. aureoviridella*.

Life history. We have found this species at outskirts of forest with tall herbaceous vegetation and bushes, congregating on *Aruncus dioicus* (Walter) and *Vicia sylvatica* L.. In competition with *M. rablensis* on flowers of *Aruncus dioicus* (Walter), we also have found *M. aruncella*, *M. aureatella* and *M. rothenbachii*.

Preimaginal stages. The early stages are unknown.

***Micropterix myrtetella* Zeller, 1850**

Micropteryx myrtetella Zeller, 1850: 62. Type locality: Italy, Tuscany, Montenero near Livorno. Holotype ♂: in coll. BMNH.

Description of adults. Examined: 25♂ (incl. slide of holotype), 11♀. Forewing length: ♂ 2.2–2.8 mm, ♀ 2.7–3.0 mm. Head black-brown, vestiture of hair-like scales on the head dark yellow; antennae brown, bronzy golden shining, more than 3/4 (♂), respectively, 2/3 (♀) of forewing length; thorax bronzy golden; tegulae purple, mixed with bronzy golden scales; forewing purple to purplish violet, distally often lighter, with golden, delicately bronzy golden bordered markings: a broad fascia at 1/4 across the whole width of the wing, narrowing towards the costa and sometimes not quite reaching it; a broad fascia nearly at 1/2, bent outwards, sometimes narrowed or even interrupted in the middle; seldom a small costal spot at 2/3; a broad, irregularly formed spot at 3/4, extending from costa across somewhat more than the middle of the wing, this spot sometimes also indistinct or nearly atrophied; fringe golden, outside whitish; hindwing bronzy golden with a purple tinge; fringe bronzy golden, distally lighter; legs and abdomen brown, golden shining.

♂ **Genitalia.** Uncus short with a broad rounded tip; ventrally beyond and inside the tegumen a tuft of hair-like setae; accessory claspers very broad; along their anterior margin on the inner surface a row of short, straight spinoid setae, slightly bent at their end; at the lower end, somewhat separated basally, a second row of five or six short, straight spinoid setae; particularly stout setae have not been found; valvae moderately long, slender, constricted medially, the distal fourth spatulate to somewhat triangle-shaped and somewhat bent upwards; postbasally a row of three or four moderately long, nearly straight spinoid setae at the inner surface of the valvae; at the inner surface of the enlarged end a row of six or seven straight, short spinoid setae and some setae.

♀ **Genitalia.** Tergite IX missing, sternite IX reduced, strongly constricted medially, not characteristic. Terminal papillae with sclerotization in an indistinct band; receptaculum seminis short and stout, the second half like a sac, with typical striation; vestibulum moderately large, simple like a sac.

Diagnosis. *M. myrtetella* is very similar to *M. rablensis* and *Micropterix croatica* Heath & Kaltenbach, 1984 (all three species are of about the same size), but can be separated most easily by its golden spot at 3/4, which spreads across the whole width of the forewing.

The male genitalia of all three species are also very similar. *M. myrtetella* can be recognized by the less stout shape of the whole genitalia and by its distinctly pronounced uncus. Furthermore, the species can be separated from *M. rablensis* by its postbasal row of spines on the valvae. Very similar is *Micropterix trinacriella* Kurz, Zeller & Kurz, 1997 from Sicily, which can be distinguished easily by its genitalia. An undescribed species from central Italy (*Micropterix wockei* sensu auctorum) can be recognized for certainty only by examination of the genitalia.

Individuals from southern and south-eastern Greece show a strong reduction of the wing markings (lacking the spot at 3/4 and the fascia in the middle), also often with

a brighter purple colouration. They are considered to be a distinct subspecies (*Micropterix myrtetella idae* Rebel, 1902).

Distribution. According to Heath (1996) and Karsholt (2004) this species occurs in Italy, Austria, Hungary, Croatia, Macedonia, Yugoslavia, Romania, Bulgaria, Albania and Greece (see also Heath 1965b).

Some of these records may refer to *M. rablensis* or *Micropterix croatica* Heath & Kaltenbach, 1984. The records from Slovakia and Czech Republic (Karsholt 2004) seem to be doubtful.

The male specimen found in Austria (Gumpoldskirchen) has been verified by genitalic examination. Further confirmed records are from the type location in Italy, Croatia, Montenegro and Greece (NW-Greece, Pilion, Peloponnes).

Life history. This species inhabits outskirts of medium canopy height to tall, dense mediterranean woody shrubland. Also at the type locality (Italy, near Livorno, Montenegro) we found a female flying in Mediterranean maquis shrubland.

Preimaginal stages. The early stages are unknown.

Remarks. The holotype shows a small, but distinct costal spot at 2/3, a character missing in most other specimens, especially those from the Balkans.

A male of *Micropterix myrtetella idae* Rebel, 1902 from Peloponnes with dark scales on head (very similar to *M. aruncella*) also belongs to this species as recognized by its genitalia.



Figs 39–42. Typical habitats of some *Micropterix* species. **39.** Slope of moor with *Alnus* sp. association (*M. mansuetella*). **40.** Nutrient-poor meadow with grass, *Galium* sp., *Rumex* sp., and shrubs along the side of a path at the fringe of a spruce forest in the montane zone (*M. aruncella*). **41.** Edge of a spruce forest with areas of *Vaccinium* sp. and *Frangula alnus* in the lowlands (*M. aureatella*) **42.** Moist meadow with *Ranunculus* sp. and shrubs at the fringe of a lowland coppice forest (*M. calthella*).



Figs 43–46. *Micropterix* adults in their natural habitat. **43.** *M. mansuetella*. Specimen resting on *Alnus* sp.: Austria, Eastern Tyrol, Lienzer Dolomiten, Lavant, Kienbichl, June 10, 2004. **44.** *M. aruncella*. Specimen feeding on *Plantago media*. Austria, Vorarlberg, Bregenzer Wald, near Bezau, Sienspitze, upper Hinteregg-Alpe. **45.** *M. aureoviridella*. Specimen feeding on *Pinus mugo*. Austria, Vorarlberg, Rätikon, Lünnersee, near Douglashütte, 2000 m, July 30, 2004. **46.** *M. calthella* (♀, ♂). In copula. Austria, Salzburg, Flachgau, Köstendorf, Tannberg, from the summit to the Lassbergweg, May 15, 2005.



Figs 47–54. Forewings golden without any or with small silvery markings (first ♂, second ♀). **47–48.** *Micropterix calthella*. **49–50.** *M. isobasella*. **51–52.** *M. paykullella*, unicolourous form with strongly reduced markings, see also Figs 65–66. **53–54.** *M. aruncella*, typical form, see also Figs 55–56.



Figs 55–62. Forewings golden with silvery or coppery to purple markings (first ♂, second ♀). **55–56.** *Micropterix aruncella* f. *atricapilla*, see also Figs 53–54. **57–58.** *M. fenestrellensis*. **59–60.** *M. mansuetella*. **61–62.** *M. tunbergella*.



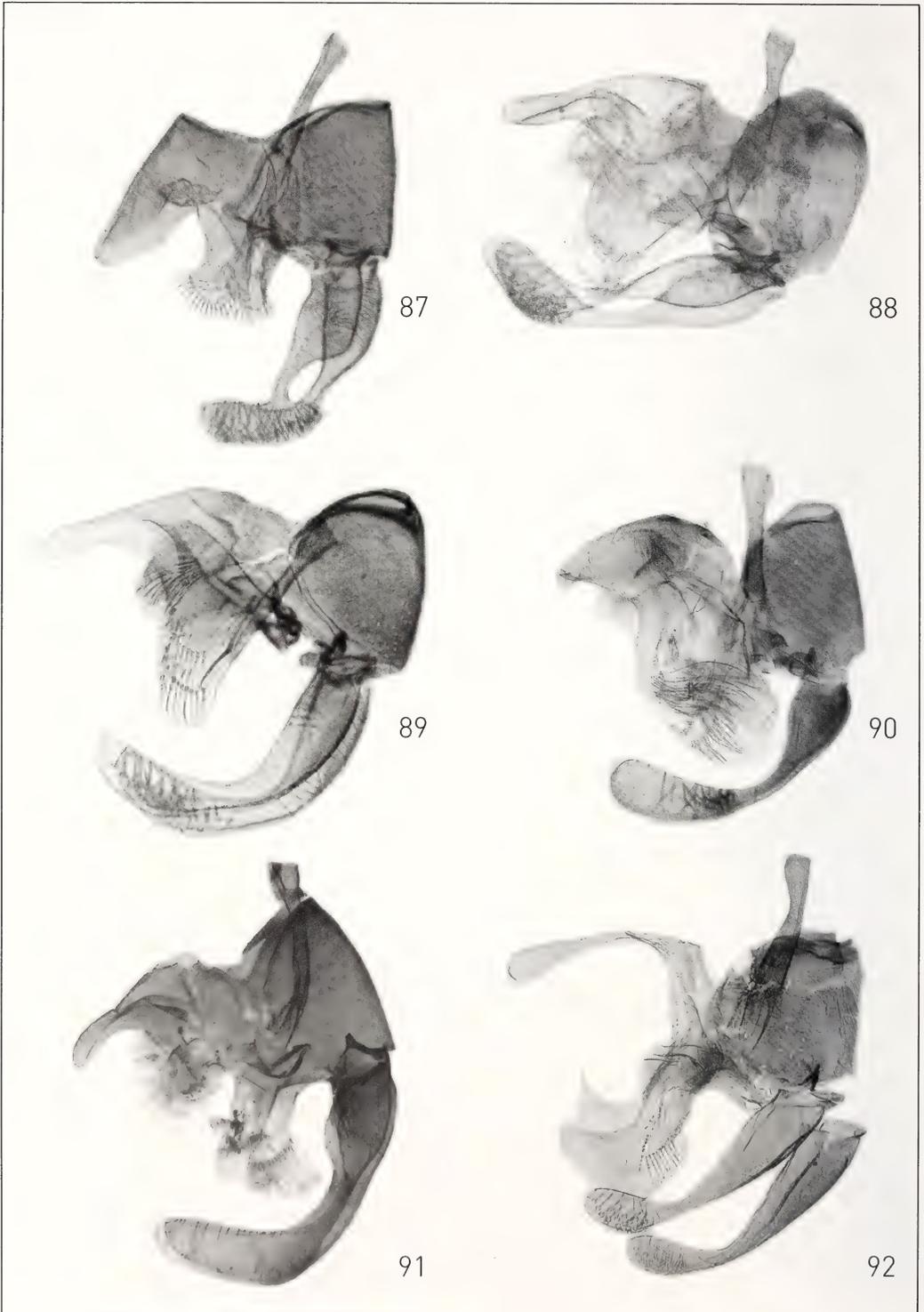
Figs 63–70. Forewings reddish golden to purple violet, with 2 golden fasciae and a spot at 3/4 (first ♂, second ♀). 63–64. *Micropterix aureoviridella*. 65–66. *M. paykullella*, typical form, see also Figs 51–52. 67–68. *M. aglaella*. 69–70. *M. aureatella*.



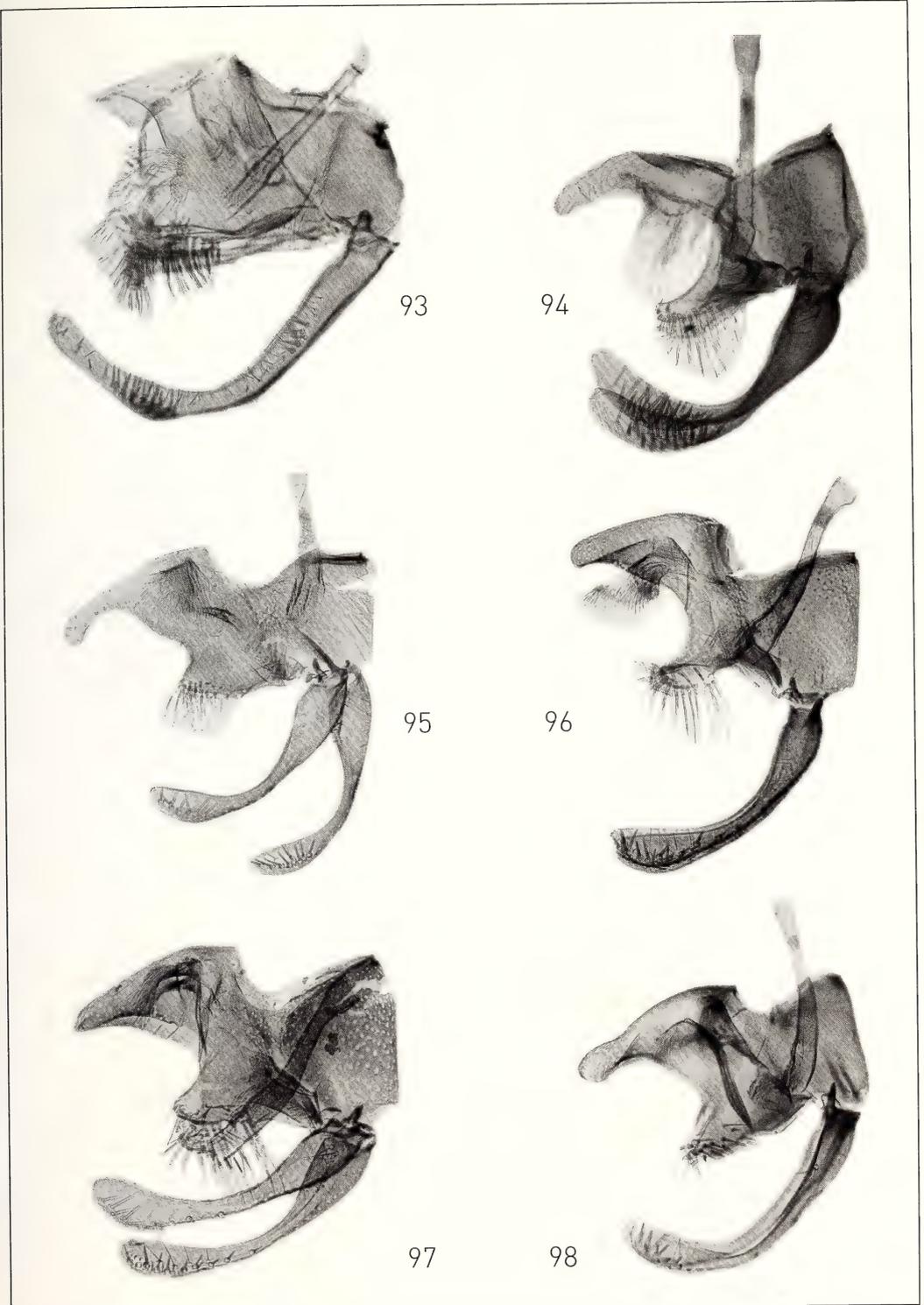
Figs 71–78. Forewings brownish golden to blue-violet with 3 fasciae (first ♂, second ♀). 71–72. *Micropterix rablensis*, ♂ with aberration on forewing. 73–74. *M. myrtetella*. 75–76. *M. trifasciella*, ♀ with aberration on forewing. 77–78. *M. huemeri*, not mounted.



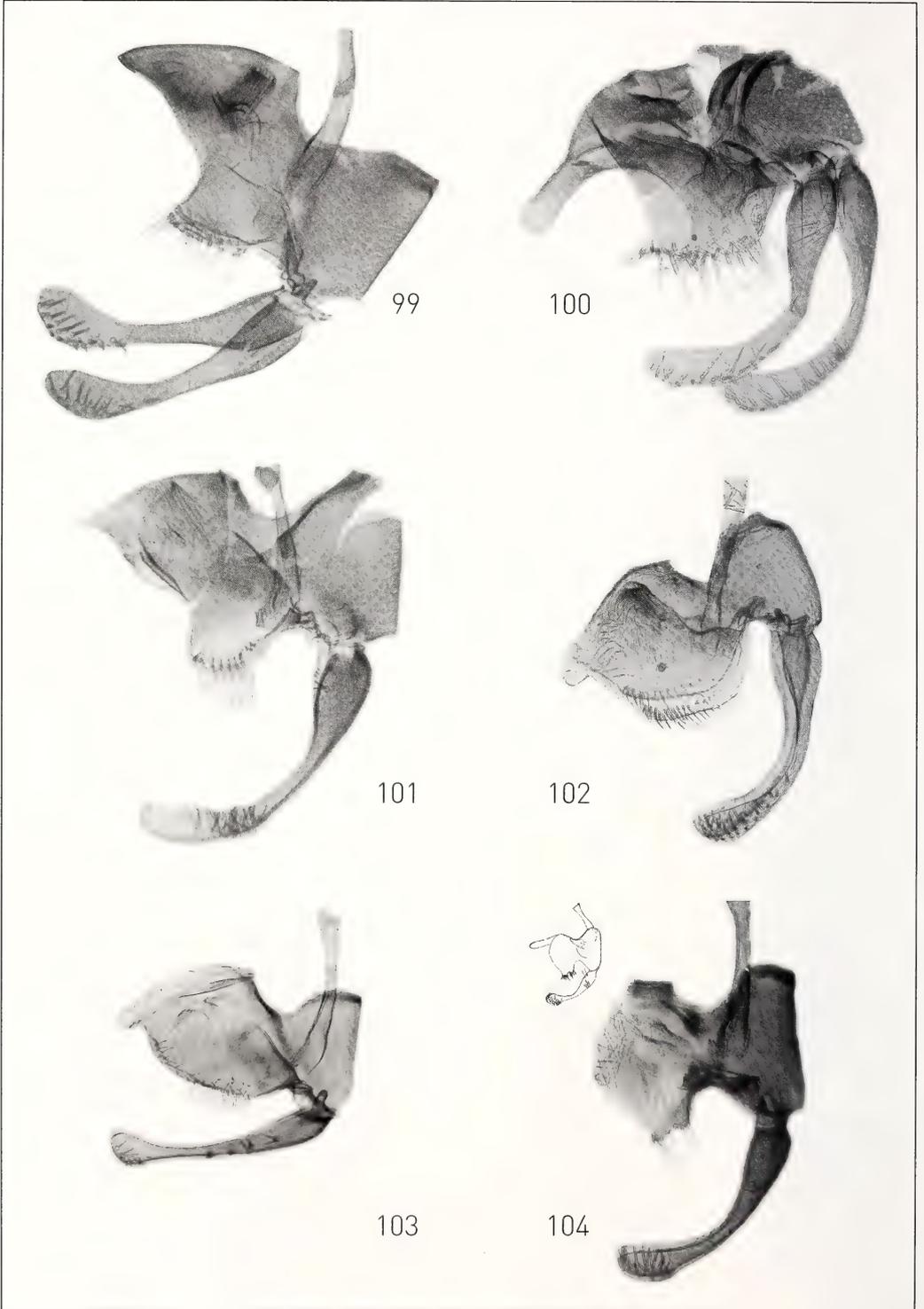
Figs 79–86. Forewings with additional golden drawings at the outer and/or at the inner margin (first ♂, second ♀). 79–80. *Micropterix allionella*. 81–82. *M. rothenbachii*. 83–84. *M. schaefferi*. 85–86. *M. osthelderi*.



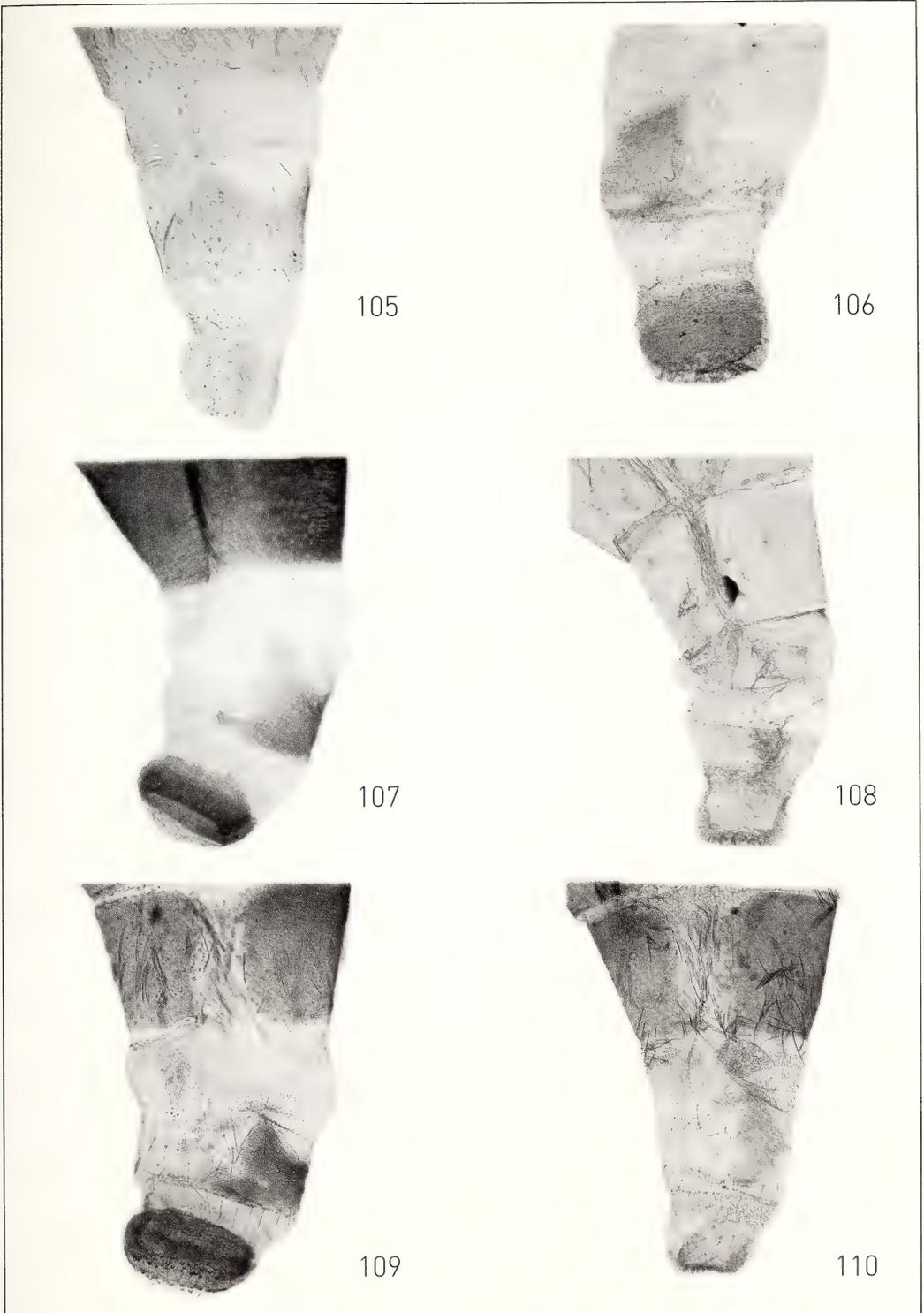
Figs 87–92. ♂ genitalia. 87. *Micropterix mansuetella*. 88. *M. calthella*. 89. *M. isobasella*. 90. *M. aglaella*. 91. *M. aureatella*. 92. *M. aruncella*.



Figs 93–98. ♂ genitalia. 93. *M. tumbergella*. 94. *M. aureoviridella*. 95. *M. paykullella*. 96. *M. allionella*. 97. *M. trifasciella*. 98. *M. rothenbachii*.



Figs 99–104. ♂ genitalia. **99.** *M. huemeri*. **100.** *M. schaefferi*. **101.** *M. osthelderi*. **102.** *M. rablensis*. **103.** *M. myrtetella*. **104.** *M. fenestrellensis* (uncus destroyed, see Fig. 20).



Figs 105–110. ♀ abdomen. **105.** *Micropterix mansuetella*. **106.** *M. calthella*. **107.** *M. isobasella*. **108.** *M. aglaella*. **109.** *M. aureatella*. **110.** *M. aruncella*.



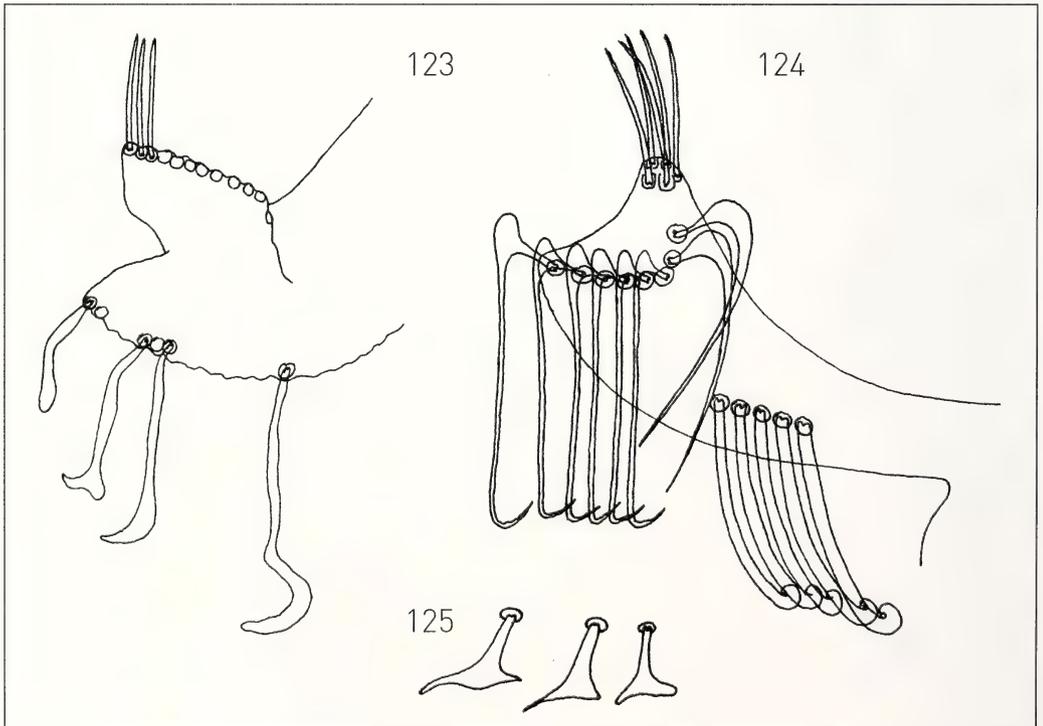
Figs 111–116. ♀ abdomen. **111.** *M. tunbergella*. **112.** *M. aureoviridella*. **113.** *M. paykullella*. **114.** *M. al-ionella*. **115.** *M. trifasciella*. **116.** *M. rothenbachii*.



Figs 117–121. ♀ abdomen. **117.** *M. schaefferi*. **118.** *M. osthelderi*. **119.** *M. rablensis*. **120.** *M. myrtetella*. **121.** *M. fenestrellensis*.



Fig. 122. Geographical area considered for this work.



Figs 123–125. Different forms of thickened setae on the accessory claspers. **123.** *M. aureatella*. **124.** *M. sicanella* (distinctly three groups of setae) **125.** *M. schaefferi*, T- or Y-shaped.

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Mating behaviour and copulation mechanisms in the genus *Scopula* (Geometridae: Sterrhinae)

PASI SIHVONEN

Käärmekuusenpolku 4 C 11, 02880 Veikkola, Finland; e-mail: pasi.sihvonen@aka.fi

Abstract. The mating behaviour and functional morphology of the copulatory organs in the sterrhine genus *Scopula* Schrank, 1802 (Lepidoptera: Geometridae) were studied in order to determine the role the male 8th sternite's specialized structures (sclerotized cerata and membranous mappa) play during copulation. The study included field observations, i.e. specimens studied *in situ*, and laboratory experiments using the Palaearctic species *S. immorata* (Linnaeus, 1758) and *S. frigidaria* (Möschler, 1869). It was found for *S. immorata* that mate locating behaviour is vagrant, i.e. males search for females, courtship behaviour is simple, copulation is carried out in the end-to-end position, taking place early in the morning (between 6 a.m. to 10 a.m.) and lasting between 60 and 90 minutes. Sclerotized cerata in *S. immorata*, especially the stout setae at their distal end, were found to brush against the sclerotized lamella antevaginalis of the female genitalia during copulation. The interaction of these structures suggests that the male organs are involved in the tactical sexual stimulation of the female. In *S. frigidaria* the structures associated with the 8th sternite of the male are rudimentary and do not touch the female at all. For neither species a mechanic function was observed for the mappa, and females of both species were found to be polygamous. During copulation the sclerotized parts of the internal genitalia of the male and female (cornutus and ductus bursae, respectively) were aligned to each other.

Introduction

Structures of the sclerotized parts of the genitalia are among the most important sources of character information in Lepidoptera systematics, their value being especially pronounced in alpha taxonomy. Despite the large amount of information that has been published on the morphology of these structures, we know little about their functional morphology. This mismatch has been acknowledged in the few papers that have been published on the subject (e.g. Miller 1988).

Pioneering works on copulatory mechanisms in Lepidoptera are those by Chapman (1916) and Stekolnikov (e.g. 1967) and Stekolnikov and Kuznetsov (1982), but undoubtedly the most remarkable contributions are those by Callahan (1958, 1960) and Callahan and Chapin (1960). These papers deal with a detailed analysis of copulation, spermatophore production, and egg formation in Noctuidae. A total of 11 species were examined, and a method of serial homology, or serial dissection, of moth pairs at various stages during copulation was presented.

Scopula Schrank, 1802 is a widespread and most species-rich genus in the geometrid subfamily Sterrhinae (Sihvonen & Kaila 2004). Currently over 800 species are considered valid, and the majority of species are presumably tropical (Sihvonen & Siljander 2005). Nearly all *Scopula* species possess sclerotized lateral appendices, called cerata (singular: ceras), on the 8th sternite of the males. Often these appendices are slightly curved inwards, of unequal length, and the apex of either one or both cerata bear a few stout setae (Fig. 4) (Hausmann 2004; Sihvonen 2005). Between the cerata lies a soft, flexible, membranous structure termed the mappa (Fig. 4). In most instances it is a bare structure, but a few species have long, flattened, scale-like setae in its caudal margin. The basal region of the 8th sternite, i.e. its cephalic part, often takes the form of

a sclerotized, convex, plate-like structure (Fig. 4). The cephalic margin of 8th sternite may be medially elongated, medially invaginated or trifid in shape (Sihvonen 2005). Similar structures are also found in closely related genera of Scopulini, for example in *Lipomelia* Warren, 1893, *Problepsis* Lederer, 1853, and *Somatina* Guenée, 1858 (Sihvonen 2005).

These structures of the male 8th sternite are species-specific in shape, and their value as a diagnostic tool in alpha-taxonomy is well recognized. As a result, they are routinely illustrated in taxonomic works (e.g. Covell 1970; Hausmann 2004). Interestingly, in a number of species the cerata are polymorphic, i.e. their length varies within a species, and relative proportions of different length morphs vary geographically (Hausmann 1999; 2004). The function of these peculiar, specialised structures has remained unknown, but Hausmann (1999) assumed that the 8th sternite may play a mechanical role during copulation, perhaps similar to that noted in the geometrid genus *Eupithecia* Curtis, 1825 (Larentiinae) (Mikkola 1994). Indeed, in fresh specimens or specimens that have been macerated with potassium hydroxide, the cerata of a number of species can be moved laterally. This movement is allowed by a loose, membranous abdominal cuticle at a point where the cerata join the base of the 8th sternite. In other words, the abdominal skin flexes when the cerata are moved laterally (unpublished, personal observation).

The purpose of this study is to document the mating behaviour of *S. immorata* (Linnaeus, 1758), and in particular to investigate what function the above-mentioned specialized pregenital structures may play during copulation. The latter aspect was studied with the aid of two species, *S. immorata* (Linnaeus, 1758) and *S. frigidaria* (Möschler, 1869).

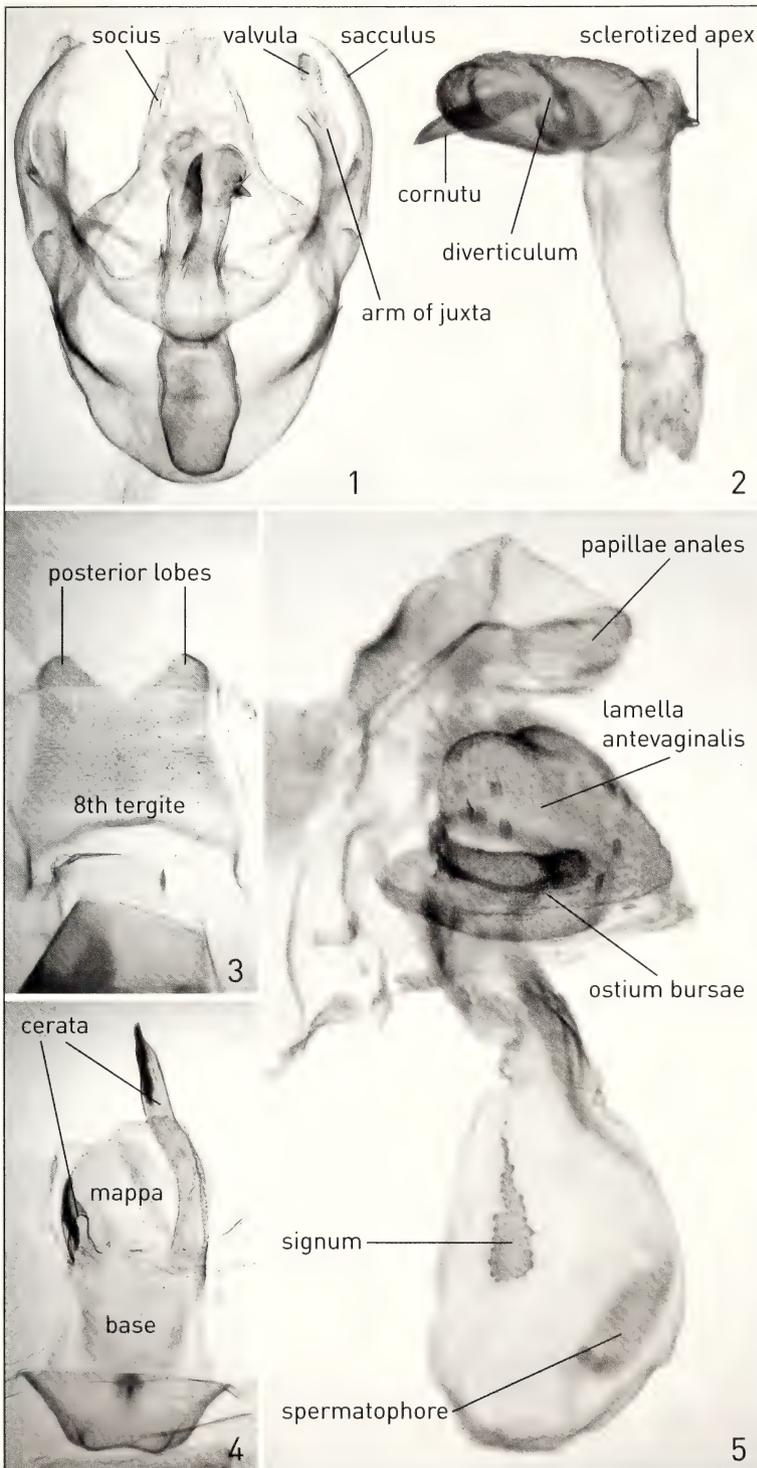
Material and Methods

The term 'functional morphology' has been used in the literature in various ways. I follow Naumann (1987) and use it to describe the interaction of male and female genitalia structures during copulation, i.e. the mechanism of copulation. The terminology for genitalia follows Covell (1970), Klots (1970) and Kristensen (2003).

Species studied and their genital structures

The two species were chosen for the study on the grounds that morphological structures of their genitalia are quite different (Figs 1–9). It was hoped that inclusion of morphologically different species might help to better understand the copulation mechanisms and the possible role of male's 8th sternite structure and so to allow wider interpretation of the results.

***S. immorata*.** A Euro-Siberian species, which is widely distributed in temperate areas. It is a thermophilous species preferring open habitats, including waste lands, meadows and road sides. The larva is polyphagous, feeding on withered leaves of herbaceous plants, for example on *Plantago* (Plantaginaceae), *Taraxacum* (Asteraceae) and *Hieracium* (Asteraceae) (Ebert 2001; Hausmann 2004). The species is usually bivoltine in June and August, except in the northern and mountainous areas of its distribution, where the second generation is incomplete or absent.



Figs 1–5. Male and female genitalia of *Scopula immorata*. **1.** Male genitalia and phallus in ventral view, coremata removed (slide PS1040). **2.** phallus, vesica everted (PS1041). **3.** 8th abdominal tergite (PS1041). **4.** 8th abdominal sternite (PS1041). **5.** Female genitalia in ventral view (PS1043).

Male genitalia (Fig. 1). Ovoid, symmetrical; socii membranous, covered with short setae; valvae consist of ventral sacculi, sclerotized and acute; and dorsal valvuli, membranous, blunt ending, setose. The sacculi have a small membrane at their proximal part allowing lateral movement. Juxta with large lateral arms, widest apically; vinculum large, U-shaped; transtilla weakly developed, membranous bridge. Phallus (Figs 1, 2) wide, straight; apex bearing one large and several small sclerotized teeth dorsoventrally; caecum slightly curved ventrally; vesica opens ventrally, with one large, blunt-ended diverticulum that opens to left (when viewed ventrally); cornutus large, acute; ductus ejaculatorius opens ventrally. 8th tergite weakly developed (Fig. 3); cerata of unequal length, apices covered with stout setae; mappa round; base partly concealed by membrane (Fig. 4). The cerata of this species have not been recorded to be polymorphic (Hausmann 2004).

Female genitalia (Fig. 5). Papillae anales soft, setose; apophyses posteriores and a. anteriores long; lamella postvaginalis sclerotized, narrow ring; lamella antevaginalis large, sclerotized, proximal membrane allows ventral movement; lamella antevaginalis conceals ostium bursae; ductus bursae wide, short, partly sclerotized; ductus seminalis ventrally from proximal part of ductus bursae; corpus bursae elongated sac; signum small, weakly spinulate. Female abdominal segments weakly sclerotized, undifferentiated.

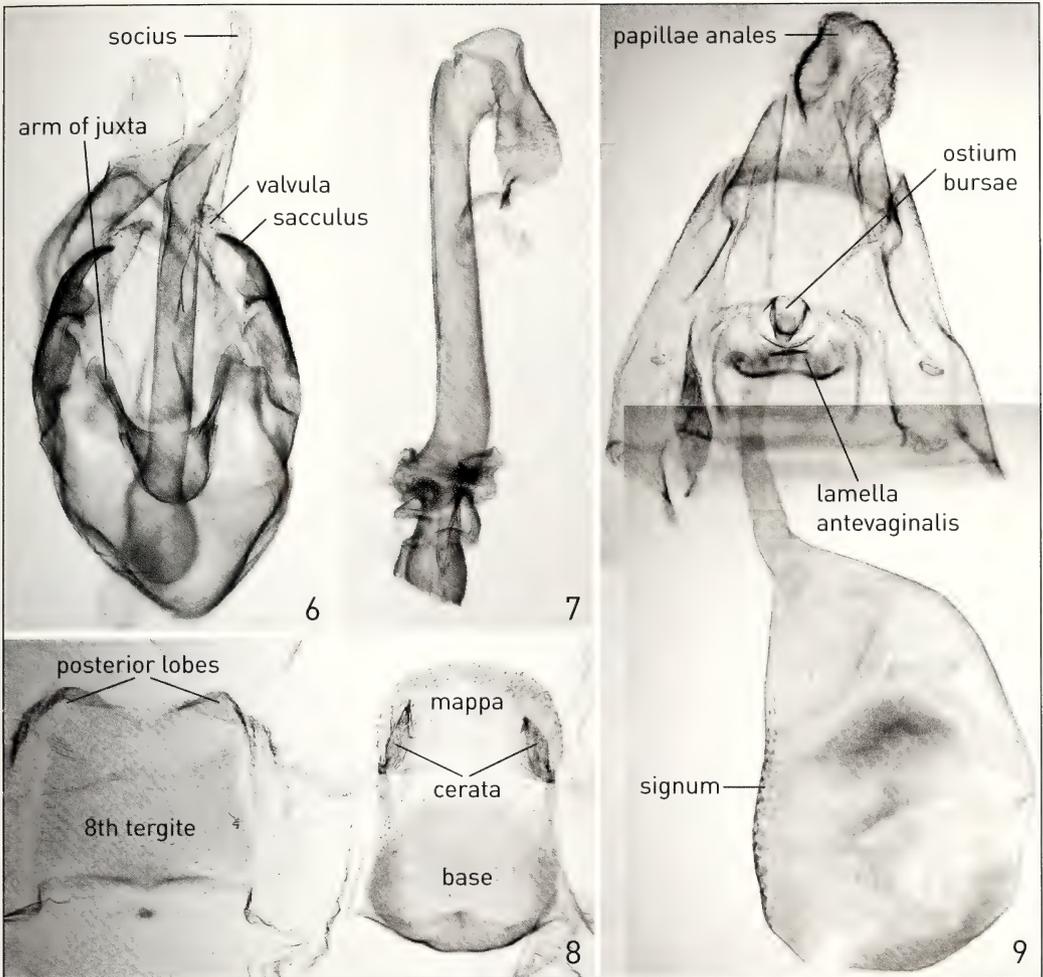
S. frigidaria. A Holarctic species, its distribution in the Palaearctic region being confined to its northernmost areas, whereas in the Nearctic region it is widespread from Alaska to Newfoundland. It occurs in open tundra habitats, but is also found in coniferous and mixed forests. In the Palaearctic region the larva has been recorded to feed on the leaves of *Vaccinium myrtillus* (Ericaceae), in the Nearctic region immature stages are unrecorded (Covell 1970). The species is univoltine from early June to late August.

Male genitalia (Fig. 6). Ovoid, symmetrical; valvae short, resulting in fused appearance; socii long, narrow, covered with setae; sacculi melanized, short, acute; valvuli short, membraneous, setose; juxta round, lateral arms short; vinculum large, U-shaped; transtilla weakly developed membranous bridge. Phallus (Figs 6, 7) long, narrow, caecum slightly curved ventrally; vesica simple sac, opening ventrally, without cornutus; base of ductus ejaculatorius weakly sclerotized. 8th tergite weakly developed (Fig. 8), cerata short, symmetrical; mappa round; base partly concealed by a membrane. The cerata of this species have not been recorded to be polymorphic (Hausmann 2004).

Female genitalia (Fig. 9). Papillae anales soft, setose; apophyses posteriores and a. anteriores long; lamella postvaginalis reduced; lamella antevaginalis narrow, horse-shoe shaped; ostium bursae small, sclerotized, cap-shaped lobe; ductus bursae unsclerotized; ductus seminalis ventrally from proximal part of ductus bursae; corpus bursae elongated sac; signum large, consisting of separate spinules or absent altogether. Female abdominal segments weakly sclerotized, undifferentiated.

Copulation experiments

Field experiments using *S. immorata*, including observations and material acquisition, were carried out at various sites in southern Finland between 2000–2005. Laboratory-



Figs 6–9. Male and female genitalia of *Scopula frigidaria*. **6.** Male genitalia and phallus in ventral view, coremata removed (PS1044). **7.** Phallus, vesica everted (PS1058). **8.** 8th abdominal segment (PS1058). **9.** female genitalia (PS1047).

bred specimens were reared in plastic cages, about 25 × 25 × 15 cm in size. When moths had emerged, the breeding cages were taken outdoors. The cages had small holes on their sides and on top, allowing female pheromones to disperse. No field or laboratory experiments of live specimens were carried out for *S. frigidaria*.

Entire mounts of copulating pairs were obtained from specimens caught *in situ* in the field, and from specimens that were bred from ova and which copulated in breeding cages. The specimens were anesthetized with chloroform and stored in a freezer. The abdomens were carefully separated from the thorax with the aid of fine scissors and macerated in a hot (7 mins at 92 °C) potassium hydroxide (KOH) solution. The abdomens and genitalia were dissected in 5% aqueous ethanol. Scales were removed from abdomens with help of fine brushes, the organs were stained with a weak solution of Chlorazol Black, and prepared following routine techniques (Hardwick 1950).

The male vesica was everted via the caecum that was cut open by placing the phallus inside a hypodermic syringe (Sihvonen 2001). The structures were preserved temporarily in glycerol, which allowed examination from various perspectives. They were subsequently transferred into ethanol tubes for 24 hours for glycerine removal and then mounted in Euparal. The cover glass was supported by small glass props. Structures were prepared using a Wild MZ6 stereomicroscope (maximum magnification 64x). Characters were examined using a Wild M10 (512x) and Leitz Diaplan phase contrast compound microscope (1560x).

The number of matings was assessed by counting the number of spermatophores stored in the female bursa copulatrix. The method relies on the assumption that only one spermatophore is transferred during each copulation (for criticisms, see Cordero 1999).

Results

Mating behaviour

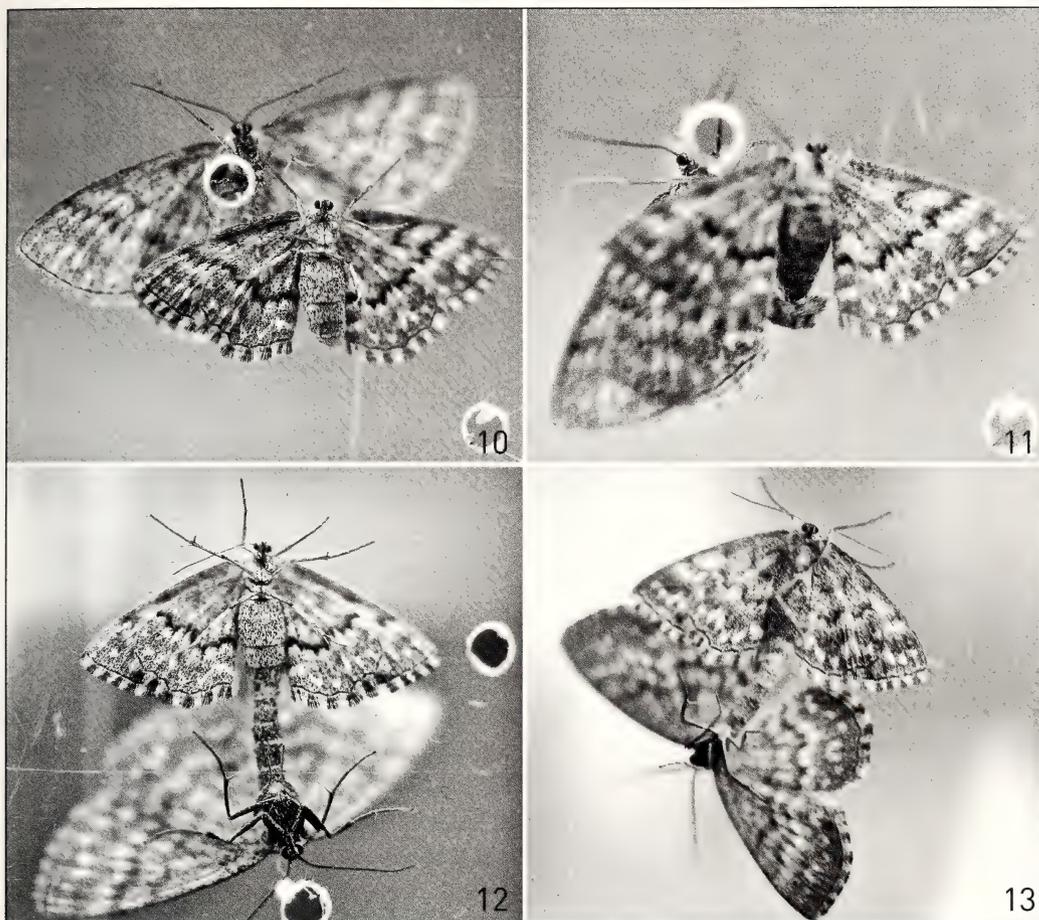
Males of *S. immorata* were found to express female-searching behaviour early in the morning, approximately from 6 to 10 a.m. This vagrant behaviour started soon, between one to five minutes, after sun had started to warm up the observation site. The males flew rapidly, just above the low vegetation, in a zigzagging manner towards the wind. Every now and then males landed in the vegetation, beat their wings swiftly a few times, and continued flying after a while.

Most females emerged from the pupa in the evening or during the night. They remained still and did not start to attract males until early in the morning, around 6 a.m. They stayed hidden in the vegetation, head facing upwards, and held the tip of the abdomen in an elevated position. After a male had located the female, they both remained with their heads upwards for a few seconds (Fig. 10), whereupon the male tried to locate the tip of the abdomen of the female, turning 180 degrees. To end up in this position, males always turned from the left-hand side (Figs 11, 12). It was when in this end-to-end position that the male attached its genitalia to the female and copulation started (Fig. 12). Copulation was observed to last 60 to 90 minutes ($n = 9$), and three phases were more or less identifiable each time:

- 1) Male moving its genitalia and 8th sternite back and forth (up and down), rubbing the cerata against the lamella antevaginalis of female. Cerata did not move laterally (Fig. 12).

- 2) Male moving its abdomen from side to side in a snake-like manner including both lateral and dorso-ventral moves (Fig. 12).

- 3). When viewed ventrally (as in Fig. 13), male turned slightly to 'left', thus male and female were at an angle of about 160 degrees. Stages one and two lasted about 15 minutes each, stage three lasted from five to ten minutes, after which the male detached itself from the female. After copulation was over, the female remained still until the following night, when oviposition took place. In three instances copulating pairs



Figs 10–13. Sequence of events occurring during copulation in *Scopula immorata* in ventral view. Pictures were taken through transparent plastic. **10.** Male approaches female by wing fanning, heads upwards (length of this phase is about 10 seconds). **11.** Male contacts and flexes abdomen toward female genitalia and starts to turn to end-to-end position (approx. 10 seconds). Male always turned to end-to-end position from left-hand side (when viewed ventrally). **12.** Copulation, end-to-end position (60 to 90 minutes). Male rubbed the cerata against the lamella antevaginalis of female, both back-and-forth and side-to-side movements were observed. **13.** End of copulation, male has tilted to left, abdomens are at an angle of 160 degrees (5–10 minutes).

remained attached to each other, in phase three (Fig. 12), until the following night. I found two copulating pairs in the field in the afternoon that were apparently in phase three of copulation. When disturbed, these separated from each other immediately and the male took to the wing.

It was noted that males were more active in sunny weather, on cloudy mornings most males were not eager to fly at all. Vagrant behaviour of males ended by 10 a.m. The same behaviour pattern was observed in the laboratory-bred specimens, when breeding cages were taken outdoors. Both males and females were active at dusk and during the night, and both sexes are attracted to light. Despite an intensive search in the field, and observations made in the laboratory, no mate searching behaviour was observed at dusk

and during the night. Neither sex was observed to feed on nectar plants. Females were observed to lay eggs from dusk until around midnight.

Field observations and laboratory experiments showed that in *Scopula* both sexes can copulate several times. Up to two spermatophores were found inside the corpus bursae of both studied species. One male *S. immorata* was observed to copulate with two different females under laboratory conditions. A further three males tried to copulate for the second time with a different female, but the proper copulation posture was not assumed.

Interaction of male and female genitalia structures during copulation

S. immorata. The membrane between the 8th abdominal segment and the genitalia is loose and partly folded. Prior to copulation, the male everts its genitalia from this membrane pocket, so that the end of its abdomen projects in a telescopic manner. Before the male inserted its phallus into the ostium bursae of the female, the valvae changed their position remarkably. The sclerotized, ventral sacculi were curved about 90 degrees medially and came into contact with the region of the female genitalia between the ventral margin of the ostium bursae and its ventral sclerotized ring. The membranous dorsal valvuli were curved even more, about 180 degrees ventrally and opened the lamella antevaginalis of the female genitalia, thus exposing the ostium bursae (Fig. 14). The lateral arms of the juxta came into contact with the areas lateral of the ostium bursae, apparently performing a support function. The socii were inserted into the membranous region between papillae anales and ostium bursae (Fig. 14).

During copulation phases one and two (Fig. 12), when the male moved its body from side to side and back and forth, it rubbed its cerata against the sclerotized lamella antevaginalis of the female (Fig. 14) (Note: The illustrated specimens were slightly distorted when they were placed under a cover slip for photography. As a result the male cerata do not touch the lamella antevaginalis in the picture). No lateral or pincer-like movements of the cerata were observed. At the same time the male inserted its phallus into the ostium bursae and started to evert its vesica. Also, the mappa was found to be adjacent to the lamella antevaginalis during copulation.

The vesica was everted into the cephalic part of the ductus bursae, beyond the branching point of the ductus seminalis (Fig. 15). The sclerotized teeth at the apex of the phallus and cornutus were found to rest in a position at the inner wall of the ductus bursae, corresponding to the sclerotized parts on the inner wall of the ductus bursae of the female genitalia (Fig 15, Table 1). This position was noted in all pairs examined. When fully everted, the vesica blocks the entire ductus bursae but it does not reach the corpus bursae. The spermatophore is formed in about 30 minutes and it is stored inside the corpus bursae (Fig. 5). The spermatophore is a simple, unsclerotized sac, which loosely fills the entire corpus bursae. The number of spermatophores found in the corpus bursae varied from zero to two, with most specimens having one. The material examined did not allow for conclusions to be made about the function of the signum.

S. frigidaria. As in *S. immorata*, the valvae of *S. frigidaria* changed their position quite remarkably (Figs 17, 18). The ventral sacculi were curved by about 90 degrees

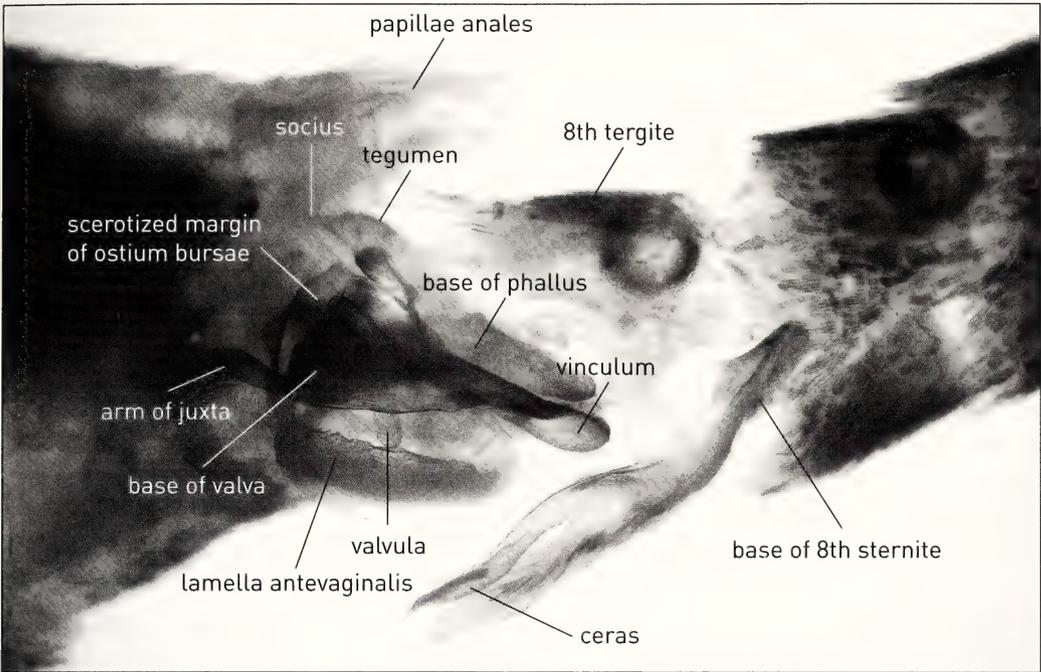


Fig. 14. Lateral view of *Scopula immorata* in copula (unstained) (PS 1059). Female is on the left, male on the right. Valvula of male valvae have turned ventrally by about 180 degrees and mechanically push open the lamella antevaginalis of female genitalia allowing phallus to penetrate into the ostium bursae. Afterwards, sclerotized cerata rub against sclerotized lamella antevaginalis.

medially and came into contact with the cap-shaped sclerotizations of the ostium bursae. The dorsal valvuli were curved even further, by about 180 degrees, and fit into the horse-shoe shaped pocket of the lamella antevaginalis. The socii were inserted on the sides of the papillae anales, the latter being pushed inwards towards the female abdomen.

The proximal part of the ductus bursae has a dorsal, half-ringed weak sclerotization, ventrally the ductus wall is membranous. The ductus bursae is concave in shape (when viewed through a cross-section of the ductus bursae). When the male inserts its phallus into the ductus bursae, the weakly sclerotized dorsal wall opens and the ductus bursae assumes a round shape. The number of spermatophores found in the corpus bursae varied from zero to two, with most specimens having one. Unlike in *S. immorata*, the rudimentary cerata and large mappa of male 8th sternite were not observed to have any mechanic function during copulation (Fig. 16).

Discussion

Mating behaviour. For a good number of Lepidoptera species, especially for those that are nocturnal and small, we do not know the basic attributes of their biology. Among those aspects are behavioural traits, and to give a concrete example, the timing of mating of the Small Tortoiseshell (*Nymphalis urticae*) was discovered only a few years

ago, despite this being a common and familiar species that occurs widely throughout the Palaearctic region. Males of this species search for females in bright daylight, and when a female is found, the pair fly into a sheltered place and the actual copulation takes place around midnight (Mikkola *et al.* 2005). A similar lack of basic biological information for *S. immorata* made it difficult to study the mechanisms of its copulation because it was unknown at what time of the day copulation takes place. Rearing experiments revealed that mate location and copulation take place in the early morning sunshine. This was against the *a priori* assumption that a nocturnal species is likely to copulate during the dark hours of the day.

It is unknown what kind of mate locating behaviour is predominant in the large, cosmopolitan genus *Scopula*. The strategy where males search for passive females in the morning sunshine, is here reported for *S. immorata*. In addition, I have made similar field observations for the Palaearctic *S. ternata* (Schrank, 1802) and *S. floslactata* (Haworth, 1809) (unpublished). The vagrant strategy, combined with early morning activity, may therefore be a common strategy at least for the North Palaearctic species of the genus.

The courtship behaviour of *S. immorata* was found to be simple; after the male had located the female, copulation occurred in a tail-to-tail position (the male remained facing in the opposite direction as the female). The tail-to-tail position is typical for most Lepidoptera (for an overview, see Phelan & Baker 1990; for exceptions see Charlton & Cardé 1990). It is likely, however, that more complex and interactive courtship behaviour prior to copulation is widespread in *Scopula* and related genera of Scopulini. The reason for this is that unlike in *S. immorata*, which has vestigial hair pencils on its hind legs, males of a number of other Scopulini species possess specialized, eversible scent emitting structures in their hind tibiae, termed hair pencils (Hashimoto 1992, Sihvonen 2005). Some of these secondary sexual structures are very pronounced, e.g. in *Scopula urnaria* (Guenée, 1858, illustrated in Sihvonen 2005). Further, a few species of closely related genera possess eversible scent structures on the male 8th abdominal segment (e.g. *Pseudasellodes fenestraria* (Guenée) or on the hind wings (e.g. *Crypsityla quinquelineata* (Dognin), illustrated in Sihvonen & Kaila 2004). Possibly, species whose males either lack or have vestigial scent-emitting secondary sexual characters, such as *S. immorata*, have a simple courtship behaviour whereas species with such structures have a more complex and interactive courtship behaviour. In an extensive comparative study that was carried out on phycitine moths (Pyalidae), it was found that all species displaying the interactive courtship pattern possessed male scent-disseminating structures on the forewing and/or the eight abdominal segment, whereas those species engaging in a simple courtship had neither of those structures or only vestiges of them (Phelan & Baker 1990).

Functional morphology of the male and female genitalia. The specific function of the male 8th sternite in *Scopula* and closely related genera during copulation is still unclear. Mikkola (1994) suggested for certain species of North American *Eupithecia*, which possess species-specific structures similar to cerata, that the recognition function between sexes during the early phase of copulation has shifted from the valvae to

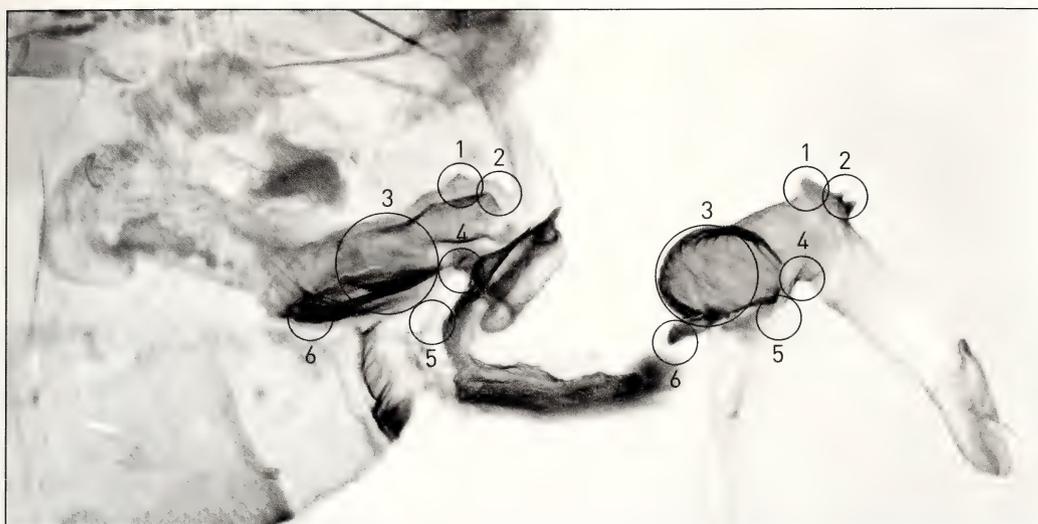


Fig. 15. Lateral view of female genitalia (left, PS1060) and male phallus (right, PS1041) of *Scopula immorata*. The structures are turned to show the anatomical correspondence during copulation. During copulation sclerotized structures of male phallus and female ductus bursae were adjacent to each other, see Table 1 for details.

Tab. 1. Corresponding anatomical structures of male and female internal genitalia of *Scopula immorata*.

No.	Male phallus and vesica	Female bursa copulatrix
1.	Apex of phallus sclerotized, projecting	Slightly sclerotized projection in the ductus bursae
2.	Apex of phallus with dorsal teeth	Ductus bursae slightly sclerotized dorsally
3.	Diverticulum in phallus	Ductus bursae wide
4.	Ventral margin of phallus angled	Ventral margin of ductus bursae angled
5.	Ductus ejaculatorius opens ventrally	Ductus seminalis opens ventrally
6.	Cornutus at apex of vesica (direction in slides variable)	Ductus bursae sclerotized ventrally and laterally

these structures. This hypothesis is supported by the observation that valvae of those *Eupithecia* species are simple and uniform, compared to Lepidoptera valvae in general, which are often species-specific in structure. The material I examined does not allow to draw conclusions for or against this proposed recognition function.

The hypothesis of Hausmann (1999) that the male 8th sternite may play a mechanical role during copulation is confirmed but the exact function remains unexplained. It was observed that sclerotized cerata of the male, especially the stout setae at their distal end, come into contact with the sclerotized lamella antevaginalis of the female during copulation. The male moves the distal end of the abdomen laterally and back-and-forth in a snake-like manner, with the result that the cerata rub against the sclerotized lamella antevaginalis. This mechanical movement suggests that the male organs are likely to be involved in tactical stimulation of the female. Besides sclerotizations of the female, I have failed to find any other morphologically detectable surface or cuticular structures

that could be sensory in nature. To achieve this conclusion, I have studied unsclerotized areas in 15 female *S. immorata*, in addition to routine dissections of female genitalia of more than 400 *Scopula* species.

It is emphasized that the cerata of *S. immorata* are non-articulated at their cephalad part, therefore I doubt that the male can move its cerata independently without moving its abdomen. There are a number of *Scopula* species, e.g. *S. floslactata* (Haworth, 1809), *S. transsecta* (Warren, 1898) and *S. submutata* (Treitschke, 1828), to mention a few, whose cerata are mediocephalically unsclerotized and which are articulated to a loose abdominal skin fold at the base of the 8th sternite. It is likely that those species are capable of moving their cerata *passively* in a pincer-like manner when they come into contact with female abdomen. This kind of ability to move sclerotized structures of the male 8th sternite, similar to cerata, has been suggested for certain North American species of *Eupithecia* (Mikkola 1994). The study was not based on *in situ* experiments, and it remained unverified whether the male could move those structures actively or not.

As was mentioned in the Introduction, in a number of *Scopula* species the cerata are polymorphic, i.e. their length varies within a species, and relative proportions of different length morphs vary geographically (Hausmann 1999, 2004). This polymorphism of genitalia observed by Hausmann (1999, 2004) is unique among insects; I have managed to find data only on a species of Thysanoptera (thrips), in which winged and apterous male specimens differ remarkably with respect to the size of their genitalia (Mound *et al.* 1998), on water striders (Arnqvist & Danielsson 1999) and on *Selenia tetralunaria* (Hufnagel, 1767) (Geometridae: Ennominae), in which the genitalia showed negative allometry in relation to body size (Mutanen & Kaitala 2006). The latter argue, however, that although genital dimorphism is rarely documented, it is quite expected. The scarcity of observations may be partly as a result of circular reasoning as species are often delimited by differences in genital characteristics (Mutanen & Kaitala 2006). The observed scrubbing function of the cerata in *S. immorata* does not offer clues that could explain the possible role of cerata in polymorphic species. If the main function of cerata is mechanic in nature, then in specimens with short cerata these most likely cannot perform the same mechanic function as in specimens with long cerata. If the main function of cerata is sexual stimulation or titillation, then polymorphism of this organ may be quite common within the species, or even expected, if one accepts that the main evolutionary force affecting genitalic diversification is sexual selection (Arnqvist 1997; Jocqué 2002; for a review on the subject see Hosken & Stockley 2004). Specifically, according to the cryptic female choice hypothesis of Eberhard (1985, 1996), polyandrous females are able to control the sperm that fertilize their eggs, and males with the best ability to stimulate females during copulation are favoured. A study on the subject by Arnqvist and Danielsson (1999) dealt with fertilization success and the shape of male genital sclerites (plates) in a water strider when females mated with two males. After controlling for body size, it was found that sclerite shape influenced fertilization success. Further, the sexual selection hypothesis predicts that genitalia of species with polyandrous mating systems should be more divergent than those of monandrous species (see Arnqvist 1998). These findings and hypotheses are relevant in the context of this paper, because against this theoretical setting species of *Scopula*, and also of

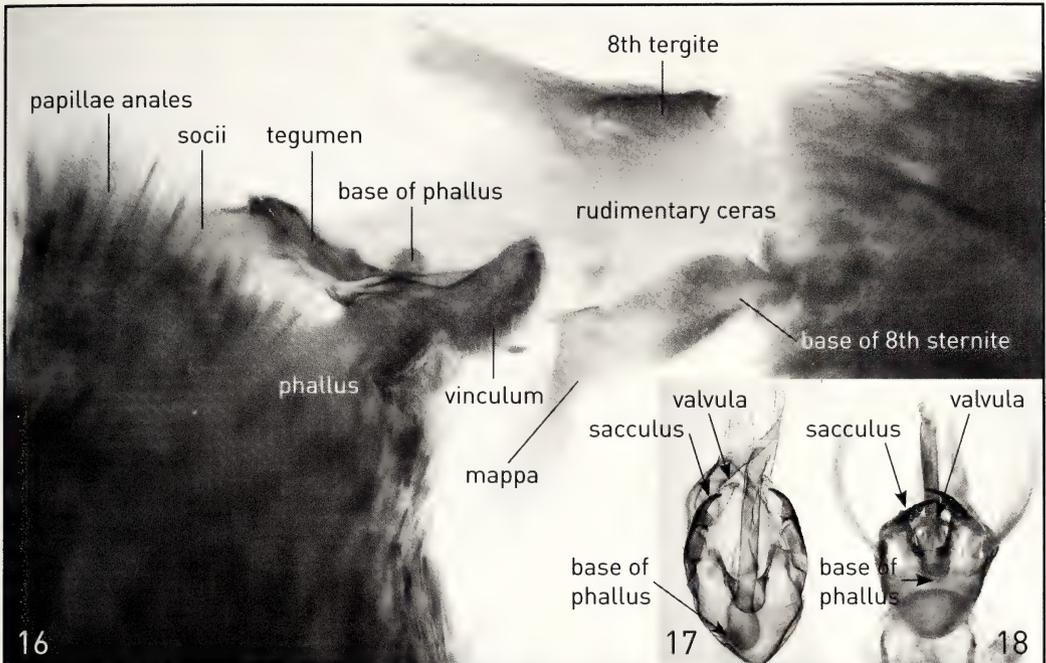


Fig. 16. Lateral view of *Scopula frigidaria* in copula (unstained). Female is on the left, male is on the right. Rudimentary cerata do not touch female genitalia during copulation.

Figs 17–18. Male genitalia in ventral view. **17.** Position of sacculus, valvula and phallus before copulation (PS1040). **18.** Position of sacculus, valvula and phallus during copulation (PS414).

Scopulini in general, seem a very attractive target group for experiments studying the mechanisms of genitalia diversification. It would be interesting to know how monandry (if it exists in *Scopula* and in Scopulini) vs. polyandry of *Scopula* and Scopulini species correlates with polymorphic vs. non-polymorphic genitalia (see Arnqvist 1997). For this purpose detailed experiments on their basic biology need to be carried out. In non-polymorphic *S. frigidaria* the cerata are rudimentary and apparently do not come into contact at all with the female genitalia during copulation.

The male genitalia have a rather fused appearance in *Scopula*, in a number of species this is due to the reduction in length of the valvae and enlargement of the immobile vinculum. Thus it was quite surprising to learn that the sacculi and valvuli of the valva are flexible structures (Figs 17, 18). Especially the latter undergoes a quite drastic change in posture when the valvuli turn by 180 degrees ventromedially and they mechanically ‘open’ the lamella antevaginalis of the female genitalia before copulation (Fig. 15). Prior to copulation, the socii provide a dorsal support, and the lateral arms of the juxta provide lateral support for the male and female genitalia. The support function of the juxta in general is pronounced in many North American species of *Scopula*, e.g. in *S. inductata* (Guenée, 1858), *S. luteolata* (Hulst, 1880) and *S. sideraria* (Guenée, 1858) (illustrated in Covell 1970), where the juxta is transformed into an elongated, round tube that corresponds to the sclerotized ductus bursae of the female genitalia. This is not unique in Lepidoptera, however, but more typically precopulation support is pro-

vided by a combination of uncus and valvae. When copulation proper occurs, i.e. the male has everted its vesica into the bursa copulatrix of the female, the support function is further facilitated by internal genitalia. This is also true for *S. immorata*.

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The nomenclature of the family-group names of Eupterotidae (Bombycoidea)

WOLFGANG A. NÄSSIG^{1,3} & ROLF G. OBERPRIELER²

¹ Entomologie II, Forschungsinstitut und Museum Senckenberg, Senckenberganlage 25, D-60325 Frankfurt am Main, Germany; e-mail: wolfgang.naessig@senckenberg.de

² Zimmerman Fellow, CSIRO Entomology, GPO Box 1700, Canberra, ACT 2601, Australia; e-mail: rolf.oberprieler@csiro.au

³ Studies in Eupterotidae no. 6

Abstract. The origin and historical use of all family-group names pertaining to the bombycoid family Eupterotidae are determined. The family-group name Eupterotidae takes Swinhoe, 1892 as authorship, although the name was evidently originally coined by Hampson, 1893. However, three older family-group names are available for the taxon: Striphnopterygidae Wallengren, 1858, Phialidae Wallengren, 1865 and Janidae Aurivillius, 1892. Striphnopterygidae has been used as the valid name for the family by at least ten authors until at least 1965 and again in 2006, and as a valid subfamily name throughout, but the younger Eupterotidae gained almost universal acceptance as the name of the family in the literature since about 1928. Application of Article 35.5, introduced in the current, 4th edition of the Code (ICZN 1999), allows the retention of the younger name Eupterotidae as the valid name of the family. The authorship of another bombycoid family name, Lemoniidae, is corrected from Hampson, 1918 to Neumoegen & Dyar, 1894.

Introduction

The bombycoid family Eupterotidae contains about 53 genera, the majority of them occurring in the Ethiopian and Oriental regions but a few also in the eastern Palaearctic, the Australian region and Central America. The classification and phylogeny of the group remains inadequately studied, the major recent works being Forbes (1955), Minet (1994) and Oberprieler et al. (2003). The family was deemed to be monophyletic by Minet (1994) and Lemaire & Minet (1998) based on three synapomorphies, but Oberprieler et al. (2003) demonstrated that two of them cannot be regarded as such, leaving the family defined on a single (weak) character and its monophyly under some doubt. However, a recent study of the phylogenetic relationships of the Anthelidae (Zwick 2006) provides some molecular support for the monophyly of the Eupterotidae.

The division of the family into natural subfamilies and tribes is also not yet settled. Following Aurivillius (1901a), early classifications (e.g., Distant 1903; Gaede 1927) generally recognised only two subfamilies, Striphnopteryginae and Janinae, although American authors often also included *Apatelodes* Packard, 1864 and related genera in Eupterotidae as a subfamily Apatelodinae (e.g., Grote 1896; Forbes 1923; Remington 1954). In his revision of the entire family, Forbes (1955) added to it the Australian Panacelinae and Asian Prismostictinae and divided the Eupterotinae into five tribes, Janini, Tissangini, Eupterotini (including *Striphnopteryx*), Phialini and Cotanini. Minet (1994) again restricted the concept of the family by excluding Apatelodinae and Prismostictinae and recognised five subfamilies: Hibrildinae, Tissanginae, Janinae, Eupterotinae (including Striphnopteryginae) and Panacelinae (including Cotanini). Oberprieler et al. (2003) included Tissanginae and Hibrildinae in Janinae and Cotanini in Eupterotinae, treated Striphnopteryginae as a separate subfamily and identified an informal “*Ganisa* group” that does not fit into any of the formal subfamilies.

Apart from these taxonomic issues, the nomenclature of the family is also subject to some confusion, regarding both its valid name and its precise authorship. This issue resurfaced recently when the older name Striphnopterygidae was again used for the family (Mielke & Casagrande 2006), despite changes introduced to the latest edition of the International Code of Zoological Nomenclature (ICZN 1999) designed to preserve the stability of widely used family-group names when threatened by older but less often used ones. In this paper we clarify the nomenclature and synonymy of all the family-group names applying to the taxon Eupterotidae. The authorship of another bombycoid family name, Lemoniidae, is corrected at the same time.

The family-group names

The reference point to the use of the family name Eupterotidae in all recent literature appears to be Fletcher & Nye (1982: viii), who gave its authorship as “Swinhoe, 1892”. Earlier works, however, either explicitly (Aurivillius 1894b, 1901a; Dyar 1895; Distant 1903; Bryk 1944; Griveaud 1962) or seemingly implicitly credited the name to “Hampson, 1892”. Neither Swinhoe nor Hampson stated specifically that they established a new family, but they were evidently in contact with each other at the time and seemingly coordinated their classification systems. In his preface, Hampson (1893b: iii) wrote that he hoped to have “evolved” a natural classification scheme of the Heterocera, to replace the outdated one of Guenée, and he provided a description of the family Eupterotidae, whereas Swinhoe (1892) only gave the family name and, in the preface to his work, thanked Hampson for “working out the genera”. Shortly before he had still treated *Eupterote* in Lasiocampidae (Swinhoe 1891), the usual classification by British authors at the time (e.g., Butler 1881; Moore 1883; Cotes & Swinhoe 1887; Kirby 1892). Also Distant (1892), describing a new species in Eupterotidae, thanked Hampson for deciding its “true generic position”. No contemporary author ever credited Swinhoe with the family name, and therefore it appears that it was, in fact, Hampson who originally coined the name Eupterotidae. However, the *Moths Volume 1* of the *Fauna of British India* series, in which Hampson’s description of the family Eupterotidae was published, only became available in 1893 (see Fletcher & Nye 1982, Nässig & Nye 1991, and the bibliographical notice of Butler 1893), and hence both Swinhoe (1892) and Distant (1892) published the name Eupterotidae before Hampson. In both these works the name meets the conditions of Art. 11.7.1 of the Code (ICZN 1999) and is thus available. Swinhoe’s *Catalogue* only bears a publication date of 1892, but the preface is dated 1 October and the copy in the Macrolepidoptera Sectional Library of the Natural History Museum, London, is annotated “Nov 4th” in Hampson’s handwriting (Kitching, pers. comm. 2007), taken here as the earliest day on which the work is demonstrated to have been in existence as a published work (Art. 21.3). Hampson’s (1893a) bibliographical notice of Swinhoe’s *Catalogue*, issued in January 1893, confirms that the latter was indeed published in 1892. The publication date of Distant’s (1892) paper is given in the journal as “November 1892”, for nomenclatural purposes deemed to be the 30th November (Art. 21.3.2). Consequently, the name Eupterotidae must take Swinhoe, 1892 for its authorship.

Hampson may have simply based the name of the family on the oldest included genus, *Eupterote* Hübner, 1820, but, although no such origin is cited, he may also have taken the concept from Hübner's original name "Eupterotae". In fact, Grote (1896: 45) explicitly credited the name Eupterotidae to Hübner, not to Hampson. Hübner (1820: 187) used the plural noun "Eupterotae" in his category of *Verein*, or *Coitus*, and included in it two species, *Eupterote fabia* Cramer and *E. petosiris* Cramer. Hemming (1937: 16) established that Hübner's *Coitus* is equivalent to the genus category in modern nomenclature, and "Eupterotae" must therefore be regarded as the original citation of the genus name *Eupterote* Hübner, 1820 ("1816"). Furthermore, plural nouns merely referring to members of a genus are not considered valid family-group names (Art. 11.7.1.2). Therefore, the family name Eupterotidae cannot take Hübner, 1820 for its authorship.

Describing numerous new genera of moths particularly from the expeditions of Delegorgue and Wahlberg in southern Africa, Wallengren (1858: 210) proposed a new family, "Fam. Striphnopteryges", for two new genera, *Striphnopteryx* from "Caffraria" (South Africa) and *Festra* from "N. Hollandia" (Australia), the latter a synonym of *Chelepteryx* Gray, 1835 ("1836"), now placed in Anthelidae. A few years later he supplied a proper description of the family (Wallengren 1865: 28) and added the genus *Homochroa* Wallengren, 1858 (a junior synonym of *Phyllalia* Walker, 1855, and a junior homonym; see Fletcher & Nye 1982). In the same paper he also described another new family, "Fam. Phialidæ Wallengr.", for a "new" genus, *Phiala* (already validly described by Wallengren 1860, see Fletcher & Nye 1982, and a junior subjective synonym of *Euchera* Hübner, 1825 ("1816"), see Vári et al. 2002: 150, 219). Wallengren (1875) later described another species of *Phiala* in the Phialidae and Aurivillius (1879) a new genus, *Trichophiala*. Aurivillius (1892: 195) proposed another new family, Janidae, for a new species of *Jana* Herrich-Schäffer, 1854 ("1850–1858") from Cameroon. The *Häfte* 2–3 of vol. 13 of the Entomologisk Tidskrift, in which this family name was published, was issued on 1 June 1892, Janidae thus also taking priority over Eupterotidae Swinhoe, 1892. Aurivillius (1893) placed some other African genera in Janidae and also the Asian genus *Melanothrix* C. & R. Felder, 1874 (Aurivillius 1894a) but then synonymised both Phialidae and Janidae with Striphnopterygidae (Aurivillius 1894b). The family name Janidae was afterwards apparently only used three times, by Strand (1911a, b) and, somewhat surprisingly, Aurivillius (1921).

Aurivillius was a firm proponent of the principle of priority in taxonomic nomenclature, which was, at the time, not yet officially entrenched in a universal code of zoological nomenclature (ICZN 1999: XXI). Being familiar with the African as well as the Asian faunas of bombycoids, Aurivillius further concluded that Wallengren's Striphnopterygidae and Phialidae, his Janidae and Hampson's Eupterotidae together constituted a "natural unit", which had to take the oldest Striphnopterygidae as its valid name, and he clearly tabulated this synonymy of family names (Aurivillius 1894b: 185). He consistently used Striphnopterygidae in all his later publications dealing with this group of moths (Aurivillius 1901a, b, 1904, 1905a, b, 1906, 1909, 1910, 1911, 1914, 1925a, b), and this concept and name was also adopted by many contemporary German-speaking authors (e.g., Karsch 1895, 1898a, b; Weymer 1909; Grünberg 1910; Strand 1909, 1911c, 1927; Schultze 1915; Krausse & Wolff 1919), but not by, e.g., Semper (1896), Rebel (1900,

1914) and the authors of the chapters on Eupterotidae in Seitz' *Gross-Schmetterlinge der Erde* (Grünberg 1911; Strand 1922; Gaede 1927; Draudt 1928). English-speaking authors, however, used the name Eupterotidae throughout, often dealing only with the Asian or Australian fauna (the "true" eupterotines) (e.g., Hampson 1896, 1918; Bethune-Baker 1904, 1908; Swinhoe 1905; Rothschild 1917a; Turner 1922, 1947) but sometimes also including African (striphnopterygine and janine) genera (Butler 1898; Hampson 1910; Rothschild 1917b; Platt 1921). Distant (1903) was an exception in using Striphnopterygidae for the South African fauna. The American authors, too, following Schaus (1894), placed their *Apatelodes* (or Apatelodinae) in Eupterotidae and apparently always used this name (e.g., Dyar 1895, 1901; Grote 1896; Fracker 1915; Forbes 1923), except Holland (1920), who placed African taxa in Striphnopterygidae. In some cases the use of the name Eupterotidae may have arisen out of ignorance of Aurivillius' work, but in others (e.g., Rebel 1900; Hampson 1901; Gaede 1927) it evidently flowed out of a rejection or disregard of the priority principle. After Aurivillius' death in 1928, Striphnopterygidae almost completely disappeared from the literature as a family name in favour of Eupterotidae (e.g., Candèze 1927; de Joannis 1929; van Eecke 1930; Mell 1930, 1937; Golding 1940; Bryk 1944; Sevastopulo 1944; Remington 1954; Forbes 1955; Berger 1958, 1980; Griveaud 1962; Kuznetsov 1967; Fletcher 1968; Brock 1971; D'Abbrera 1974; Fontaine 1975; Pinhey 1975; Holloway 1976, 1987; Dall'Asta 1979; Fletcher & Nye 1982; Inoue et al. 1982; Barlow 1983; Vári & Kroon 1986; Holloway et al. 1987, 2001; Nässig 1989, 1995, 2000; Viette 1990; Common 1990; Nielsen & Common 1991; Scoble 1992; Kishida 1992; Minet 1994; Oberprieler & Duke 1994; Becker 1996; Edwards 1996; Lemaire & Minet 1998; Heppner 1998; Kroon 1999; Deml & Nässig 2001; Robinson et al. 2001; Vári et al. 2002; Oberprieler et al. 2003; Fu & Tuzuo 2004), although Striphnopteryginae persisted as a valid subfamily name throughout (e.g., Gaede 1927; Fontaine 1975; Pinhey 1975; Vári & Kroon 1986; Oberprieler et al. 2003). A lone exception was Taylor (1949, 1950, 1951, 1957, 1961, 1965) in South Africa, who continued using Striphnopterygidae as the name of the family. No further uses of this family name have come to light until the recent bibliographic catalogue of ordinal names in Lepidoptera (Mielke & Casagrande 2006), which again listed Striphnopterygidae as the valid family name over Eupterotidae.

Additional family-group names were proposed in the Eupterotidae by Forbes (1955) – Tissangini, Cotanini and Panacelinae (seemingly also Phialini, not cited as of Wallengren, 1865) –, and Minet (1994) added Hibrildinae, proposed as a family by Berger (1958). None of the family-group names pertaining to this taxon of moths is contained in the official lists of valid names in zoology (Hemming & Noakes 1958a; Melville & Smith 1987; Smith 2001; ICZN 2006) or in the index of rejected and invalid family-group names (Hemming & Noakes 1958b). Their priority is as follows:

Striphnopterygidae Wallengren, 1858: 210 (type genus: *Striphnopteryx* Wallengren, 1858)

Phialidae Wallengren, 1865: 33 (type genus: *Phiala* Wallengren, 1860 [= *Euchera* Hübner, 1825 ("1816")])

- Janidae Aurivillius, 1892 [1 June]: 195 (type genus: *Jana* Herrich-Schäffer, 1854 (“1850–1858”))
- Eupterotidae Swinhoe, 1892 [4 November]: 408 (type genus: *Eupterote* Hübner, 1820 (“1816”))
- Tissangini Forbes, 1955: 98 (type genus: *Tissanga* Aurivillius, 1903)
- Panacelinae Forbes, 1955: 120 (type genus: *Panacela* Walker, 1865)
- Cotanini Forbes, 1955: 131 (type genus: *Cotana* Walker, 1865)
- Hibrildidae Berger, 1958: 73 (type genus: *Hibrildes* Druce, 1888).

The valid family name

From the above overview of the history of the family-group names pertaining to the taxon in question we conclude that:

- the name Eupterotidae, although evidently originally coined by Hampson, takes Swinhoe, 1892 for its authorship;
- when the genera *Striphnopteryx*, *Euchera* (= *Phiala*), *Jana* and *Eupterote* are placed in the same family-group taxon, Striphnopterygidae Wallengren, 1858 is the oldest available family-group name for it;
- Striphnopterygidae Wallengren, 1858 was used as the valid name for the family by at least ten authors until at least 1965, and again in 2006, and as a valid subfamily or tribe name continuously into the present;
- the junior synonym Eupterotidae Swinhoe, 1892 gained almost universal acceptance as the name of the family after about 1928, the priority of Striphnopterygidae, Phialidae and Janidae being overlooked or ignored.

In strict compliance with the Principle of Priority (ICZN 1999, Art. 23), the name of the family taxon in question should therefore be Striphnopterygidae. The moderation of this principle as regulated by Art. 23.9 (reversal of precedence) does not apply, as the conditions of Art. 23.9.1.1 are not met since Striphnopterygidae has been used as a valid family-group name well after 1899. A further moderation of the priority principle specifically in the family-group category was added in the current, 4th edition of the Code (ICZN 1999), preserving, after 1999, prevailing usage of a younger name when threatened by an older name in use for a category of lower rank (Art. 35.5). However, since this moderation is not specifically included in Art. 23, and Art. 35.5 does not explicitly state that it moderates Art. 23, only the general statement in Art. 23.1 “unless ... another name is given precedence by any provision of the Code” provides grounds to regard Art. 35.5 as a valid moderation of Art. 23. Further ambiguity exists in Art. 35.5 in that it stipulates that the older name (of the lower-ranked taxon) has to be “in use” and, in the example given, that its precedence over the younger name (of the higher-ranked taxon) is maintained (only) as long as both names “are used for different subfamilies [= lower-ranked taxa] within the [family, = higher-ranked taxon]”. This implies that, if the older name is not in use for a separate taxon (i.e. is a plain older synonym of the same taxon), Art. 35.5 does not apply and the matter has to be settled by application of Art. 23.

In Eupterotidae, Art. 35.5 is readily applicable as, in the current classification system (Oberprieler et al. 2003), the older name is in use for a different lower-ranked taxon (subfamily Striphnopteryginae) than that denoted by the younger name (subfamily Eupterotinae), and the name in prevailing usage for the higher-ranked taxon (family Eupterotidae) is therefore to be maintained. Before 2000, i.e. before Art. 35.5 came into existence, the family would have had to be called Striphnopterygidae, in compliance with Art. 23.

In this group of moths, the current family-group names and their synonymies (following Oberprieler et al. 2003) therefore are:

Family Eupterotidae Swinhoe, 1892

Subfamily Janinae Aurivillius, 1892 (= Tissanginae Forbes, 1955; = Hibrildinae Berger, 1958)

Subfamily Striphnopteryginae Wallengren, 1858 (= Phialinae Wallengren, 1865)

Subfamily Eupterotinae Swinhoe, 1892 (= Cotaninae Forbes, 1955)

Subfamily Panacelinae Forbes, 1955

The confusion surrounding the names of this family, and the time and effort spent on resolving it, highlight the urgent need for stabilisation of the Lepidoptera family-group names and their authorships. The only currently available attempt to do so (Fletcher & Nye 1982, and other volumes of the *Generic Names of Moths of the World* series) is clearly inadequate; only for the Noctuoidea a more complete catalogue has recently been compiled (Speidel & Naumann 2005).

As a further example, the bombycoid family name Lemoniidae does not take Hampson, 1918 for its authorship (Fletcher & Nye 1982: viii) but in fact Neumoegen & Dyar, 1894 (as Lemoniinae – Neumoegen & Dyar 1894: 121), thus avoiding the invocation of Art. 35.5 to preserve this family name over Sabaliidae Hampson, 1901 (in the current concept of the family Lemoniidae). Likewise, the correction of the family-group name Lemoniidae Kirby, 1871, based on the riodinid butterfly genus *Lemonias* Hübner, 1807, to Lemoniadidae by Hall & Heppner (1999, as Lemoniadini) had already been effected a century earlier by Rebel (1900), who then also proposed a new family Lemoniidae for *Lemonia* Hübner, 1820 (“1816”). Rebel (1900) therefore did not create a homonym with Kirby’s name, but he evidently did not know that Neumoegen & Dyar (1894) had already proposed this family name earlier, and a homonymy between the Kirby and the Neumoegen & Dyar family-group names thus existed only between 1894 and 1900 – even though Rebel (1914) himself later incorrectly used “Lemoniidae” for the butterfly group again.

An analogous situation involving family-group names in Coleoptera was addressed by the compilation of a comprehensive synopsis of family and subfamily names (Lawrence & Newton 1995). While necessitating a number of name changes at the time (under the previous edition of the Code), this list provides an invaluable reference point to beetle family-group names and their authorships and greatly stabilises their nomenclature. We believe that a similar effort is urgently needed in Lepidoptera. The recent bibliographic catalogue of ordinal names (Mielke & Casagrande 2006) provides a first step in this direction but needs to be expanded to the family level.

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Geographical variation and Pleistocene history of the *Erebia pandrose* – *sthenny* complex (Nymphalidae; Satyrinae)

FRANS CUPEDO

Processieweg 2, NL-6243 BB Geulle, Netherlands; e-mail: frans@cupedo.eu

Abstract. The *Erebia pandrose-sthenny* complex consists of two taxa: *pandrose*, with a Eurosiberian, arctic-alpine disjunct distribution, and *sthenny*, hitherto considered a Pyrenean endemic. Their taxonomic status is uncertain because of their strictly allopatric distributions. The discovery of a *sthenny*-like population in the Alps was cause for the present re-examination of the geographical distribution of typical *pandrose* and *sthenny* characters, in 43 populations covering the whole geographic range of the *E. pandrose-sthenny* complex. The investigated populations indeed split up into two taxonomical units, *pandrose* and *sthenny*. The latter is not confined to the Pyrenees, but also inhabits the southeastern Alps, the Durmitor (Montenegro) and the southern Altai (Kazakhstan). No sympatric occurrence of *pandrose* and *sthenny* was found. In the Alps, *pandrose* and *sthenny* are separated by a belt of intermediate populations, resulting from intermingling in a zone of contact. Apparently they are not reproductively isolated. **Pleistocene history.** Both *pandrose* and *sthenny* have a Eurosiberian distribution, resulting from spread in the glacial trans-palaeartic tundra belt, and subsequent shrink and disruption of the occupied area during interglacial times. As, however, *pandrose* and *sthenny* are not reproductively isolated, they cannot have occupied the tundra simultaneously. Consequently their expansion has to be dated back to different glacial periods. Two arguments point to *sthenny* as the first to have established its actual distribution: (i) The *sthenny* populations of the Pyrenees, the Alps and the Altai show morphological differentiations, in wing design, wing shape, and in one genital character, whereas *pandrose* is uniform throughout its territory. The *pandrose* populations differ merely in the extent of *sthenny* traits, resulting from former gene exchange. (ii) Today, *pandrose* is still inhabiting the northern region of the Alps, bordering the previous tundra zone, whereas *sthenny* occupies refugial areas in the southern Alps, completely cut off from its former dispersion route. It is argued that the spread of *sthenny* must date back to (at least) the Mindel glaciation (MIS8), and the spread of *pandrose* to (at least) the Riss period (MIS6). The main argument being that colonization of the Apennines (from the western Alps) and the Balkans (from the southern Carpathians) must date (at least) from the Würm glacial (MIS2-4), which implies that *pandrose* already lived in the Alps and the Carpathians during the Riss-Würm interglacial (MIS5). Scandinavian populations are completely intermediate. *Sthenny*, present since the end of the Mindel glaciation, survived the Riss glaciation on the southern edge of the polar ice cap, where it interbred with *pandrose*. At the end of Riss, Scandinavia was repopulated by these mixed populations. **Taxonomy and nomenclature.** As *pandrose* and *sthenny* are not reproductively isolated, they have to be considered conspecific. The hierarchical structure of *E. pandrose* is best reflected in taxonomy by creating two groups of subspecies, according to art. 6.2 of the ICZN, which should be named *Erebia pandrose (pandrose)* and *Erebia pandrose (sthenny)*. Alpine and Scandinavian intermediate populations are arbitrarily placed in the *pandrose* group. Within the *pandrose* group, *ingana* Fruhstorfer, 1911 is shown to be a junior synonym (**syn. n.**) of *pandrose* (Borkhausen, 1788). Within the *sthenny* group, *infraclara* Verity, 1953 is shown to be a junior synonym (**syn. n.**) of *marmolata* Dannehl, 1927. The South Altai population of the *sthenny* group is described as *narymica* **ssp. n.**

Introduction

The geographical distribution pattern of oreo-tundral species is the result of repeated cycles of areal expansions and contractions, generated by Pleistocene climatic fluctuations (De Lattin 1967). During glacial times the arctic tundra shifted southwards, extending into a continuous trans-palaeartic belt between the polar ice sheet and the southern mountain systems (Pyrenees, Alps, Carpathians, Caucasus, and Altai). Not only tundral species, but also part of the populations inhabiting these mountain systems spread into the tundra. In many cases this led to oreo-tundral (arctic-alpine) disjunction, and/or to long-distance expansion in an east-west direction, resulting in a Eurasian dis-

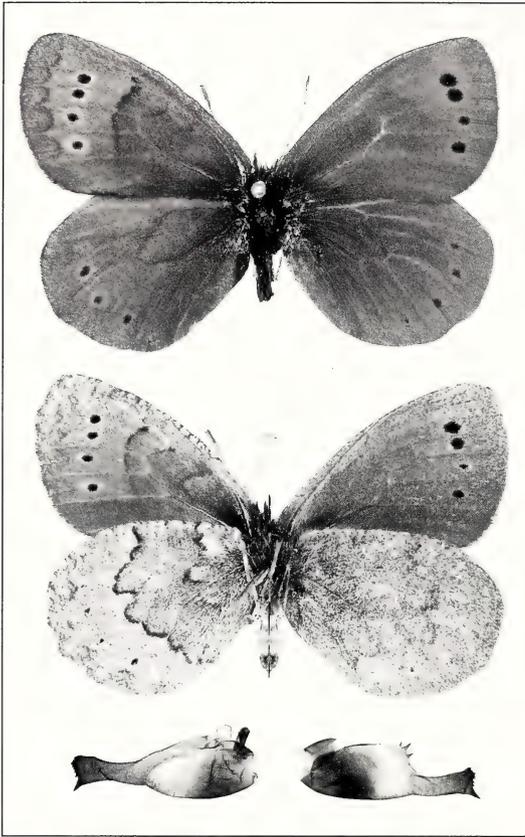


Fig. 1. Typical upperside, underside and valve of *pandrose* (left) and *sthenny* (right).

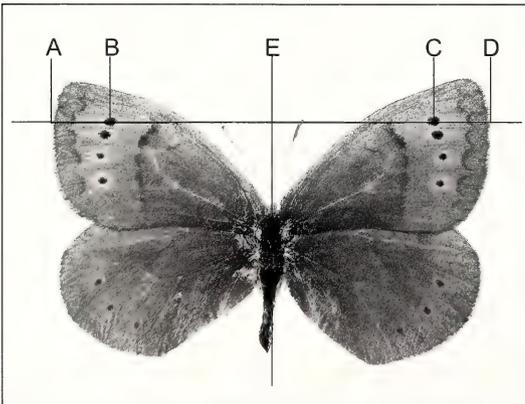


Fig. 2. Ocelli position. The ratio AB/AE was calculated from the measured AD and BC .

tribution (De Lattin 1967; Kostrowicki 1969). Arctic-alpine disjunction and Eurasian distribution are strongly correlated (Varga 1996), as both result from tundra dispersion during glacial periods. In addition, populations inhabiting the southern mountain ranges could survive in spatially restricted peripheral refugia. These were characterised by the vertical distance between the ice-surface and the snowline being sufficient to enable permanent settlement of alpine organisms in between. Through the pioneering work of Penck & Bruckner (1909, first published in separate issues 1901–1908) detailed data on glacier altitude and snowline altitude on the outskirts of the Alpine ice sheet became available for the first time. Soon, locations of potential refugia were reconstructed, and distributional areas of alpine plant species were related to them (Chodat & Pampanini 1902; Briquet 1906; Brockmann-Jerosch & Brockmann-Jerosch 1926). Meanwhile, the location of those potential refugia has been refined (Stehlik 2000; Schönswetter et al. 2005), and postglacial dispersal routes in the Alps have been reconstructed for a considerable number of plants (Stehlik 2003, Tribsch & Schönswetter 2003) and a few alpine animal taxa. In the latter, such reconstructions have been based on molecular markers (e.g., Schmitt & Hewitt 2004, Vila et al. 2005, Schmitt et al. 2006) or morphological characters (Holdhaus 1954, Cupedo 2004).

This paper deals with the *Erebia pandrose-sthenny* complex, which consists of two, closely related taxa, *pandrose* (Borkhausen, 1788) and *sthenny*

(Graslin, 1850). Because of strong morphological similarities they are widely considered conspecific (Warren 1936, Manley & Allcard 1970, Gómez Bustillo 1974, Higgins 1975, Leraut 1980). Because of certain constant differences, however, both in genital

characters and in wing design, some authors consider them specifically distinct (Willien 1990, Kudrna 1986, Lafranchis 2000). Biological evidence for either of these views is lacking.

Erebia pandrose is a tundra and high mountain species with a Eurosiberian distribution (Warren 1936, Kostrowicki 1969). The European part of the area is oreo-tundra disjunct. The tundra component includes Scandinavia and the adjacent Russia, as far as the Kanin peninsula (Warren 1936) and Kolguev Island (Tatarinov & Dolgin 1999). The oreal area is fragmented: it comprises the Alps, Pyrenees, Apennines, Carpathians, and the Balkan mountains. The Asian subarea is exclusively oreal, and is confined to the Altai-Sayan mountain range. The species is absent from the East Palaearctic tundra. Records from the Caucasus (Kostrowicki 1969) have not been confirmed and are supposedly erroneous (Nekrutenko 1990, Tuzov et al. 1997). *Erebia sthenno* has only been recorded from the central Pyrenees, where it lives in close proximity to *Erebia pandrose* (De Lesse 1952).

In the 1990's, however, the author found several populations in the southern Alps that, according to both male genital characters and wing design, belong to *sthenno*. They probably remained unnoticed because since Warren (1936) genital characters of alpine *pandrose* populations never received serious attention, as these were a priori considered not to belong to *sthenno* (Verity 1953, Varga 1971, Roos & Arnscheid 1976). As a result our actual knowledge of the geographical distribution of typical *pandrose* and typical *sthenno* characters is incomplete. This paper presents the results of a re-examination of a large number of populations, covering the whole geographical range of the *E. pandrose-sthenno* complex, and based on a predefined set of differentiating morphological characters. It aims to establish the actual geographical distribution of typical *pandrose* and typical *sthenno* characters, in order (i) to determine the validity of the taxa *pandrose* and *sthenno*, (ii) to examine to what extent their Pleistocene history can be reconstructed, based on distributional data, and (iii) to work out the taxonomic and nomenclatural implications of the results.

Abbreviations

ZMAN = Zoological Museum Amsterdam (NL); MNHL = Nationaal Natuurhistorisch Museum Leiden (NL); CFC = Collection Frans Cupedo, Geulle (NL); CSC = Collection Sergei Churkin, Moscow (RU); SP = Number of spines per valve; OP = Ocelli Position; FWD = Forewing Design; HWD = Hindwing Design; MIS = Marine Isotope Stage.

Material and Methods

Samples were studied from 43 localities. See table 1 and figure 3. (Tables in the appendix). Five differentiating *sthenno* characters have been quantified and measured as follows (figure 1; see also note 1):

Male valve: the *sthenno* male has prominent spines on the dorsal edge of the valve, which are lacking in *pandrose*.

The number of spines on the dorsal ridge of the valve (SP) was counted. Asymmetry being rule rather than exception, left and right valve were scored separately. (Stereomicroscope, 20×)

Male forewing upperside: in *sthenny* the apical ocelli are situated closer to the wing margin than in *pandrose*.

Well set males were photographed and printed on a 2:1 scale. The position of the apical ocelli relative to the wing margin (OP) was expressed in the ratio AB/AE in Figure 2.

Male forewing upperside: in *sthenny*, the postdiscal band is poorly developed, its edges are suffused, and the fine submarginal zigzag line, common in *pandrose*, is missing.

The development of the postdiscal field was quantified as follows:

- 0 = Band completely obscure, in ground colour.
- 1 = Lighter rings around ocelli.
- 2 = Lighter colour more extended than merely rings; less than 3.
- 3 = Lighter colour filling the postdiscal band completely, at least in cells 4 and 5, eventually in cell 3.
- 4 = Idem, including cell 2.

Distal edge of the postdiscal band:

- 0 = fading into submarginal field; 1 = distinct.

Denticulate transverse line separating submarginal and postdiscal band:

- 0 = absent; 1 = present.

The sum of the three scores is used as a measure for forewing upperside design (FWD).

Male hindwing underside: In *sthenny* the design of the hindwing underside is poorly developed, and marginal elements (chevrons and its dark filling) are lacking.

Transverse lines.

- 0 = absent; 1 = faintly indicated; 2 = present

Ocelli.

- 0 = absent; 1 = one point in cell 2; 2 = more than one point

Chevrons.

- 0 = absent; 1 = indicated; 2 = present

The dark filling of the chevrons.

- 0 = absent; 1 = indicated; 2 = present

The sum of the four scores is used as a measure for hindwing underside design (HWD).

Female genitalia. In *sthenny* the antevaginal plate is wider than in *pandrose*. The width of the antevaginal plate was measured. (Measuring microscope, 30×)

Deviations from normality were calculated using the Kolmogorov-Smirnov test with Lilliefors correction. For cluster analysis three algorithms were applied: Ward-method, average linkage within groups and average linkage between groups. Z-scores were standardized and squared Euclidian distance was measured. Homogeneity of variances was determined with Levene's test, and analysis of variance was performed with one-way ANOVA or through the non parametric Kruskal-Wallis test. All statistical tests

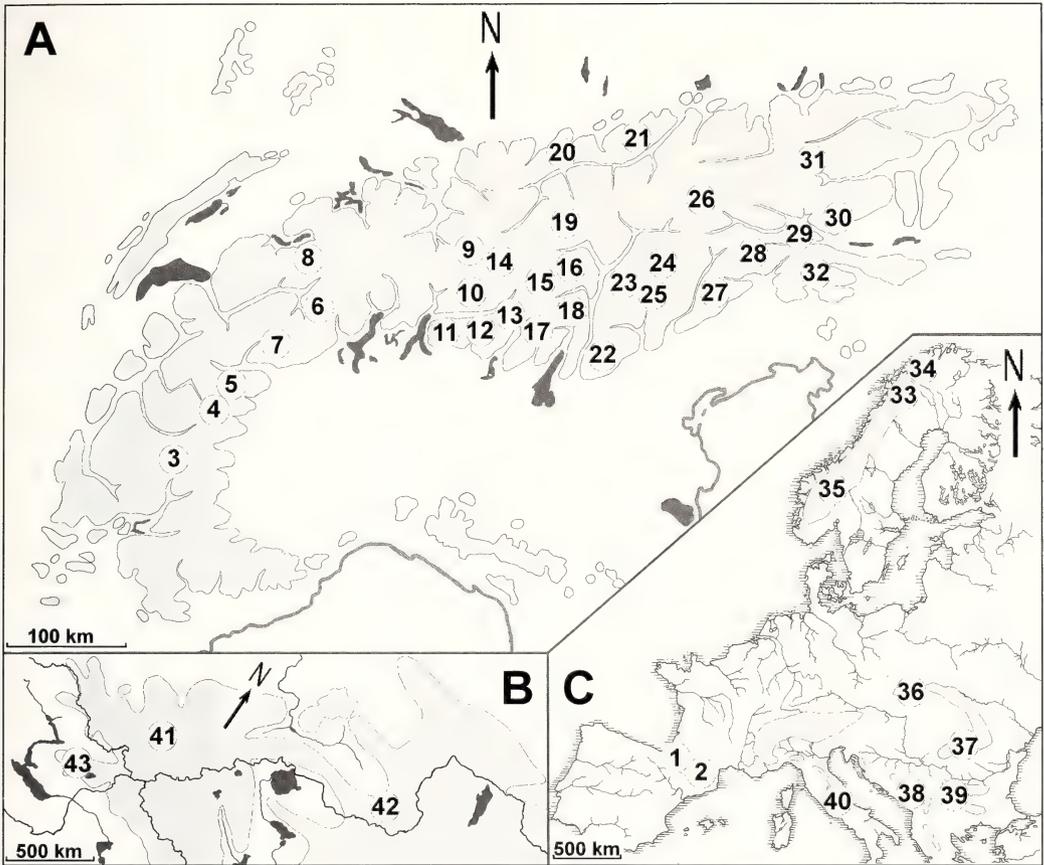


Fig. 3. Sampling sites. **A.** The Alps. Light grey = mountains >1000 m. Dark grey = lakes and coastline. **B.** Altai-Sayan. Light grey = mountains >1500 m. Dark grey = lakes and rivers. Black = political boundaries between Kazakhstan (W), Russia (N), Mongolia (E) and China (S). **C.** Europe. Light grey = main mountain systems. The numbers refer to Tab. 1.

were performed with the software SPSS 12.0. Pleistocene timetable is based on oxygen isotope dating (MIS stages).

Results and conclusions

1.1. Male characters (Fig. 4)

The population average values for each of the four variables are listed in Table 2 and graphically presented on Figure 4. Only the distribution of the number of spines per valve deviates significantly from normality (Kolmogorov-Smirnov $p < 0.001$). It is even discontinuous, with values either < 0.5 or > 1.0 . Hierarchical cluster analysis (Ward method), based on the four male characters, resulted in the dendrogram in Figure 5. The two main clusters were designated A and B. For forewing design and hindwing design (equal variances, Levene's $p = 0.445$ and 0.421 respectively) ANOVA gave a very good discrimination between the clusters A and B ($F = 15.4$ and 23.5 respectively; $p < 0.001$

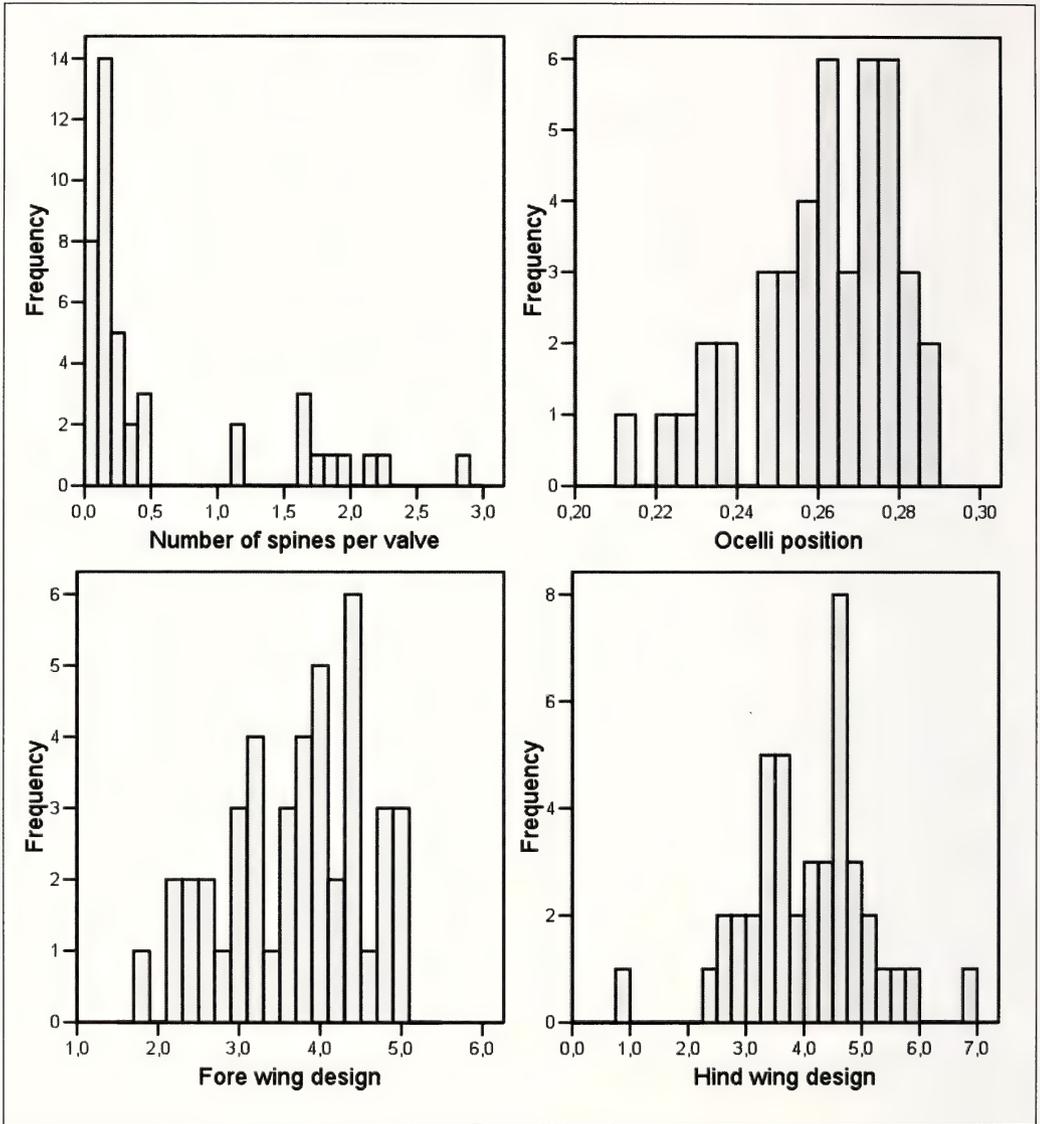


Fig. 4. Frequency distribution of the population means of the four differentiating characters in males.

in both cases). For the number of spines and ocelli position (variances significantly unequal, Levene's $p < 0.001$ and $= 0.019$, respectively) Kruskal-Wallis test confirmed significant difference between both clusters ($p < 0.001$ for both variables). Average linkage within groups resulted in identical clustering. Using between-groups algorithm, sample 33 was transferred to the B-cluster.

The main conclusion is that, on the basis of the morphological characters that are traditionally used to discriminate between *pandrose* and *sthenny*, the populations of the *E. pandrose-sthenny* complex indeed split up into two distinct groups. As the populations with typical *pandrose* characters belong to the A-cluster, and populations with *sthen-*

nyo characters to the B-cluster, these will provisionally be referred to as the *pandrose* group and the *sthenny* group, in short *pandrose* and *sthenny*, without any taxonomical bearing.

1.2. Female genitalia

There is a discrepancy between the Pyrenean *sthenny* population (sample 1) and all other populations investigated. Because of the extremely small sample size ($n=1-5$ per population), these results were omitted from the cluster analysis. If the available data were included, sample 1 would branch off from the B-cluster at a distance of 7 scale-units (not shown).

1.3. Geographical distribution

The geographical distribution of the taxon *sthenny*, hitherto considered a Pyrenean endemic, is far more extended than ever thought. It inhabits three major mountain systems and at least one small one: the Pyrenees, the southeastern Alps, the Altai, and the Durmitor in Montenegro.

Within the *pandrose* group, each of the studied characters showed a continuous variation, the extremes of which can be characterised as “typical *pandrose*” and “more or less *sthenny*-like” respectively. To what degree each of the populations of the *pandrose* group tends towards a *sthenny* habitus is best visualised by a simple ranking (Table 3), based on the rescaled (0–100) sum of the rescaled scores for the four characters. The most typical *pandrose* (sum = 0) ranks at the top. Geographical distribution in relation to ranking was not random. In Figure 6, populations with a sum ≤ 50 and those with a sum > 50 are plotted in different symbols. The most *sthenny*-like populations turned out to be concentrated in the eastern Alps, in a zone bordering the area of the *sthenny* group. Beyond the Alps such populations were found in Scandinavia only. The other extreme, the most typical *pandrose* populations, were found in the southern Carpathians and the Balkans (Bucegi and Rila), followed by the Siberian populations (Altai and Sayan).

Discussion

1. Monophyly of the *pandrose* group and the *sthenny* group

The *pandrose* group and the *sthenny* group share three mountain systems: Pyrenees, Alps, and Altai. It is quite unlikely that the morphological differences between both groups arose independently in each of these regions. Obviously, *pandrose* and *sthenny* form two monophyletic groups, i.e. the differences between them must date back to their respective common ancestors. The primary dichotomy in the dendrogram thus reflects the oldest detectable geographical disjunction within the *Erebia pandrose-sthenny* complex, which has resulted in two isolated populations that subsequently differentiated into the *pandrose* ancestor and the *sthenny* ancestor.

The fact that the most *sthenny*-like populations in the Alps are concentrated in a zone bordering the area of the *sthenny* group, strongly suggests that they originate from

postglacial intermingling in a contact zone. Apparently, *pandrose* and *sthenny* did interbreed where they met. That was emphatically the case in the eastern Alps. To a minor extent, however, intermingling with *sthenny* genes has taken place anywhere in the Alps: populations with a relatively high score for one of the studied characters are found throughout the Alps, and in the Apennines (Table 3).

2. Pleistocene history

2.1. Würm–glacial refuges in the Alps, the Apennines, the Carpathians, and the Balkans

Each population of the *sthenny* group, and some populations of the *pandrose* group, can easily be related to one of the well known glacial refugia. For the remaining *pandrose* populations, there is a logical relation with a refugium, but they cannot be morphologically linked to it, as this study focuses merely on differentiating characters between *pandrose* and *sthenny*. Those refugia are printed in small font.

The Bergamasque Alps

The Bergamasque Alps remained largely unglaciated during the Würm glaciation (MIS2-4, 75–10 ky BP). They harboured an isolated refugial flora and fauna, including *sthenny*. During Würm, the valleys of Adda and Oglio attained their actual depth by glacial erosion, which largely prevented post-glacial expansion. *Sthenny* could just infiltrate the southern Ortler group across the Aprica pass, which accounts for the intermediate population found there (sample 15, see table 3). The Bergamasque *sthenny* populations show endemic differentiations (see the taxonomy and nomenclature section).

The Brescian refugium

The area between Lake Iseo and Lake Garda is considered here a separate refugium, called Brescian refugium. From this refuge the Adamello-Presanella group has been repopulated in postglacial times. It has been noticed for a long time that the populations of the Adamello-Presanella group and those of the adjacent Brenta group are strikingly different (Hartig 1937). That is confirmed by the results of this study: the former has a *pandrose* habitus, the latter a prominent *sthenny* habitus (sum= 49 and 91 respectively). This applies also to the southernmost known population in the Adamello group, on the Passo Croce Domini, which contributed substantially to sample 17. Thus, it cannot be excluded that a population with a *pandrose* habitus has survived the Würm-glacial in the Brescian refugium, whereas the adjacent refugia were inhabited by *sthenny*. In addition, postglacial gene flow across the Passo Carlomagno must have been minimal or absent, a phenomenon that has also been reported for *Erebia pluto* (Cupedo 2004).

The refugia east of Lake Garda

The southern-alpine *sthenny* populations East of Lake Garda have their origin in a series of well known small refuges on the southern border of the eastern Alps (Tribsh & Schönswetter 2003): the Lessinic Alps, the Venetian and Carnic Pre-Alps, and the

Julian Alps. Postglacially they just moved to higher altitudes, and spread more or less northwards, into the Dolomites and the mountains south of the High Tauern watershed, where they apparently intermingled with populations of the *pandrose* group. The populations of the Lessinic Alps and the Venetian Pre-Alps (samples 22 and 27) have been living, up to present time, in unglaciated areas.

The East-alpine refugium

The vast refugial area that existed in the non-glaciated parts of the Styrian Alps (Penck & Bruckner 1909, Tribsch & Schönschwetter 2003) was another dispersion centre of the *pandrose* group. Populations on the Zirbitzkogel (Reichl 1992) and in the eastern Karawank mountains (Jakšić 1998) have even persisted here within the refugial area to date. At least the populations of Gurktal Alps and Niedere Tauern (samples 29, 30, 31) must have their origins in this refugium.

The Apennines

During glacial stages the Apennines were ecologically contiguous with the Ligurian and Maritime Alps, and must have acted as an important refugium for many species. This is reflected in the morphological resemblance of their *Erebia* species with western Alpine forms. For *E. cassioides* this relation has been confirmed by molecular data (Lattes et al. 1994). The small witness population in the Laga mountains proves that also *pandrose* withdrew into the Italian peninsula. As there is only one pathway, there is no doubt that the Apennines were colonised from the western Alps. (Note that this does not necessarily imply a postglacial colonisation of the western Alps from the Apennines!)

Northern refugia

The northern limestone Alps must logically be colonised from refuges at its northern outskirts, or even from the periglacial tundra.

Western alpine refugia

Vast refugia existed in the French Pre-Alps (Vercors, Diois, Provence), many narrow refugial areas were found at the eastern slopes of the Cottian and Graian Alps (Briquet 1906). Undoubtedly these refugia contributed to the present-day *pandrose* populations in the western Alps, but this cannot be inferred from the present study.

Carpathians and Balkans

Varga (1975b) demonstrated that populations of many species in the Bulgarian mountains (Stara Planina, Rila, Pirin), including *Erebia pandrose*, were morphologically closely related to Carpathian populations. He made clear that the Balkan mountains were colonised from the southern Carpathians, and that the oldest differentiations among Balkan *Erebia* dated to the Würm-glacial. The present data (samples 37 and 39) agree with that hypothesis. In the western Balkans on the other hand, the Dinarics and the mountains of Bosnia-Herzegovina, Montenegro, and Macedonia were connected with the Julian Alps, which harbour closely related butterfly faunas (Varga 1975b). The fact that the Julian Alps and the Durmitor currently are both inhabited by *sthenny* supports such a connection.

2.2. Pre-Würm history

Dispersion routes. Both the *pandrose* group and the *sthenny* group show distribution patterns that range from the European mountains to Central Asia. This is due to the fact that dispersion of both groups took place along the same pathway: the glacial trans-palaeartic tundra belt (De Lattin 1967, Kostrowicki 1969). As, however, *pandrose* and *sthenny* would have intermingled wherever they met, they can not have occupied the tundra belt simultaneously. Consequently, *pandrose* and *sthenny* must have spread in two waves, at different moments in history, i.e. during different glacial cycles.

Sequence. The populations of the *pandrose* group are rather uniform throughout their territory. They differ merely in the extent of the *sthenny* influence. The *sthenny* populations are morphologically far more differentiated: the Kazakhstan population shows a different arrangement of forewing ocelli and a different forewing shape; the Pyrenean population developed an apomorphic genital character in the females; the populations of the Bergamasque Alps differ in their wing design from the remaining populations in the south-alpine subarea (see the taxonomy and nomenclature section). That suggests that spread and subsequent disjunction of the *pandrose* group is of more recent date than that of the *sthenny* group. This is confirmed by their actual distribution in the Alps: *pandrose* is widespread in the northern regions, bordering the glacial tundra belt along which both groups have reached the Alps, whereas *sthenny* has been completely cut off from the previous tundra zone: it has been forced into refugial areas, “dead ends”, on the southern outskirts of the Alps.

Dating. The witness population in the Apennines unequivocally proves that the *pandrose* group was present in the Alps before the beginning of the Würm glacial, i.e. during the Riss-Würm interglacial (MIS5, 128-75 ky BP). The same goes for the southern Carpathians, in view of the presence of *pandrose* in the Rila mountains. Thus, the spread of *pandrose* in the tundra belt has to be dated at its latest to the Riss glaciation (MIS6, 185-128 ky BP) [Note 2+3]. Consequently, the spread of *sthenny* along the tundra belt took place at its latest during the Mindel glaciation (MIS8, 300-242 ky BP). That means that more or less unmixed *sthenny* populations persisted in the southeastern Alps for at least two glacial cycles. This is probably due to the predominant east-west orientation of mountain chains in this part of the Alps. In the western Alps, however, no geographic barrier prevented intensive gene flow between *pandrose* and *sthenny*. As a result, no *sthenny* populations exist there today, but a number of *pandrose* populations show *sthenny* traits to some degree (cf. the mean SP values of samples 4 and 7, table 3).

Scandinavia. The Scandinavian populations must result from the same two colonisation waves. During Riss, however, Scandinavian *sthenny* populations were shoved south by the growing land ice cap and survived at its edge. Here they intermingled with *pandrose* already during glacial time, prior to the repopulation of Scandinavia. As a result Scandinavia nowadays is inhabited entirely by intermediate populations, in contrast with the Alps, where postglacial encounter led only to borderline mixing. Nonetheless, the Scandinavian populations are far from uniform, as was already stated by Henriksen & Kreutzer (1982). Therefore, it is not surprising that one of these populations (sample 33) is placed in the *sthenny* cluster when using a different algorithm for hierarchical cluster analysis.

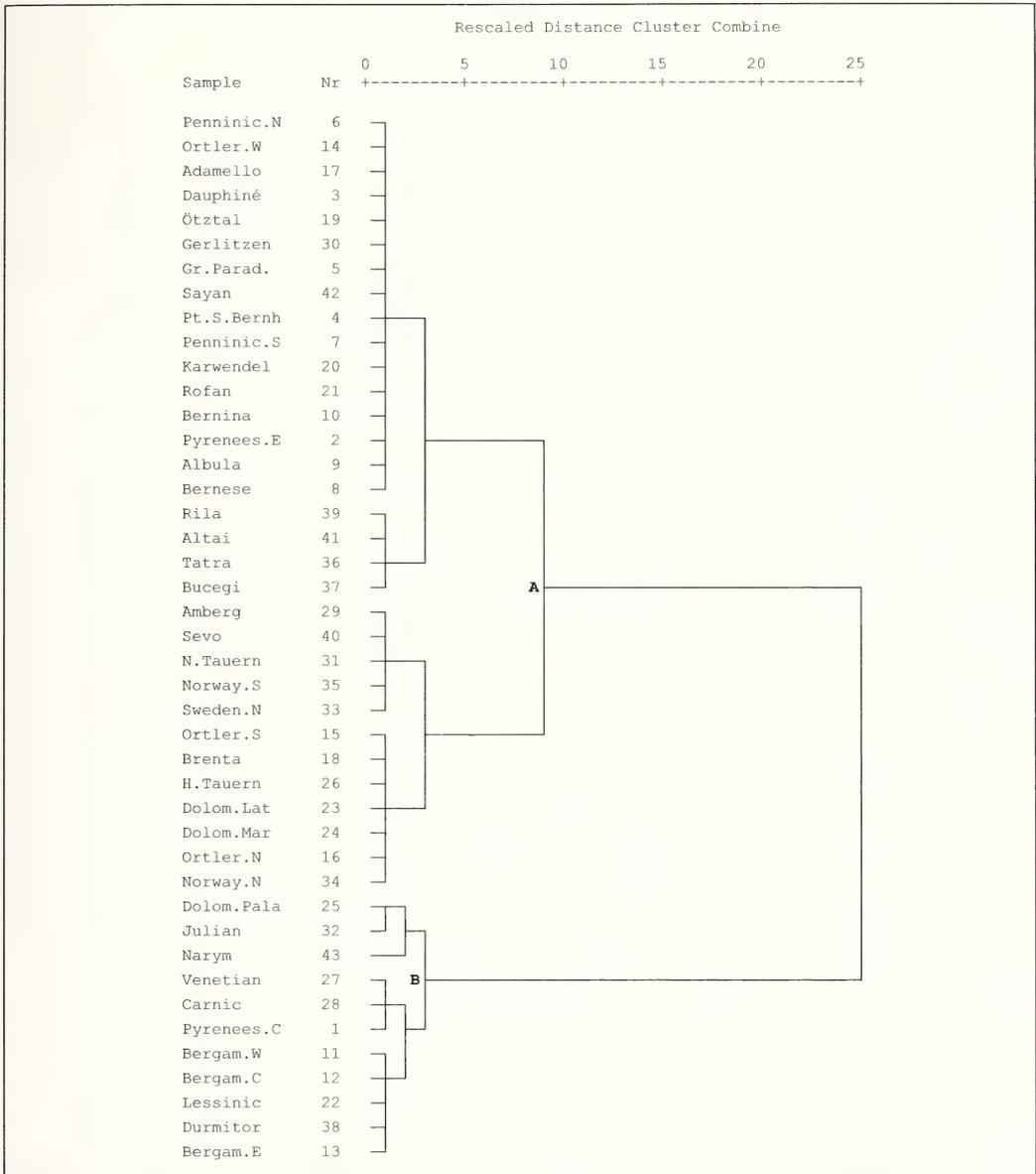


Fig. 5. Dendrogram resulting from hierarchical cluster analysis (Ward algorithm).

Centres of differentiation. The results of this study provide no clue to the geographic differentiation centres of the ancestors of the *pandrose* group and the *sthenny* group, nor to the direction of their glacial expansion. From the above can only be inferred that, prior to the dispersion of *pandrose*, *sthenny* already occupied the European mountains (Alps and Pyrenees), the European tundra (Scandinavia), and the Siberian mountains (Altai). That leaves the Siberian tundra as a hypothetical centre of origin for *pandrose*. The differentiation of *pandrose* and *sthenny* might, theoretically, have resulted from an early Pleistocene oreo-tundral disjunction in the eastern Palaeartic.

3. Taxonomy and nomenclature

3.1. The type locality of *Erebia pandrose* Borkhausen, 1788

Erebia pandrose was originally described as *Papilio castor* Esper, 1781. Borkhausen (1788) replaced this name (a primary homonym of *Papilio castor* Cramer, 1775) by *pandrose*. Description and type locality, however, were fixed by Esper. His material came from “Steiermark” (Stiria), without further specification. The only Styrian massifs harbouring *E. pandrose* are the Niedere Tauern and the northern Saualpe (Reichl 1992). In the material investigated for this study, sample 31, from the western end of the Niedere Tauern, is regarded to be closest to nomotypical *Erebia pandrose*.

3.2. The taxonomic status of the *sthenny* group

In the Pyrenees, despite intensive and targeted research by de Lesse (1952), *sthenny* and *pandrose* were nowhere found living sympatrically. He just found one possible hybrid, flying together with some *pandrose*, in the region separating the areas of *sthenny* and *pandrose*. His observation has been interpreted as a sympatric occurrence (Lafranchis 2000), but is certainly not a proof of reproductional isolation. In the Alps, both groups have intermingled where they met. That implies that, at least in the Alps, no reproductive barriers exist between members of the *pandrose* group and members of the *sthenny* group. Consequently, *pandrose* and *sthenny* are to be considered conspecific.

Nonetheless, there are constant anatomical differences between unmixed populations of the two groups, which result, as has been shown, from at least 240,000 year of isolation. The subspecies of *Erebia pandrose* thus can be grouped in two monophyletic aggregates of subspecies which, according to Art. 6.2 of the Code, should be designated as *Erebia pandrose* (group *pandrose*) and *Erebia pandrose* (group *sthenny*) (ICZN 2000).

3.3. *Erebia pandrose pandrose* Borkhausen, 1788 and *E. pandrose ingana* Fruhstorfer, 1911

In the Alps, two subspecies of the *pandrose* group have been described. The validity of ssp. *ingana*, characterised by the intensively coloured postdiscal band and the prominent black spots on the forewing upperside, has long been questioned. Warren (1936) states that “such specimens occur wherever *pandrose* flies, and always in company with poorly marked specimens”. Von der Goltz (1938), after studying Fruhstorfer’s cotypes, concluded that the typical characters of *ingana* are individual characteristics, not typical of the population. Both Warren’s and Von der Goltz’s opinion are confirmed by the large sample 5, which was collected at exactly the same place where Fruhstorfer collected his type series. Fruhstorfer’s description applies to a minority of brilliantly coloured specimens, which occur equally in many other samples. This explains why distributional data for *ingana* of leading authors are so different, sometimes even contradictory, and lack any zoogeographical logic (compare Fruhstorfer 1911, Hartig 1937, Verity 1953, Varga 1975b, Roos & Arnscheid 1976 and Arnscheid 1981). In addition,

none of the characters investigated in this study justifies a subdivision of the alpine populations of the *pandrose* group into two morphologically defined and geographically coherent units. Consequently, *Erebia pandrose ingana* Fruhstorfer, 1911 is to be considered a subjective junior synonym of *Erebia pandrose pandrose* (Borkhausen, 1788).

3.4. *Erebia pandrose marmolata* Dannehl, 1927 and *E. pandrose infraclara* Verity, 1953

In the Alps, two subspecies of the *sthenny* group have been described. The type locality of *marmolata*, in spite of its name, is the Pala group (Dannehl, 1927 p. 3), the type locality of ssp. *infraclara* is Val Milbach above Sappada in the Carnic Pre-Alps (Verity 1953, p. 132). Samples 25 and 28 have been collected at both type localities. Valve morphology and wing design are strikingly similar. Indeed, Dannehl's description of the *marmolata* upperside is an accurate description of the *sthenny* form inhabiting the southern Alps from the Adige valley to the Tagliamento valley, including Verity's *infraclara*. According to Warren (1936) the ground colour of the hindwing underside is the main differentiating character. In both sample 25 and 28, however, fresh males have the silvery grey hindwing underside which Verity considered typical of *infraclara*, whereas in worn males the ground colour has turned into a rusty grey-brown, fitting Dannehl's description of *marmolata*. The only real difference is found in the sprinkling of dark scales on the hindwing underside, which is denser in Pala specimens than in Sappada specimens. Before describing *infraclara* (1953), Verity explicitly denied the subspecific nature of *marmolata*, stating that each of the *marmolata* characters mentioned by Dannehl, is found in other regions as well. As was shown earlier in this paper, this is correct: *sthenny* characters do occur in many alpine populations. In fact, Verity misled himself by taking the description of *marmolata* as a reference, instead of material from the type locality. Had Verity's collection contained specimens from the Pala group, ssp. *infraclara* would not have been described. Consequently, *Erebia pandrose infraclara* Verity, 1953 is to be considered a subjective junior synonym of *Erebia pandrose marmolata* Dannehl, 1927.

The currently known range of ssp. *marmolata* covers the Bergamasque Alps, the Lessinic Alps, the Venetian Pre-Alps, the adjacent Pala group, the Carnic Pre-Alps, the Julian Alps, and the Durmitor. As to the Monte Baldo: photographs of the (poor) existing material (Sala 1996, Sala pers. com.) suggest that the population belongs to the *sthenny* group. However, this could not be confirmed by genital examination, as no material was available for dissection. The populations inhabiting the northern and western Dolomites, the Brenta group, and Eastern Tyrol are morphologically intermediate between *marmolata* and *pandrose*.

3.5. Geographical variation within ssp. *marmolata* (Fig. 7)

In the Bergamasque Alps 27% of the individuals have only the two apical spots on the forewing upperside. In all other investigated samples this feature was encountered only incidentally. In the Julian Alps the forewing design is extremely variable, which is typi-

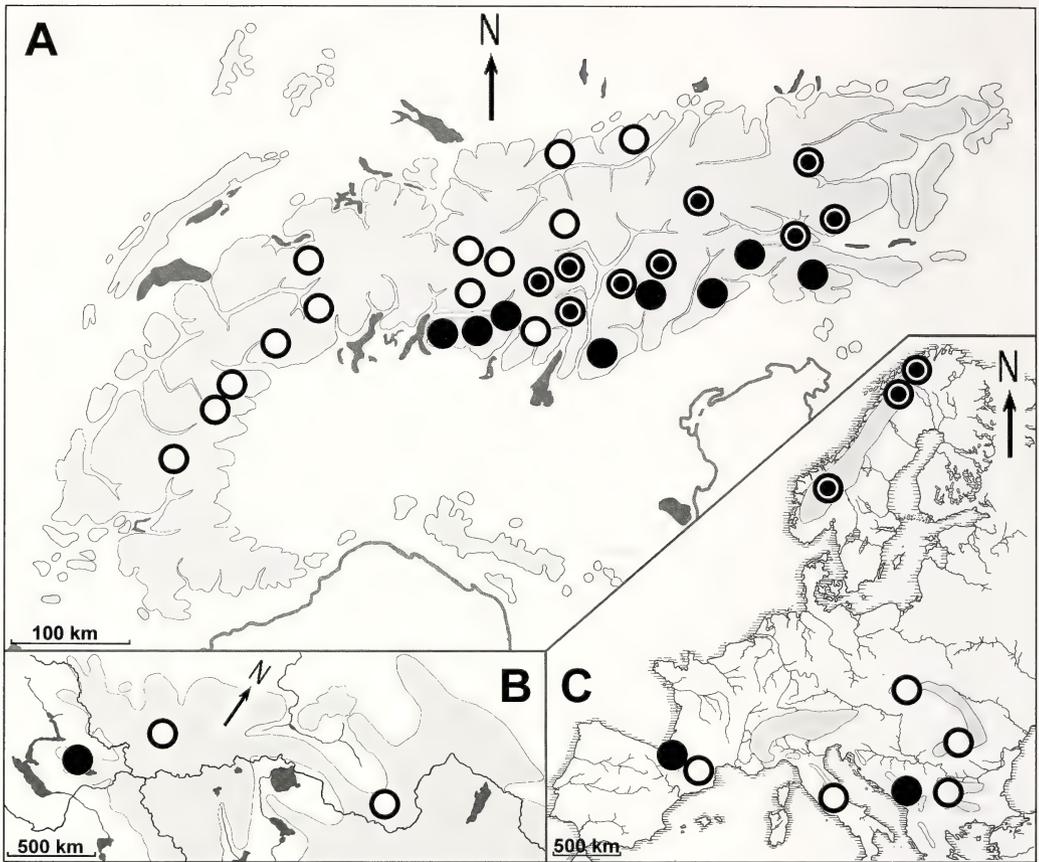


Fig. 6. Geographical distribution of the populations of the *sthenny* group (black) and the *pandrose* group, the latter in relation to their ranking in table 3. Open circle: sum ≤ 50 ; Circle with black centre: sum > 50 .

cal of populations of a mixed origin. The observed variation might be due to intermingling with *pandrose* from the Karawank mountains, which, however, is not supported by a lower SP value.

3.6. The Asian populations of the *sthenny* group

Asian populations of *Erebia pandrose* have been described as ssp. *orientalis* Goltz, 1930. This name, a junior homonym of *Erebia epiphron orientalis* Elwes, 1900, was replaced by *yernikensis* Korshunov, 1995 (Korshunov & Gorbunov 1995). Both the type locality (Sayan mountains) and the excellent description unmistakably apply to representatives of the *pandrose* group, represented in this study by samples 41 and 42. The population of the *sthenny* group inhabiting the Kazakhstan part of southern Altai (sample 43), has not been described yet. It differs from the other known populations of the *sthenny* group by its elongate forewing shape, and by the forewing ocelli being positioned as in the *pandrose* group (Figure 8). It is described here as a new subspecies within the *sthenny* group.

Erebia pandrose (sthenny) narymica* ssp. n.*(Figs 8, A1–B8)**

Material. Holotype: ♂, label in Cyrillic script (figure 9), transliteration: 'V[ostochno]-Kaz[akstanskaya] obl[ast'] Bolschenar.[ymyskiy] r[ayo]n | s[elo] Novoberezovka 2800 [m] | A.G.Aniskovich | 24.VI 1986', CFC. – Paratypes: 1♂, label in Cyrillic (figure 9), transliteration: 'S.[elo] Novoberezovka 3000 m. | Bolshenarymskiy r[ayo]n | Vostochno-Kazakst.[anskaya] obl.[ast'] | E. pandrose 2.7.1986.', CFC; 1♂ 'E. Kazakhstan | South Altai | Narymsky range | Novoberezovka v. | 2800 m. | 25-26.06.1986 | A. Aniskovich leg.', CFC; 1♂, 1♀ '3-7-1986 USSR | Vostočno-Kazachst. | S. Novoberjezovka | 3000 m leg. Anisković', ZMAN; 1♂, label in Cyrillic script, transliteration: 'V-Kaz obl Bolschenar. rn | s. Novoberezovka 2800 | A.G.Aniskovich | 30.VI 1986', CSC.; 2♂, label in Cyrillic script, transliteration: 'V-Kaz obl Bolschenar. rn | s. Novoberezovka 2800 | A.G.Aniskovich | 2.VII 1986', CSC.; 4♂, 1♀, 'E. Kazakhstan | South Altai | Narymsky range | Novoberezovka v. | 2800 m. | 25-26.06.1986 | A. Aniskovich leg.', CSC.

Holotype and paratypes form a series collected by A. Aniskovich & G. Makhat on a trip in the Narymsky Range from 24 June until 3 July 1986. The specimens were papered and dispersed among several collectors, who wrote their own labels, according to Aniskovich's data. The holotype and three paratypes bear handwritten labels by Aniskovich.

Description. Male forewing length: 21–23 mm. Forewing with pointed apex; upper-side pattern indistinct, submarginal zigzag line absent; position of forewing ocelli as in *Erebia p. pandrose*, not shifted towards the wing margin as in *Erebia p. sthenny*. Hindwing underside design vague, ocelli and marginal elements absent.

Male genitalia: Dorsal ridge of valve provided with a prominent spines, with mean of 2.8 spines per valve in studied sample.

Diagnosis. Differs from all subspecies of the *Erebia pandrose (pandrose)* group by the spines on the valve and the indistinct pattern of the forewing upperside and the hindwing underside. Differs from all other subspecies of the *Erebia pandrose (sthenny)* group by the pointed forewing, and by the forewing ocelli being situated less close to the wing margin.

Etymology. The name refers to the type locality, the Narym mountains (Narymsky Range).

Geographical distribution. Apart from the type locality (South Altai, Narym Mountains in East Kazakhstan, Bolshenarymskoye district, south-east of the city of Novoberezovka), the new ssp. is known from the adjacent Sarym-Sakty mountains (CSC).

Remark. Males from the Lystviaga and Kholsun mountains (Russian Altai) have similar valves, but the wing design tends towards *yernikensis* (V. Lukhtanov, pers. comm.). Probably intermediate populations exist.

4. Checklist

4.1. *Erebia pandrose* (group *pandrose*)

Diagnosis: mean number of spines per valve < 0.5. Design of forewing upperside and hindwing underside complete and distinct.

- *Erebia pandrose (pandrose) pandrose* (Borkhausen, 1788).
(=*Erebia pandrose (pandrose) ingana* Fruhstorfer, 1911, **syn. n.**)
Distribution: Alps. Absent from the area of the *sthenny* group in the south-east (see below), and from the Chartreuse and the Vercors in the west (Willien 1990).



Fig. 7. European representatives of the *sthenny* group of *E. pandrose*. **A.** *ssp. sthenny*, Central Pyrenees (sample 1). **B.** *ssp. marmolata*, Bergamasque Alps (sample 11–13). **C.** *ssp. marmolata*, Pala group (sample 25). **D.** *ssp. marmolata*, Julian Alps (sample 32). **e.** *ssp. marmolata*, Durmitor (sample 38).



Fig. 8. *Erebia pandrose* (*sthenny*) *narymica* ssp. n., (A=upperside, B=underside) and *Erebia pandrose* (*pandrose*) *yernikensis* Korshunov, 1995, (C=upperside, D=underside). Row 1-7: males; row 8: females. A1 and B1: holotype, A2 – B8 paratypes.

Note: Most populations are in variable degree intermediate between the *pandrose* group and the *sthenny* group. This is most prominent in the eastern Alps.

- *Erebia pandrose (pandrose) sevoensis* Willien, 1975.
Distribution: Apennines. One single population on the Pizzo di Sevo in the Monti della Laga, Lazio (Chiavetta 2000).
- *Erebia pandrose (pandrose) yernikensis* Korshunov, 1995.
Distribution: Altai and Sayan Mountains (Siberia), recently also found in the Barguzin Mountains in Transbaikalia (S. Churkin, pers. comm.).
- *Erebia pandrose (pandrose) gracilis* v.d. Goltz, 1930.
Distribution: Pyrenees. Occupies a restricted region in the French provinces of Arriège and Pyrénées Orientales, in the Spanish provinces of Lleida and Girona, and in Andorra (Gómez Bustillo & Fernández-Rubio 1974, Willien 1990).
- *Erebia pandrose (pandrose) roberti* Peschke, 1920.
Distribution: northwestern Carpathians. Found in the High Tatra, Lower Tatra, Belér Alps and Liptau Mountains (Moucha 1959, Krzywicki 1966, 1982).
- *Erebia pandrose (pandrose) cibiniaca* Dannehl, 1927
Distribution: eastern and southern Carpathians. Found in the Bihar, Retezat, Cibin, Bucegi, and Rodna Mountains (Hormuzaki 1901, Varga 1971).
- *Erebia pandrose (pandrose) ambicolorata* Varga, 1971.
Distribution: Rila mountains (Varga 1971).
Note: Subspecies *roberti*, *cibiniaca*, and *ambicolorata* are closely related. They share the pronounced design, especially of the marginal elements, on the hindwing underside. The differences have been worked out by Varga (1971).
- *Erebia pandrose (pandrose) lappona* Thunberg, 1791.
Distribution: Scandinavia, Kanin peninsula and Kolguev Island (Warren 1936, Tatarinov & Dolgin 1999).
Note: A rather heterogeneous group of populations that are morphologically intermediate between the *pandrose* group and the *sthenny* group. They are provisionally placed within the *pandrose* group.

4.2. *Erebia pandrose* (group *sthenny*)

Diagnosis: the mean number of spines per valve >1. Design of forewing upperside and hindwing underside incomplete and more or less suffused.

- *Erebia pandrose (sthenny) sthenny* (Graslin, 1850).
Distribution: Pyrenees. Confined to the French departments of Pyrénées Atlantiques, Hautes Pyrénées, Haute Garonne and Arriège, and the Spanish provinces of Lleida and Huesca (Gómez Bustillo & Fernández-Rubio 1974, Willien 1990).
- *Erebia pandrose (sthenny) marmolata* Dannehl, 1927.
(= *Erebia pandrose (sthenny) infraclara* Verity, 1953, **syn. n.**)

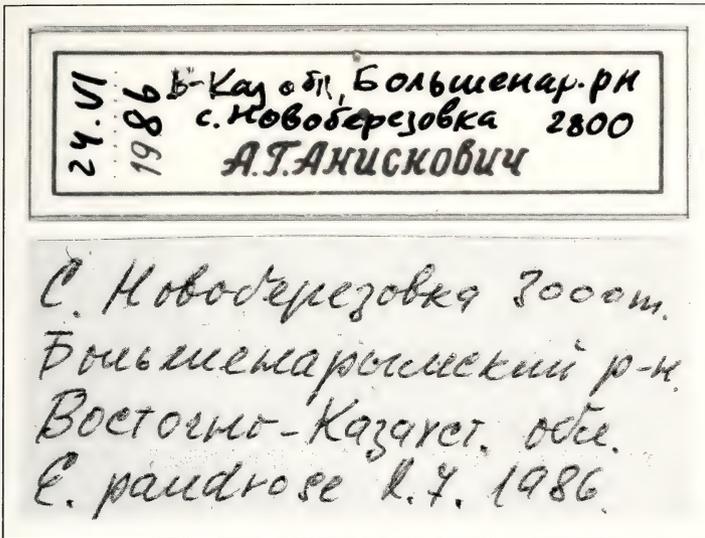


Fig. 9. *Erebia pandrose* (*sthenny*) *narymica* ssp. n., label of holotype (top) and of paratype no. 1 (bottom).

Distribution: the sp. occupies three separated subareas.

- a. The Bergamasque Alps.
- b. The southeastern Alps, from the Lessinic Alps (possibly from Monte Baldo) to the Julian Alps, and penetrating into the Pala group of the Dolomites.
- c. The Durmitor (Montenegro). Probably all populations in Bosnia-Herzegovina, Montenegro, Macedonia (Jakšić 1988), and in Albania (Turner 1964) belong to this subspecies.

Erebia pandrose (*sthenny*) *narymica* **ssp. n.**

Distribution: Hitherto known from the Narym and Sarym-Sakty mountains in the Kazakhstan part of the Altai [Note 4].

Notes.

1. Differentiating characters between *pandrose* and *sthenny* have been taken from De Lesse (1952) and Warren (1936). De Graslin (1850), describing *Erebia sthenny*, was not even aware of the existence of *E. pandrose*. He described the species as being different from what he called *E. manto* but what, according to his description, most probably was *E. pronoe*.
2. From the present data it cannot be inferred whether *pandrose* colonised the Pyrenees already during the Riss glaciation, or reached them from the Alps during Würm.
3. As far as distributional events (expansion, or withdrawal into refuges) are being related to a glacial or interglacial period, this should be regarded a minimum dating. Glacial cycles may have passed by without recognisably affecting the overall distribution of a taxon.

4. It may well be that specimens of this subspecies have already been known to lepidopterists for a long time, possibly even from other localities. Warren (1936) writes that “in the Sayan the f. *aglauros* is the prevalent male form”, and Varga (1971) states that the Scandinavian and the Central Asiatic form are very similar, characterised by its hazy, monotonous colouring and frequent occurrence of the f. *aglauros*. Both statements are in sharp contrast with v. Goltz’ description of ssp. *orientalis* (= *yernikensis*) and with the habitus of the *yernikensis* populations investigated for this study, but do apply to *narymica*.

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Appendix

Tab. 1. Sampling sites and sample sizes. Listed from west to east approximately. --- = sampled at more than one locality. WD = sample size for male wing design. MG = sample size for male genital characters. FG = sample size for female genital characters.

nr	sample	massif or region	locality	country	WD	MG	FG
1	Pyrenees.C	Central Pyrenees	Gourette	F	50	31	5
2	Pyrenees.E	Eastern Pyrenees	---	And+F	41	39	3
3	Dauphiné	Dauphiné Alps	---	F	35	27	5
4	Pt.S.Bernh	Grajan Alps	Petit St. Bernhard	F	13	13	2
5	Gr.Parad	Grajan Alps	Valnontey	I	46	22	3
6	Penninic.N	Northern Penninic Alps	Wallis	CH	26	13	4
7	Penninic.S	Southern Penninic Alps	Val St. Barthélémy	I	25	40	2
8	Bernese	Bernese Alps	---	CH	34	28	5
9	Albula	Albula Alps	---	CH	50	30	5
10	Bernina	Bernina Alps	---	CH	22	24	5
11	Bergam.W	Western Bergamasque Alps	Pizzo Tre Signori	I	11	11	1
12	Bergam.C	Central Bergamasque Alps	Passo Vivione	I	32	28	1
13	Bergam.E	Eastern Bergamasque Alps	Passo Aprica	I	12	10	4
14	Ortler.W	Western Ortler Alps	Umbrailpass	CH	36	30	5
15	Ortler.S	Southern Ortler Alps	Gaviapass	I	45	38	5
16	Ortler.N	Northern Ortler Alps	Martelltal	I	14	14	0
17	Adamello	Adamello	Pso Croce Domini	I	32	32	5
18	Brenta	Brenta	Passo Grostè	I	50	36	2
19	Ötztal	Ötztal Alps	---	A	49	25	1
20	Karwendel	Northern Chalk Alps	Karwendel mountains	A	26	26	0
21	Rofan	Northern Chalk Alps	Rofan mountains	A	30	30	2
22	Lessinic	Lessinic Alps	Cima Carega	I	36	36	5
23	Dolom.Lat	Dolomites	Latemar	I	40	32	5
24	Dolom.Mar	Dolomites	Marmolada	I	23	16	5
25	Dolom.Pala	Dolomites	Pala	I	49	32	5
26	H.Tauern	Hohe Tauern	Gr. Glockner	A	44	33	4
27	Venetian	Venetian Pre-alps	Monte Cavallo	I	7	7	4
28	Carnic	Carnic Alps	Sappada	I	38	49	5
29	Amberg	Gurktal Alps	Amberg	A	13	13	2
30	Gerlitzten	Gurktal Alps	Gerlitzten	A	20	20	4
31	N.Tauern	Niedere Tauern	Tauernpass	A	42	33	2
32	Julian	Julian Alps	---	SLO	46	41	5
33	Sweden.N	Northern Sweden	Abisko	S	37	37	1
34	Norway.N	Northern Norway	Alta	N	37	37	5
35	Norway.S	Southern Norway	Dovre, On	N	44	44	4
36	Tatra	Carpathians	High Tatra	SK	28	21	5
37	Bucegi	Carpathians	Bucegi mountains	RO	28	20	1
38	Durmitor	Durmitor	Durmitor	XM	14	14	1
39	Rila	Balkans	Rila mountains	BG	10	12	2
40	Sevo	Apennines	Pizzo di Sevo	I	24	24	1
41	Altai	Central Altai	Kurai	RU	34	40	5
42	Sayan	Southern Sayan	Southern Tuva	RU	35	30	5
43	Narym	Southern Altai	Narym mountains	KZ	14	8	1

Tab. 2. Population means of the measured parameters. SP = number of spines per valve. OP = ocelli position. FWD = forewing design. HWD = hindwing design. AV = width antevaginal plate (mm). sd = standard deviation (for interval/ratio variables with adequate sample size).

Nr	Sample	SP	sd	OP	sd	FWD	HWD	AV
1	Pyrenees.C	2.113	1.0623	0.226	0.0193	2.12	2.63	1.17
2	Pyrenees.E	0.154	0.5150	0.274	0.0120	4.54	4.13	0.72
3	Dauphiné	0.111	0.2887	0.274	0.0293	4.00	4.52	0.81
4	Pt.S.Bernh	0.462	0.6279	0.277	0.0185	4.85	4.69	0.75
5	Gr.Parad.	0.091	0.2505	0.280	0.0157	4.46	5.06	0.81
6	Penninic.N	0.154	0.5547	0.269	0.0603	4.36	4.96	0.76
7	Penninic.S	0.400	0.6222	0.278	0.0414	4.48	4.72	0.78
8	Bernese	0.107	0.2841	0.278	0.0212	4.18	3.50	0.81
9	Albula	0.100	0.2754	0.281	0.0242	4.44	4.27	0.75
10	Bernina	0.042	0.1412	0.278	0.0214	3.52	4.07	0.76
11	Bergam.W	1.636	0.9244	0.212	0.0133	3.00	3.36	0.82
12	Bergam.C	1.196	0.7739	0.220	0.0310	2.75	3.57	0.73
13	Bergam.E	1.700	0.5869	0.232	0.0202	3.67	3.83	0.83
14	Ortler.W	0.117	0.2520	0.266	0.0184	4.36	5.00	0.69
15	Ortler.S	0.500	0.6778	0.259	0.0226	2.42	3.63	0.78
16	Ortler.N	0.179	0.5409	0.252	0.0261	3.14	4.57	--
17	Adamello	0.156	0.4295	0.259	0.0199	3.81	4.97	0.61
18	Brenta	0.292	0.5526	0.259	0.0242	2.10	3.39	0.80
19	Ötztal	0.260	0.4592	0.274	0.0320	4.08	4.65	0.80
20	Karwendel	0.135	0.5207	0.288	0.0260	3.92	3.96	--
21	Rofan	0.033	0.1826	0.290	0.1398	3.63	4.40	0.84
22	Lessinic	1.125	0.8650	0.238	0.0226	3.15	3.07	0.82
23	Dolom.Lat	0.484	0.7012	0.266	0.0196	3.25	4.59	0.77
24	Dolom.Mar	0.281	0.4820	0.262	0.0320	2.61	4.67	0.81
25	Dolom.Pala	1.813	1.3664	0.260	0.0248	3.47	3.31	0.78
26	H.Tauern	0.197	0.4667	0.264	0.0227	2.56	3.18	0.80
27	Venetian	2.286	0.9063	0.251	0.0107	1.86	2.86	0.83
28	Carnic	1.735	1.3961	0.248	0.0462	2.32	2.70	0.79
29	Amberg	0.115	0.2996	0.247	0.0323	4.00	4.50	0.61
30	Gerlitz	0.375	0.6463	0.274	0.0237	3.80	4.30	0.72
31	N.Tauern	0.197	0.3737	0.261	0.1586	4.16	3.33	0.73
32	Julian	1.634	1.1991	0.261	0.1034	3.78	3.42	0.89
33	Sweden.N	0.135	0.3466	0.237	0.0220	3.74	2.32	0.67
34	Norway.N	0.284	0.5075	0.259	0.0250	3.14	3.72	0.71
35	Norway.S	0.261	0.4510	0.248	0.0198	4.02	3.57	0.74
36	Tatra	0.119	0.3502	0.261	0.0169	4.75	5.93	0.74
37	Bucegi	0.000	0.0000	0.271	0.018	5.00	6.96	0.75
38	Durmitor	1.929	1.0535	0.231	0.0163	3.07	2.93	0.84
39	Rila	0.045	0.1508	0.275	0.0244	4.91	5.36	0.73
40	Sevo	0.021	0.1021	0.253	0.0276	4.37	4.04	0.87
41	Altai	0.125	0.3349	0.274	0.1711	5.02	5.53	0.79
42	Sayan	0.083	0.2306	0.281	0.0148	4.83	5.10	0.76
43	Narym	2.812	1.3076	0.275	0.0098	3.07	1.00	0.69

Tab. 3. Population means for SP, OP, FWD and HWD, rescaled to 0–100, and their rescaled sum. The populations (*pandrose* group only) are sorted according to increasing sum.

nr	sample	SP	OP	FWD	HWD	SUM
37	Bucegi	0	36	1	0	0
39	Rila	9	28	4	34	14
42	Sayan	17	17	7	40	15
41	Altai	25	30	0	31	17
5	Gr.Parad.	18	19	19	41	21
21	Rofan	7	0	48	55	26
36	Tatra	24	55	9	22	26
9	Albula	20	17	20	58	28
20	Karwendel	27	4	38	65	34
14	Ortler.W	23	45	23	42	34
6	Penninic.N	31	40	23	43	35
2	Pyrenees.E	31	30	16	61	36
3	Dauphiné	22	30	35	53	37
10	Bernina	8	23	51	62	38
8	Bernese	21	23	29	75	39
40	Sevo	4	70	22	63	43
19	Ötztal	52	30	32	50	45
7	Penninic.S	80	23	18	48	47
4	Pt.S.Bernh	92	25	6	49	48
17	Adamello	31	58	41	43	49
29	Amberg	23	81	35	53	55
31	N.Tauern	39	55	29	78	58
30	Gerlitzén	75	30	42	57	59
16	Ortler.N	36	72	64	52	66
35	Norway.S	52	79	34	73	72
24	Dolom.Mar	56	53	83	49	72
34	Norway.N	57	58	64	70	75
23	Dolom.Lat	97	45	61	51	77
26	H.Tauern	39	49	84	81	77
33	Sweden.N	27	100	44	100	83
18	Brenta	58	58	100	77	91
15	Ortler.S	100	58	89	72	100

Une nouvelle espèce d'*Hyponephele* du Pakistan (Nymphalidae: Satyrinae)

JÉRÔME PAGÈS

Agrocampus, 65 rue de Saint-Brieuc, F-35042 Rennes cedex;
e-mail: jerome.pages@agrocampus-rennes.fr

Résumé. Une nouvelle espèce, *Hyponephele filistigma* sp. n., est décrite de la région de Chitral, Pakistan. Elle appartient au groupe *H. davendra* (Moore, 1865) et se distingue immédiatement des autres espèces du groupe par une longue tache androconiale filiforme pour le mâle et, pour les deux sexes, au dessous des ailes postérieures, par une ligne postdiscale brune présentant un angle aigu vers l'extérieur très prononcé au niveau de l'espace 3.

Abstract. A new species, *Hyponephele filistigma* sp. n., is described from the vicinity of Chitral (Pakistan). It can be distinguished readily from the other species of the *H. davendra* (Moore, 1865) group, to which it belongs, by its long and filiform androconial band for the male, and, for both genders, on the underside of the hind wing, by the postdiscal line with the outer acute angle prominent in area 3.

Introduction

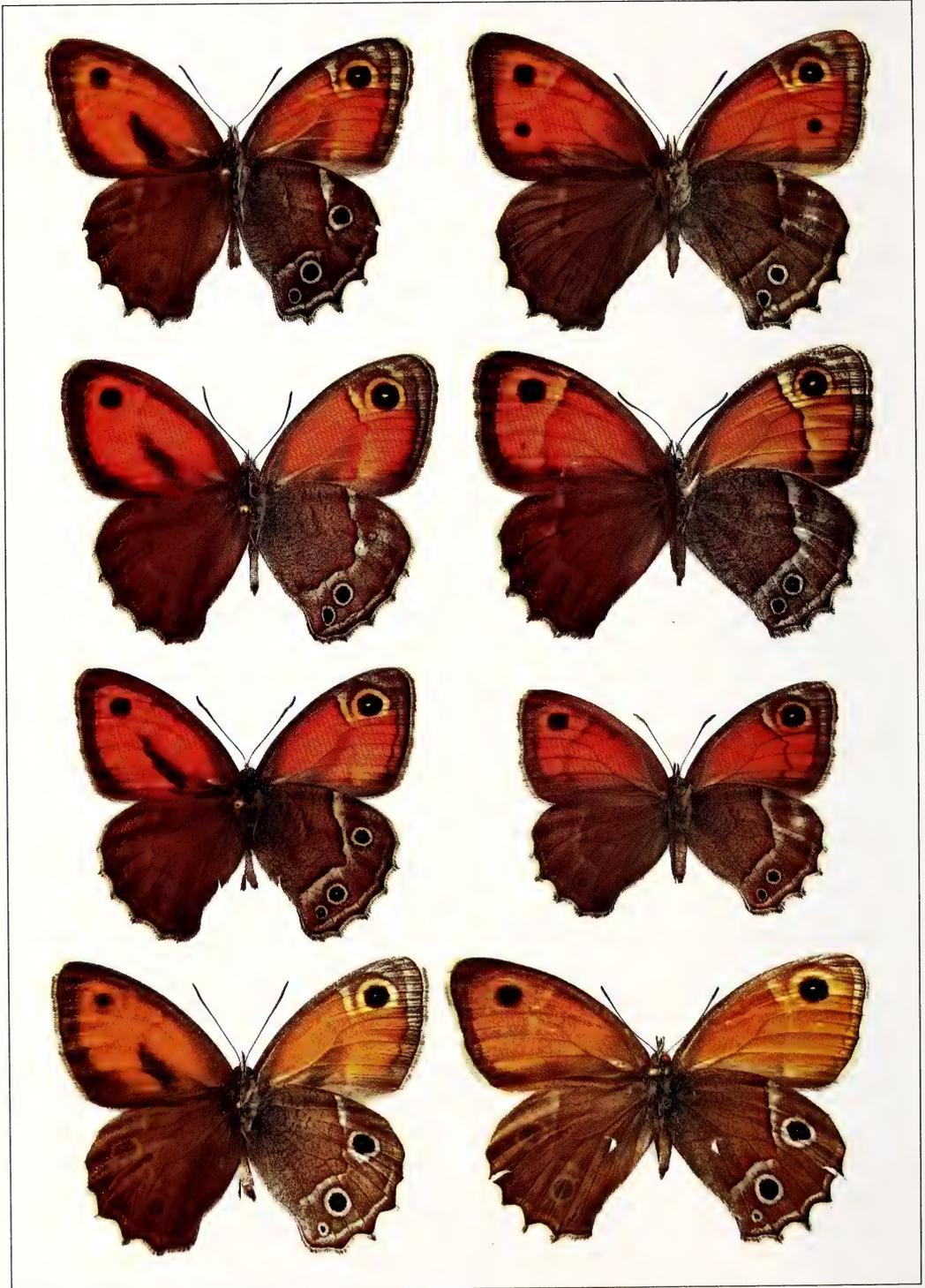
On trouve dans la région de Chitral, quatre espèces d'*Hyponephele* (Muschamp, 1915) du groupe *davendra* (Moore, 1865). Trois sont connues et nous rappelons les principales caractéristiques de leur habitus. Une quatrième forme présente des caractéristiques bien marquées qui suggèrent qu'il s'agit là d'une espèce distincte des précédentes mais aussi des autres du groupe (des synthèses récentes se trouvent dans Carbonell (1997, 2000) et Samadurow et al. (1997)). Nous décrivons ci-après cette nouvelle espèce, en référence aux trois précédentes que l'on trouve dans des zones assez voisines mais aussi par rapport à *H. brevistigma* (Moore, 1892), espèce de haute altitude connue, pour le Pakistan, de la partie est (Hunza) et dont on trouve une description dans Carbonell (1997) et des représentations dans Tshikolovets (2005b).

Hyponephele tenuistigma (Moore, 1892), avec la sous-espèce *laspura* (Evans, 1932)

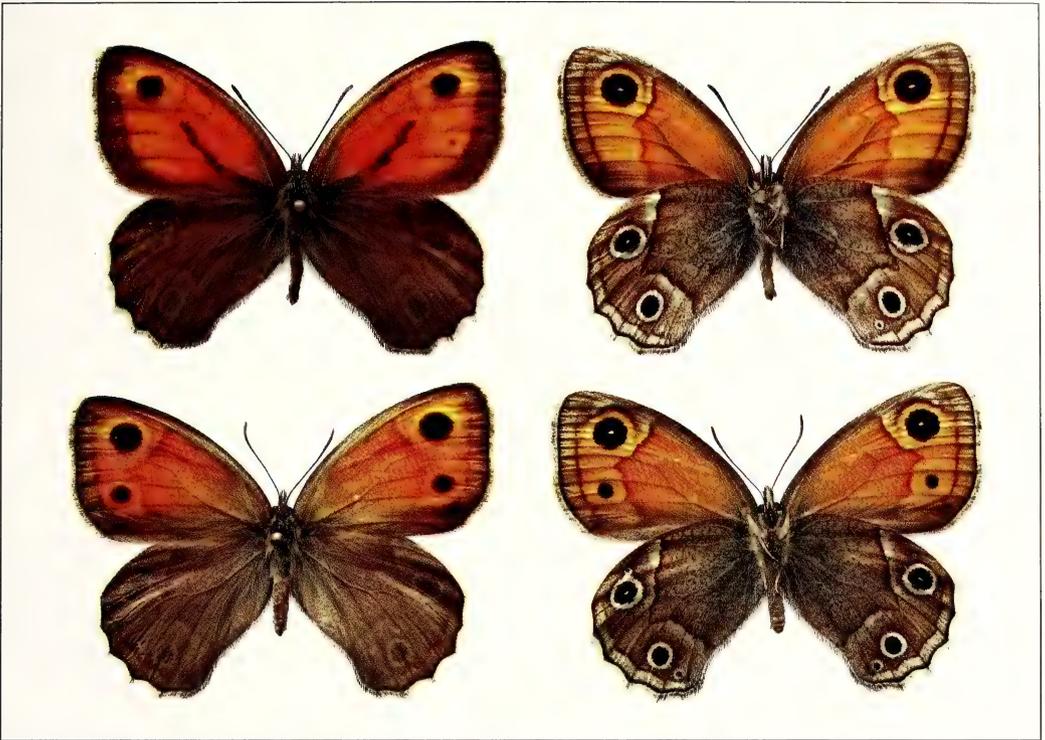
Localité type: Pakistan, Chitral, au-dessus de 9,000 pieds.

Cette espèce de taille moyenne (σ : 34–38 mm; f : 39–41 mm) présente, pour le mâle, une tache androconiale assez longue (1 cm) et étroite (environ 2 mm). Au dessous des ailes antérieures, une ligne discale est généralement nette, critère cité par d'Abnera (1992) pour séparer *tenuistigma* de *davendra* mais qui est encore plus caractéristique chez *chitralica* (Evans, 1932), traitée ci-après. Une caractéristique de la sous-espèce *laspura* ne semble pas avoir été citée: les nervures de la face supérieure des ailes antérieures sont soulignées de noir. Les exemplaires que j'ai capturés dans les environs de Chitral sont bien conformes au type déposé au BMNH (Londres, Angleterre).

Evans (1932) indique: « Chitral over 9,000 ft, rare ». Nous avons observé cette espèce entre 2700 m et 3200 m dans une seule zone des environs de Chitral. En revanche, je l'ai observée en plusieurs autres endroits des montagnes du Nord du Pakistan (Hunza, Astor).



Pl 1. De haut en bas : *H. davendra* (Chitral), *H. chitralica* (Chitral), *H. laspura* (Chitral), *H. brevistigma* (♂ Passu, Pakistan; ♀ Sabu, Ladakh). Pour chaque ligne, de gauche à droite: mâle (dessus, dessous); femelle (dessus, dessous).



Pl 2. *H. flistigma* n. sp. En haut, holotype mâle (Chitral) dessus dessous. En bas, allotype femelle (Chitral) dessus dessous.

Hyponephele chitralica (Evans, 1923)

Localité type: Khyber (Pakistan).

Cette espèce de taille moyenne (σ : 34–38 mm ; φ : 39–41 mm) est caractérisée, pour le mâle par une tache androconiale entrecoupée par les nervures qui ne longe que partiellement la cellule et, sur le revers des ailes antérieures des deux sexes, par une ligne discale bien marquée. Une autre caractéristique de cette espèce, assez nette lorsque l'on compare des séries, ne semble pas avoir été citée : la forme arrondie des ailes antérieures. Un syntype de cette espèce peu connue est représenté dans Tshikolovets (2005a). Evans (1932) indique: « Chitral, not rare ». Ceci est en accord avec le fait que j'ai observé cette espèce en des endroits variés de 1600 m (pelouses sèches de la vallée de la Kunar river) à 2800 m (allées forestières). Je ne l'ai pas observée ailleurs qu'à Chitral.

Hyponephele davendra (Moore, 1865)

Localité type: Spiti (Tibet).

Espèce de taille plutôt grande (σ : 41–43mm ; φ : 45mm). Les exemplaires que j'ai capturés aux environs de Chitral ressemblent bien à ceux de la région de Kaboul figurés par Wyatt & Omoto (1966) ou par de Freina & Aussem (1986) ainsi qu'à ceux d'Afghanistan figurés par Sakai (1981). En première analyse, ils ne diffèrent pas particulièrement d'exemplaires trouvés en plusieurs endroits des montagnes du Nord du Pakistan. La

tache androconiale est grande mais pas au point de rattacher spontanément la forme de Chitral au taxon *latistigma* (Moore, 1893) (voir par exemple l'exemplaire figuré par Nazari (2003), ou ceux, même si cela apparaît un peu moins nettement, figurés dans Eckweiler (2005)). Toutefois, il est prudent de dire que ce rattachement n'est pas une certitude absolue.

Hyponephele filistigma sp. n.

Pl. 2

Matériel. Holotype ♂, 'Pakistan | Chitral 10 km W | 3200 m | 26 vii 1996', leg. J. Pagès, coll. Muséum National d'Histoire Naturelle de Paris. – Allotype ♀, 'Pakistan | Chitral 10 km W | 3200 m | 4 vii 2006', Leg. et Coll. J. Pagès. – Autres paratypes (4♂, 3♀: Leg. et Coll. J. Pagès): 1♂, 'Pakistan | Chitral 10 km W | 3500 m | 26 vii 1996'; 1♂, 'Pakistan | Bumburet | 3200 m | 26 vii 1997'; 1♂, 'Pakistan | Chitral 10 km W | 3500 m | 14 vii 2006'; 1♂, 'Pakistan | Kalam 7 km N | 2400 m | 1 vii 2006'; 2♀, 'Pakistan | Chitral 10 km W | 3500 m | 10 vii 2006'; 1♀, 'Pakistan | Kalam 7 km N | 2200 m | 1 vii 2006'.

Description. Mâle. Envergure entre 39 et 44 mm. Dessus aile antérieure : fond jaune orangé bordé de brun-gris ; forme peu élancée ; la tache androconiale, longue (plus d'un cm de long) et filiforme (moins d'un mm de large) borde la cellule en allant de la base de l'aile au milieu de l'espace 3 ; franges grises à la base et blanches sur leur moitié extérieure. Dessus aile postérieure : couleur de fond brun-gris uniforme avec un fin liséré près de l'angle anal. Dessous aile antérieure : fond jaune orangé plus clair que le recto ; ligne postdiscale bien visible ; elle sépare une aire intérieure sensiblement plus foncée que l'aire extérieure ; irrégulière, elle montre en particulier un angle aigu vers l'extérieur au niveau de l'espace 3. Ocelle apical généralement assez grand. Dessous aile postérieure : allure générale comme *brevistigma* mais avec des dessins plus nets ; fond gris clair ; ligne postdiscale brune, bordée extérieurement de blanc ; elle présente un angle aigu vers l'extérieur très prononcé au niveau de l'espace 3 ; deux lignes foncées, submarginale et marginales, délimitent un bande claire ; deux ocelles proéminents dans les espaces 2 et 5.

Femelle. Envergure entre 41 et 45 mm. Dessus aile antérieure. Fond jaune orangé bordé de brun-gris ; deux ocelles bien marqués dans les espaces 2 et 5. Bande postdiscale à peine visible. Dessus aile antérieure. Comme chez le mâle. Dessous. Identique à celui du mâle, excepté un second ocelle souvent présent dans l'espace 2.

Variation individuelle. Faible. Au-dessous, la ligne postdiscale des antérieures est plus ou moins nette.

Diagnose. Par rapport aux autres espèces du groupe, la tache androconiale, longue et filiforme, permet d'identifier le mâle au premier coup d'œil. Pour les deux sexes, le dessous est proche de celui de *brevistigma* mais avec des dessins plus nets et une ligne postdiscale brune, bordée extérieurement de blanc présentant un angle aigu vers l'extérieur très prononcé au niveau de l'espace 3 (chez *brevistigma* cet angle existe mais est moins marqué). Deux lignes foncées, submarginale et marginales, délimitent un bande claire (chez *brevistigma* il y a un simple liséré clair submarginal).

Biotope. *Hyponephele filistigma* n. sp. a été trouvé de la fin juin à la fin juillet sur des pentes rocailleuses à des altitudes plutôt élevées (3000–3500 m) dans la région de Chitral et à une altitude moindre (2200–2500 m) dans les environs de Kalam (Swat valley).

Remerciements

Il m'est agréable de remercier V. Tshikolovets qui m'a fourni une photographie d'un syntype de *H. tenuistigma laspura*.

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Tuzov, V. K. & G. C. Bozano 2006. Guide to the butterflies of the Palearctic Region. Nymphalidae part II. Tribe Argynniini: *Boloria*, *Proclassiana*, *Clossiana*. – Omnes Artes, Milano. 72 pp. ISBN 8887989079, 40.00 €.

This book is the latest addition to the series “Guide to the butterflies of the Palearctic Region” edited by G. C. Bozano, a series that is renowned for splendid figures and detailed taxonomic treatment of the various groups of Palearctic butterflies. The current volume deals with the Argynniini genera *Boloria*, *Proclassiana*, and *Clossiana*, commonly known as “small fritillaries”. The group reaches its highest diversity in the Eastern Palearctic region with several little known or doubtful species or subspecies. The book is for that reason alone a very welcome contribution to the study of Palearctic butterflies.

The authors take a rather conservative but also refreshingly bold approach to the classification of the group. They are conservative with respect to the higher classification where they retain the three classic genera instead of merging all three into one unified *Boloria*. As the precise relationships between these genera at the present still are somewhat uncertain, this approach is fairly sound, though using a large unified *Boloria* for all three genera probably would have been a more straightforward approach. On the other hand, the authors make some quite bold statements when it comes to the taxonomic status of some of the species/subspecies, giving full species status to what they term “most of the ‘strong’ subspecies”. This approach is commendable as it forces students of the group and conservationists alike to focus on problematic taxa that could otherwise be dismissed as “mere” subspecies. Furthermore, though some of these species may later be “sunk” to subspecies again, a detailed analysis of the true status of these species falls well outside the scope of the book. And by giving full species status to what may or may not be a species, the authors point to future subjects for taxonomic research within the group. Along these lines the authors also recognize a wide range of subspecies. Though the use of subspecies is debated, this approach too seems sound, as it allows students and collectors to name different geographical forms. Furthermore, some of these subspecies may later prove to be full species. By recognizing them here, the authors enhance the chance that future studies will focus on these groups and perhaps recognize them as full species.

Each genus is described with its diagnostic characters, and a full checklist of species and subspecies found in the Palearctic region is provided, including all species and several subspecies found outside the region. Each species is provided with a full list of synonyms, a description of diagnostic characters, a list of recognized subspecies (including synonyms), a discussion of taxonomic problems (if any), a brief summary of the distribution range of each subspecies, and an easily understood (albeit small) distribution map. Each species is richly illustrated with high quality photos (or in rare cases, drawings from older literature) of the upper and under sides of both sexes for almost all subspecies, and important recognition characters are clearly marked on the figures and explained in the text. Drawings of the male genitalia or parts of the male genitalia are provided for all species. These drawings are not quite of the same standard as the other illustrations. The drawing styles, level of details, and, in some cases, angle of view are not consistent between drawings. This can make comparing different drawings problematic at times. The bibliography at the end of the book is a very comprehensive (if not exhaustive) account of the literature on the group and as such a very important tool for any student of these genera.

To sum up: this volume of the “Guide to the butterflies of the Palearctic Region” is a very high quality, and virtually indispensable tool for any amateur, student, or researcher who wishes to work on taxonomic or systematic aspects of *Boloria*, *Proclassiana*, and *Clossiana*. The book is by far the most comprehensive taxonomic treatment of the group to date.

Une nouvelle espèce de *Pseudochazara* du Pakistan (Nymphalidae, Satyrinae)

JÉRÔME PAGÈS

Agrocampus, 65 rue de Saint-Brieuc, F-35042 Rennes cedex;
e-mail: jerome.pages@agrocampus-rennes.fr

Résumé. *Pseudochazara annieae* sp. n. a été découvert dans la vallée de Swat (Nord Pakistan). Le mâle est immédiatement reconnaissable par ses ailes antérieures de couleur brun gris foncé ne présentant qu'une faible trace de bande postmédiane et ses ailes postérieures présentant, sur le même fond brun gris foncé, une bande postmédiane fauve orangé. La femelle présente ces mêmes caractéristiques à un degré moindre avec un fond brun clair. Dans les deux sexes, le revers des postérieures est gris avec des lignes postmédiane et antémarginal bien marquées. L'habitus des mâle et femelle est illustré en couleur en vues dorsale et ventrale. L'habitus de *Pseudochazara droshica* (Tytler), l'espèce la plus semblable à *P. annieae*, est également illustré.

Abstract. *Pseudochazara annieae* sp. n., was discovered in the Swat Valley (Pakistan). The male can be distinguished immediately from the other *Pseudochazara* by its dark grey-brown forewings with only a trace of a postdiscal band and by a orange postdiscal band on the hindwings. The female presents the same features but less prominent and with a clear brown background. In the two genders, the verso of the hindwings is grey with marked postdiscal and sub-marginal lines. The habitus is illustrated in colour for both sexes in dorsal and ventral view. *Pseudochazara droshica* (Tytler), the species most similar to *P. annieae* is also illustrated.

Introduction

On trouve dans la vallée de Swat (Nord Pakistan) une espèce se référant au genre *Pseudochazara* présentant un habitus bien caractéristique: de grande taille, les ailes antérieures du mâle sont de couleur brun gris foncé et ne présentent qu'une faible trace de bande postmédiane alors que les ailes postérieures montrent une bande postmédiane frappante fauve orangé. Bien que le Nord Pakistan ait donné lieu à des prospections entomologiques depuis plus d'un siècle, cette espèce ne semble pas avoir été signalée. Nous donnons ci-après quelques points de repère bibliographique.

L'ouvrage récent de T. J. Roberts (2001) cite, pour le Pakistan, deux espèces du genre *Pseudochazara* (en les affectant au genre *Eumenis*): *mniszechii gilgitica* (Tytler) qu'il cite des provinces suivantes: Balouchistan, frontière du Nord Ouest (North West Frontier Province: NWFP) et régions du Nord. (Northern Areas: NA); il considère cette espèce synonyme de *baldiva* (Moore); *telephassa* (Hübner), qu'il cite du Balouchistan et de la région frontalière ouest de la province de la frontière du nord ouest. Il considère cette espèce synonyme de *lehana* (Moore).

L'ouvrage ancien mais fort complet de Talbot (1947) mentionne quant à lui les *Pseudochazara* suivants pour l'ensemble Inde + Pakistan (en les affectant au genre *Hipparchia*): *mniszechii balucha* (Evans), Balouchistan; *mniszechii droshica* (Tytler), Chitral, Gilgit, Baltistan; *mniszechii gilgitica*, Chitral, Gilgit, Baltistan; *mniszechii lehana*, Ladak; *mniszechii baldiva*, Shipki, Kunawur to western Tibet; et *telephassa*, Balouchistan Khyber pass.

Ces taxa sont repris (dans le genre *Hipparchia*) par Mani (1986) qui n'en ajoute pas d'autres pour l'Himalaya. L'ouvrage de Wynter-Blyth (1957), dédié au sous-continent



Fig. 1. *Pseudochazara annieae* n. sp. En haut, holotype ♂, recto verso ; en bas, allotype ♀, recto verso.

indien, mentionne, quant à lui (dans ce groupe taxonomique mais en les rattachant au genre *Eumenis*), les seuls taxa *mniszecii* (sans mention de sous-espèce) et *telephassa*.

Concernant la faune indo-pakistanaise, il convient enfin de mentionner le taxon *Hipparchia diffusa* Butler, 1880; ce taxon n'a été repris par aucun des « grands » auteurs, Evans (1932) et Talbot (1947). Kudrna (1977) le mentionne parmi les types du BMNH qu'il a examinés et le considère comme synonyme de *Hipparchia semele semele* (Linnaeus), en suggérant, à propos de la localité type (India: Punjab: Ravi River): « locality certainly erroneous ». Les spécimens de l'espèce décrite ici présentent un habitus très éloigné de celui de *semele*.

Il en est de même dans les régions limitrophes. Tshikolovets (1997) mentionne du Pamir: *droshica badachshana* Wyatt & Omoto, *droshica rajevskiyi* Tshikolovets, *sagina* (Staudinger) et *baldiva*. Koçak & Kemal (2006) mentionnent d'Afghanistan: *kani-shka* Aussem, *telephassa*, *droshica*, *panjshira* Wyatt & Omoto, *porphyritica* Clench & Soumanov, *sagina* et *turkeстана* (Groum-Grshimailo). Sakai (1981) mentionne, pour l'Afghanistan: *baldiva*, *droshica*, *lehana* et *telephassa*. Enfin, Nazari (2003) ne mentionne que *telephassa* pour les *Pseudochazara* du sud de l'Iran.

En dehors des faunes « régionales », on trouve aussi (par exemple dans Funet (2007)) le taxon *pakistanana* Gross décrit en 1978 à partir d'exemplaires de Ziarat (Balouchistan pakistanais) et représenté dans Tuzov (1997) selon lequel la distribution est assez vaste, incluant en particulier l'Hindukush.



Fig. 2. *Pseudochazara droshica* Tytler. En haut, ♂, recto verso, 6.vii.1997, Birmoglasht (Chitral) ; en bas, ♀, recto verso, 9.viii.1997, Bumburet (Chitral).

Ce n'est pas le lieu ici de trancher les options systématiques de ces auteurs. Il suffit pour notre propos de retenir que, dans tous les taxa mentionnés, les deux sexes présentent une bande postmédiane jaune bien marquée sur les deux ailes.

En s'éloignant du Pakistan et en considérant l'ensemble des espèces du genre *Pseudochazara*, seuls *mamura* (Herrich-Schäffer) (Turquie, Iran, Irak), *beroe* (Herrich-Schäffer) (Turquie, Elbourz et Kopet Dagh), *lydia* (Staudinger) (Turquie) et *shakuhensis* (Staudinger) (Turquie, Elbours et Kopet Dagh), présentent une bande postmédiane à peine marquée ; mais ceci vaut pour les deux ailes ce qui, ajouté à leur plus petite taille, leur fond beaucoup plus clair, leur forme moins élancée et le revers de leurs ailes postérieures aux dessins confus leur confèrent une allure bien distincte de l'espèce de la vallée de Swat (cf. par exemple les iconographies de D'Abrera (1992), Hesselbarth et al. (1995), Tuzov (1997), Tshikolovets (1997, 1998) et Sakai (1981)).

Tout ceci conduit à décrire cette nouvelle espèce.

Pseudochazara annieae n. sp.

(Fig. 1)

Matériel. Holotype ♂, '*Pseudochazara annieae* | holotype | Pakistan | Kalam 2100m | 29 vi 2006 | leg. J. Pagès', déposé au Muséum National d'Histoire Naturelle de Paris. – Allotype ♀, '*Pakistan* | Kalam 2100m | 4 vii 2006', leg. et coll. J. Pagès. – Autres paratypes (30♂, 2♀: leg. et coll. J. Pagès sauf 1♂ coll. J. Mairiaux et 1♂ coll. Kiev Zoological Museum) ; mêmes localités avec 15♂ (29 vii 2006), 15♂ (4.vii.2006) et 2♀ (4.vii.2006).

Description. Mâle. Envergure entre 52 et 57 mm. Dessus aile antérieure : fond brun gris ; bande postmédiane à peine visible, légèrement plus claire que le fond ; deux

ocelles bien nets légèrement cerclés de jaune dans les espaces 2 et 5; quelquefois, deux petits points blancs dans les espaces 3 et 4. Taches androconiales, bien visibles sous certaines incidences, formant une bande médiane entrecoupée par les nervures; franges blanches entrecoupées de noir à l'extrémité des nervures. Dessus aile postérieure: couleur de fond identique à celle des ailes antérieures; bande postmédiane, limitée aux espaces 2, 3, 4 et 5; cette bande est large de couleur fauve vif, ayant un bord interne zigzaguant mais bien délimité; petit ocelle net dans l'espace 2; fine ligne antémarginale noire très légèrement sinueuse. Dessous aile antérieure: fond gris; plage médiane fauve foncé séparée d'une large bande postmédiane plus claire par une fine ligne grise à peine visible; les deux ocelles apparaissent nettement. Dessous aile postérieure: fond gris clair avec des dessins noirs assez nets; deux lignes brisées, postmédiane et submarginale, apparaissent nettement en délimitant une aire légèrement plus claire; petit ocelle dans l'espace 2.

Femelle. Envergure entre 58 et 60 mm. Dessus aile antérieure: fond brunâtre, plus clair que celui du mâle; éclaircies jaunes dans la partie discale; bande postmédiane plus apparente que chez le mâle, mais discontinue, réduite essentiellement à deux plages jaunes autour des deux ocelles proéminents. Dessous aile postérieure: comme chez le mâle mais couleur de la bande jaune orangé moins vif. Dessous identique à celui du mâle.

Variation individuelle: très faible sur les exemplaires mâles, capturés, il est vrai, la même année et dans deux stations assez voisines de même altitude. Les trois femelles étudiées sont légèrement variables quant à la taille et l'étendue des plages claires.

Diagnose. Espèce de grande taille, peut-être la plus grande dans le genre *Pseudochazara*. Chez le dessus du mâle, la bande claire postmédiane habituelle des autres *Pseudochazara* est, aux ailes antérieures, à peine plus claire que le fond et, aux ailes postérieures, est presque aussi large que chez *droshica* mais d'une nuance sensiblement plus orangée. Ce contraste entre aile antérieure et postérieure rend cette espèce immédiatement reconnaissable. Enfin, la forme de la plage androconiale, qui s'apparente à celle des espèces du groupe *Hipparchia semele*, n'a pas d'équivalent dans le genre *Pseudochazara*. Chez la femelle, sur le dessus des ailes antérieures, la bande postmédiane est plus apparente que chez le mâle mais reste beaucoup plus réduite que chez les femelles des autres espèces. Celle des ailes postérieures est large comme chez le mâle, de la même nuance orangée mais plus foncée, ici encore sans équivalent dans le genre.

Étymologie. Cette espèce est dédiée à mon épouse Annie, qui m'accompagne dans bien des aventures.

Biotope. *Pseudochazara annieae* n. sp. a été trouvé sur des pentes rocailleuses à relativement faible altitude (2 100 m). En 2006, les mâles volaient dès la fin de juin, attirés par des chardons. Quelques femelles sont apparues début juillet. Très peu d'autres espèces volaient dans ces biotopes secs; citons seulement *Strymonidia sassanides* (Kollar), assez commun dans la région.

Remerciements

Il m'est agréable de remercier Bernard Landry pour l'excellent accueil qu'il a réservé à ce travail.

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A new *Amata* species from Israel (Arctiidae, Syntominiæ)

THOMAS J. WITT¹, VASILIJ D. KRAVCHENKO², WOLFGANG SPEIDEL³,
JOSEF MOOSER⁴, AMY JUNNILA⁵ & GÜNTER C. MÜLLER⁶

¹ Museum Witt, Tengstr. 33, D-80796 Munich, Germany; e-mail: thomas@witt-thomas.com

² Department of Zoology, Tel Aviv University, Tel Aviv, Israel; e-mail: vasilij@post.tau.ac.il

³ Museum Witt, Tengstr. 33, D-80796 Munich, Germany; e-mail: speidel-wolfgang@web.de

⁴ Seilerbruecklstr. 23, D-85354 Freising, Germany; e-mail: jomooser@aol.com

⁵ Department of Parasitology, McGill University, Macdonald Campus, Ste-Anne-de-Bellevue, Québec H9X 3V9, Canada; e-mail: amyj@sympatico.ca

⁶ Department of Parasitology, Kuvim Centre for the Study of Infectious and Tropical Diseases, The Hebrew University – Hadassah-Medical School, Jerusalem, Israel; e-mail: guentermuller@hotmail.com

Abstract. A new *Amata* species, *Amata gil* sp. n., is described from Mount Hermon, Israel. It is related to *Amata libanotica* (Bang-Haas, 1906) and *A. mestratii* (Bugnion, 1837), but can be easily discriminated from these species by its considerably smaller size and its lack of the yellow ring on the first abdominal segment which is normally present in the two other species, though it can be reduced in *A. mestratii*. Here, the distribution, ecology, and phenology of the new species are reported and the habitats are pictured in colour.

Zusammenfassung. Eine neue *Amata*-Art, *Amata gil* sp. n., wird vom Berg Hermon, Israel, beschrieben. Sie steht *Amata libanotica* (Bang-Haas, 1906) und *A. mestratii* (Bugnion, 1837) nahe, aber kann von diesen Arten leicht unterschieden werden durch beträchtlich kleinere Größe und durch das Fehlen des gelben Ringes am ersten Abdominalsegment, der bei den beiden anderen Arten normalerweise vorhanden ist, obgleich er bei einigen Individuen von *A. mestratii* auch reduziert sein kann. Die Verbreitung, Ökologie und Phänologie werden dargestellt und Habitate werden auf einer Farbtafel abgebildet.

Introduction

Until recently, the name *Amata* Fabricius, 1807 has been widely used as the generic descriptor of this group and the name *Syntomis* Ochsenheim, 1808 treated as a junior synonym (e. g. Obratzov 1966; Holloway 1988; Edwards 1996; Nielsen 1996). However, a separate genus *Syntomis* has been accepted by Schneider et al. (1999). The monophyly of the genus *Syntomis* sensu Schneider et al. is very well supported by the presence of androconial hairbrushes on the foreleg coxa and by molecular genetic data (Schneider et al. 1999). However, the monophyly of *Amata*, which lacks hairbrushes on the forecoxa, is not supported by the three published phylogenetic trees based on partial sequences of the mitochondrial 16S rRNA gene. These trees show *Amata* to be polyphyletic, if *Syntomis* and *Hydrusa* are accepted as separate genera (Schneider et al. 1999). Therefore, at present, it seems best to retain *Amata* in the wide sense as defined by Holloway (1988), but to recognize a monophyletic *Syntomis* section within that genus to which the new species belongs. A generic separation of *Syntomis* from *Amata* would also necessitate the splitting of *Amata* s. str. in several genera and make the group rather unpractical, especially in the Oriental tropics. The new taxon can be further attributed to the *phegea* species group in the sense of Obratzov (1966) because of the dark front of the adults.

Material and methods

Besides the specimens mentioned in the description of the new species, the following material (all from Museum Witt) of related species was examined:

Amata sintenisi (Standfuss, 1892): 36♂, 9♀ from Asia Minor (Turkey),

Amata sintenisi aurivala (Schawerda, 1923): 9♂ (including 3 paratypes) from Iraq and Asia Minor (Turkey),

Amata tanina (de Freina, 1982): 70♂ (including holotype and 6 paratypes), 72♀ (including 5 paratypes) from Asia Minor (Turkey),

Amata libanotica (Bang-Haas, 1906): 3♂ from Lebanon,

Amata taurica (Turati, 1917): 1♂ from Asia Minor (Turkey), 20♂ from Syria,

Amata antiochena (Lederer, 1861): 9♂ from Asia Minor (Turkey),

Amata mestralii mestralii (Bugnion, 1837): 18♂, 43♀ from Lebanon and Syria,

Amata mestralii antilibanotica Obraztsov, 1966: 2♂, 1♀ (paratypes) from Antilibanon (mountain ridge separating Lebanon and Syria, exact locality (Zebdani) in Syria),

¹ *Amata mestralii palaestinae* (Bang-Haas, 1906): 54♂, 5♀ from Israel.

The present paper is based on the revision of Obraztsov (1966) and follows his terminology, including the wing pattern elements. In that monograph, the full synonymy of all mentioned species is indicated and the male genitalia are figured.

Amata gil sp. n.

(Figs 1–5, 9)

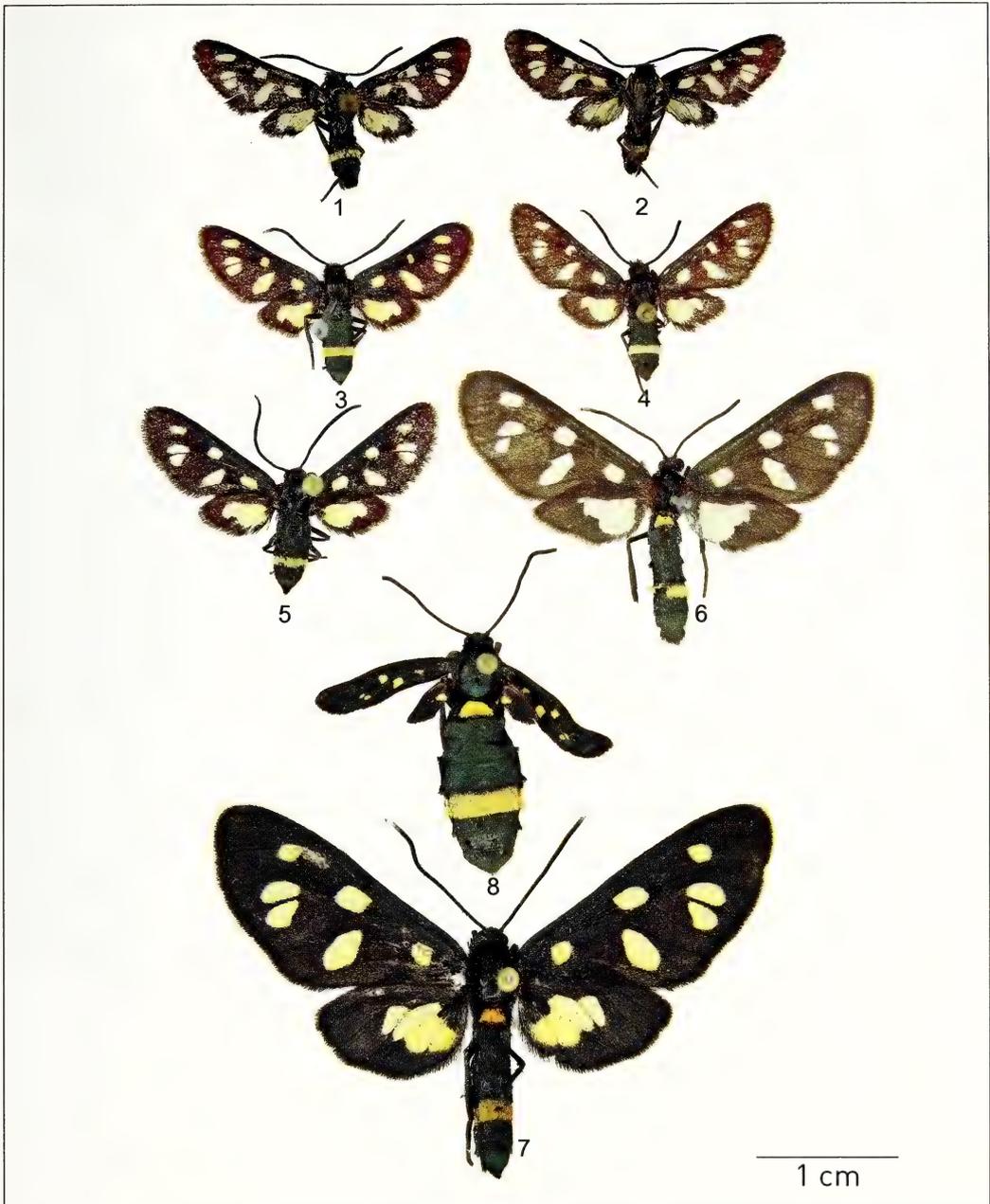
Material. Holotype: ♂, 'Israel | Hermon | 2200 m | 21. 6. 1969 | leg. Bytinski-Salz', 'coll. | Daniel', '*Amata* sp. n. | nahe *sintensis* <sic> Stdf. | det. F. Daniel 1972', 'Genitalpräparat | Nr 3379 | Museum Witt München', 'Holotypus | *Amata gil* | Witt & Kravchenko & Speidel & Mooser & Junilla & Müller'. Deposited in Museum Witt, Munich (MWM). – Paratypes: 1♂, 'Israel | Hermon | 2200 m | 21.6.1969' (MWM). 1♂, 'Israel, 1900 m | Mt. Hermon | 1.vii.1986 | A. Freidberg' (deposited in Tel Aviv University). 1♂, 'Israel | Nord Galiläa, Mt. Hermon | Lower Cable Station, 1500 m | 18.6.87 | coll. Mooser' (deposited in coll. Mooser). 1♂, 'Israel | Mt. Cheron [sic., for Hermon], 2000 m | 26.V.1967 | coll. Nisan' (deposited in Tel Aviv University). 2♂, 'Syria | Mt. Hermon, ca. 2600 m | 10.7.2003 | coll. R. Preiss' (deposited in coll. R. Preiss).

Description. Adult male (Figs 1–5). Head, antennae and body black, with yellowish white ring on abdominal segment 5. Underside of body and legs black, with few white scales on thorax and rarely on abdomen laterally.

Wingspan: 18–20 mm (Holotype 19 mm). Forewing black, with white spots: basal spot (m1) round, spot m2 small, round, spot m3 a narrow oblique stripe, m4 elongate, spots m5 and m6 very close to each other and small. Hindwing white, with margin at costa and termen broad, black; black border broader near anal angle; anal margin only with very narrow black border; wing base also with black scales.

Female. Unknown.

¹ There is a 'subspecies' *Amata mestralii palaestinae* 'Hampson, 1898' according to Obraztsov (1966). However, this name was introduced as *Syntomis mestralii* ab[erration]. *palaestinae* and so is unavailable (ICZN art. 45.6.2). It was first cited in the sense of a geographical population as var. *palaestinae* by Bang-Haas (1906) and so it became nomenclatorially available (ICZN, 4th ed., art. 10.2). *Amata mestralii palaestinae* (Bang-Haas, 1906) doubtfully represents a valid biological entity. The large material of *A. mestralii* at hand seems to demonstrate no constant geographical variability.



Figs 1–8. Adult moths (Photos by Igor Kostjuk). **1.** *Amata gil* sp. n. 'Israel, Hermon, 2200 m, 21. 6. 1969, leg. Bytinski-Salz', 'coll. Daniel', '*Amata* sp. n. nahe *sintensis* <sic> Stdf., det. F. Daniel 1972', 'Genitalpräparat Nr 3379 Museum Witt München'. Holotype. **2.** *Amata gil* sp. n. Holotype. Underside. **3.** *Amata gil* sp. n. 'Israel, Hermon, 2200 m, 21. 6. 1969', 'Museum Witt' (MWM). Paratype. **4.** *Amata gil* sp. n. 'Israel, Nord Galiläa, Mt. Hermon, Lower Cable Station, 1500 m, 18. 6. 87, coll. Mooser'. Coll. Mooser, Freising. Paratype. **5.** *Amata gil* sp. n. 'Israel, 1900 m, Mt. Hermon, 1. vii. 1986, A. Freidberg'. Tel Aviv University. Paratype. **6.** *Amata libanotica* (Bang-Haas, 1906) 'Libanon, Franz Daniel', '*Amata libanotica* B.-H. ♂ det. N. Obraztsov 1948', 'Fig. in N. Obraztsov Monogr. *Amata*'. **7.** *Amata mestratii* (Bugnion, 1837) ♂ 'Israel, Nord-Galliläa, 10 km E Quiryat-Shemona, 350 m, leg. de Freina', 'coll. de Freina, Museum Witt, München'. **8.** *Amata mestratii* (Bugnion, 1837) ♀ 'Merom, Israel, 5. v. 1975, leg. Kugler', '*Amata mestratii* (Bugnion, 1837), det. T. Witt 2003'. Tel Aviv University.

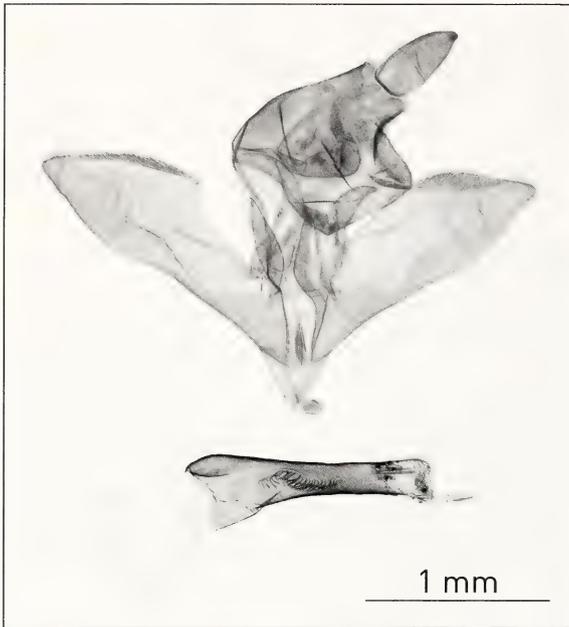


Fig. 9. *Amata gil* sp. n. Holotype, male genitalia.

Male genitalia (Fig. 9, one specimen dissected). Uncus stout; vinculum with small saccus; valvae similarly shaped, pointed at apex; phallus basally very broad, bulbus ejaculatorius rather short, inserting at base of phallus.

Diagnosis. The new species is closely related to *Amata libanotica* (Fig. 6) and *A. mestralii* (Figs 7, 8) because in these two species both valvae are more or less pointed, the right and left one of approximately the same shape. The genitalia structure of *A. sintenisi* is somewhat similar, but the valvae are more rounded at the apex.

Amata libanotica always has a quite clear basal abdominal yellow ring dorsally on abdominal segment 1, which is weak or sometimes absent

in *A. mestralii*. In this respect, the new species is very similar to *A. mestralii*, as the yellow ring is absent in all known specimens. *Amata mestralii* is therefore regarded as possibly the closest relative of the new species. However, in *A. mestralii* and *A. libanotica*, the basal processus of the left valva is longer than the processus of the right one (Obraztsov 1966), whereas in the new species the right processus is longer than the left one. Nevertheless, the new species can be clearly distinguished from *A. mestralii* by the much smaller size and the smaller forewing spots in combination with the larger white area in the hindwing. *Amata mestralii* males have a wingspan of 33–40 mm.

A. antiochena and *A. tanina* have a different shape of each valva: the right valva is angled at outer margin, with shorter processus basalis, whereas the left one is pointed, with longer basal processus (Obraztsov 1966; de Freina 1982).

Comparative figures of the genitalia of all species can be found in Obraztsov (1966) except *N. tanina*, which is figured in the original description (de Freina 1982).

Etymology. The species is dedicated to Gil D. Reichstadt-Ofarim, the well-known musician who now lives in Munich.

Distribution, ecology and phenology. The new species has so far only been collected from Mount Hermon where it inhabits elevations from 1500 to 2600 m. However, if its distribution pattern extends beyond this at all, it is probably restricted to the Levant.

Mount Hermon is a cluster of mountains, mostly made of limestone, with three distinct summits comprising the southernmost part of the Anti-Lebanon mountain range. The highest elevation in Israel is only 2224 m while the highest peak (2800 m) is in Syria. Five of the six records of this new species are from the Tragacanth high altitude zone, which is restricted to the areas above 1900 m. This area receives snow cover and has



Figs 10–14. Habitat *Amata gil* sp. n. **10.** View from Israel, towards the northeast, on the Hermon Mountain Range, with snow line at about 1500 m, mid winter. **11.** View from Syria, towards the south, traganth vegetation on Mt Hermon on a wind-facing slope, about 2200 m, mid summer. **12.** North-facing slope of Mt Hermon in Syria, about 2500 m, mid summer. **13.** Large dolinas, a traditional collecting place on the Israeli part of the mountain ridge, near the upper cable station, about 2000 m, mid summer. **14.** Rocky, south-facing summit with scattered bushes, near the lower cable station, about 1600 m, mid spring.

very low temperatures in winter, whereas summers are hot and dry. This situation creates specific plant communities dominated by spiny, round, dense, cushion-like shrubs such as *Astragalus* and *Onobrychis* (Danin 1988). The main water source in this area is melting snow, consequently most of this karstic mountain area is rather arid (Danin 1995). Only one specimen was collected in flight on a xerotherm, karstic slope about 1500 m with few scattered *Rosa canina* L. and *Crataegus* sp. bushes (Rosaceae) (see Fig. 1). The two specimens from Syria were collected sitting on flowers growing among *Astragalus* sp. bushes (see Fig. 3) in the late morning. *A. gil* appears to be a summer

species that flies from June to July. The area is well known for its wealth of indigenous animals and plants, however, it is a sensitive border area between Israel, Lebanon and Syria and as such, it was, in the last few decades, difficult to collect material there, especially on the peaks on which military installations are found (Furth 1975; Kravchenko et al. 2006). Nevertheless, the Tel Aviv University Entomology Department was able to conduct considerable day-time collecting activities in this area. Because this rather distinctive species is absent in local collections, it is probably rare. It should also be mentioned that although numerous light traps were operated for years by the Israeli-German Lepidoptera Project, on the Israeli part of Mt Hermon, and hundreds of other *Amata* were caught, all the specimens of the new species were collected during the day (Müller et al. 2006). The host plants of *A. gil* are unknown, but the larvae of the closely related *A. mestratii* in Israel are polyphagous on low herbaceous plants (unpublished data of the authors).

Remark. *Amata tanina*, which is very similar in size to *A. gil*, is found in similar habitats at high elevations and has brachypterous females with extremely small wing rudiments. The related species *A. mestratii* has reduced wings and the female of the related *Amata libanotica* has fully developed wings. Accordingly it is difficult to predict the characteristics of the wings of the female of the new species.

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Gershenson, Z. S, T. Pavlíček, V. Kravchenko & E. Nevo 2006. Yponomeutoid Moths (Lepidoptera: Yponomeutidae, Plutellidae, Argyresthiidae) of Israel. – Pensoft Series Faunistica 58, Sofia-Moscow. 200 pp. Hardcover ISSN 1312-0174, 60.00 €.

This book is nicely produced in a hard cover and at first sight it appears to be a faunal list with descriptions of species. On the back of the cover, however, is a further clue: “This monograph, part of the “Evolution Canyon” model research program, ...”

After Preface and Introduction there is a chapter headed “General Points”. This contains a full and well researched section on the biology and ecology of the group, drawing largely on European literature; however it is remarkable that in the section on larvae there is no mention of the major work on chaetotaxy by Werner, nor in that dealing with pupae is there mention of the pioneering work of Patočka & Turčani.

There is then a section on distribution where the data from within Israel read more like a research paper in a scientific journal than what one would expect to find in a book of this kind. Economic significance is the final section which is adequately presented.

A small section on classification makes reference to molecular methods, but no attempt has been made to use such methods for a comparison with the phylogeny established using conventional morphological methods. Yponomeutoid in the title makes one imagine that all Yponomeutoidea may be treated, instead it is just the three families listed in the subtitle following Moriuti in his choice of Yponomeutidae *s.l.*

Chapter 5 entitled Systematics is, as one would expect, the largest part of the book, but not massively so. Each genus and each of the 25 species is briefly described with illustrations which are line drawings, of variable quality, usually depicting the adult, male and female genitalia, and a distribution map. There is then a comprehensive list of references and a single coloured plate illustrating just six of the larger well known species described in the text.

The data used in producing this book come from just 12 localities, from the years 2000–2003, which means that the distribution maps cannot give a very clear picture of the range of each species. One always welcomes treatment of a group of small moths from a part of the world less well worked entomologically, but it is over ambitious to think that an exhaustive faunal list can result from so few data. It is likely that with further work more species may be discovered in Israel, but the species descriptions and illustrations make it possible that they might be overlooked. In these days it is disappointing that adult moths are not comprehensively illustrated, and the taxonomic relationships not explored more deeply. At the same time it is good to find the biology of a group so thoroughly described.

Overall the book rather falls between stools: the data result from a three-year research project added to which is general material about the group and brief taxonomic treatment of the genera and species encountered; these components together are inadequate for a country fauna. Despite these reservations a faunal survey is always a stimulus for further study and exploration; if it can encourage more work on the microlepidoptera of this part of the world it will have been well worth while.

Cretonotos omanirana sp. n. aus dem Oman und dem Iran (Arctiidae: Arctiinae)

JOSEF J. DE FREINA

Eduard Schmid-Str.10, 81541 München, Germany; e-mail: defreina.j@online.de

Abstract. A distinct species of *Cretonotos* Hübner, 1816, *Cretonotos omanirana* sp. n., is described from NE-Oman and the Iranian side of the Gulf of Oman (Hormozgan, Kerman). Details on life history, breeding trials, habitat preferences, and distribution are given. The holotype, male and female habitus and genitalia, male androconial organs, as well as larval instar and habitat are figured. The habitus of both sexes, genitalia, and coremata organs of the closely related *Cretonotos gangis* (Linnaeus, 1763) are compared and illustrated.

Zusammenfassung. Eine neue Art der Gattung *Cretonotos* Hübner, 1816, *Cretonotos omanirana* sp. n. wird aus dem Nordoman und der iranischen Seite des Golfs von Oman aus den Provinzen Hormozgan und Kerman beschrieben. Der Holotypus, Tiere beider Geschlechter, die Genitalmorphologie, die männlichen Duftorgane (Coremata), die Raupe sowie der omanische Lebensraum der neuen Art werden abgebildet und mit Merkmalen der nächstverwandten *Cretonotos gangis* (Linnaeus, 1764) verglichen. Zur Lebensweise, den Präimaginalstadien, dem Lebensraum und der Verbreitung von *C. omanirana* werden ausführliche Daten geliefert.

Einleitung

Die Fauna der Arabischen Halbinsel kennt drei Arten der Gattung *Cretonotos* Hübner, 1816: *C. leucanioides* Holland, 1893 (Hacker et al. 1999) und *C. albidior* Wiltshire, 1986, beides äthiopische Faunenelemente, sowie eine aus dem Nordoman bekannt gewordene und als *C. gangis* (Linnaeus, 1763) fehl interpretierte Art (Wiltshire 1986: 292, fig.), die in folgendem als *Cretonotos omanirana* sp. n. beschrieben wird. Das Taxon *arabicum* Hampson, 1896, ebenfalls lange Zeit in der Gattung *Cretonotos* kombiniert, ist jetzt Typusart der monospezifischen Gattung *Creataloum* Dubatolov, 2006. Die Konspezifität jemenitischer Tiere mit *C. leucanioides* (loc. typ. Westafrika, Kamerun, valley of the Ogové River) bedarf der Bestätigung.

Cretonotos omanirana sp. n. ist der südwestlichste Vertreter einer vorder- bis ostasiatisch tropischen „*gangis*“-Artengruppe, die nordostwärts über Nordpakistan und die himalajanische Region bis Nordchina, südostwärts über die indonesische und philippinische Inselwelt bis Queensland verbreitet ist. Habituell unterscheiden sich diese Arten nur unwesentlich. Genitaliter finden sich im weiblichen Geschlecht deutliche, bei den Männchen weniger auffällige arttypische Strukturen (vgl. hierzu Goodger & Watson 1995; Wiltshire 1980; Dubatolov 2006). Auffälliges Artmerkmal sind die unterschiedlichen androkonialen Duftorgane der Männchen. Form und Anzahl der Coremaschläuche sind arttypisch. Die variable Größe der Coremata ist dagegen taxonomisch ohne Belang. Der Grund hierfür sind quantitativ unterschiedliche aufgenommene Mengen an Pyrrolizidin-Alkaloiden während der Larvalphase (Boppré & Schneider 1985; Schneider & Boppré 1981; Schneider et al. 1982). Es ist naheliegend, dass sich die Arten auch in der chemischen Zusammensetzung ihrer Pheromone und pyrrolizidinen Alkaloide unterscheiden (Bell & Meinwald 1986; Wunderer et al. 1986; Hartmann 1999). Die neue omanische Art wird in folgendem beschrieben und mit der Typusart der Gattung *Cretonotos*, *C. gangis* (Linnaeus, 1764) verglichen.

Abkürzungen

CDF	coll. de Freina, München
Gen.Präp. de Fr.	Genitalpräparat de Freina
Hflgl.	Hinterflügel
MWM	Museum Witt, München
Vflgl.	Vorderflügel
ZSM	Zoologische Staatssammlung, München

Cretonotos omanirana sp. n.

Material. Holotypus ♂: N-Oman, Westl. Hajar-Gebirge, ca. 45 km SSW Barka, Oase (Wadi) Abyadah, ca. 150–300 m, 04.–07.4.2006, leg. de Freina, ex coll. CDF (MWM). – Paratypen: 55♂, 34♀, gleiche Daten wie Holotypus, davon 2♂ genital untersucht (Gen.Präp. de Fr. 2006/50, 2006/51), CDF (MWM); 25♂, 22♀, gleiche Daten wie Holotypus, F1-Generation 08.–25.6.2006 (aus Muttertier 04.–07.4.2006, leg. de Freina), cult. de Freina, CDF (MWM), davon 2♂ genital untersucht (Gen.Präp. de Fr. 2006/52, 2006/53). 5♂, 6♀, N-Oman, Jabal Nakhl-Gebirge, Oase Nakhl, ca. 450 m, 30.–31.3.2006, davon 1♂ genital untersucht (Gen.Präp. de Fr. 2006/54), CDF (MWM); 1♀, gleiche Daten, jedoch 12.12.2006, leg. et coll. de Freina (MWM); 24♂, 18♀, gleiche Daten, jedoch ex larva (aus L3–L5 04.–12.12.2006), 25.12.–20.1.2007, cult. et coll. de Freina (MWM), davon 1♂, 1♀ (Genitalien in Kopula vereint, Fig. 23) und 3♀ genital untersucht (Gen.Präp. de Fr. 2006/68, 2006/55 2006/56, 2006/66), ein Präparat Fühler+ Beine + Thorax + Abdomen (Präparat 2006/67); 25♂, 21♀, gleiche Daten, F1-Generation 10.–20.4.2006 (Elterntiere I.2007, cult. de Freina), cult. et coll. de Freina (MWM); 32♂, 26♀, gleiche Daten, F2-Generation 10.–20.6.2007 (Elterntiere IV.2007, cult. de Freina), cult. et coll. de Freina (MWM); 43♂, 36♀, gleiche Daten, F3-Generation 16.–30.8.2007 (Elterntiere VI.2007, cult. de Freina), cult. et coll. de Freina; 11♂, 6♀ gleiche Daten, jedoch 27.7.–10.8.2007 cult. et coll. Speidel, MWM; 116♂, 84♀, gleiche Daten, F4-Generation 08.–30.10.2007 (Elterntiere VIII.2007, cult. de Freina), cult. et coll. de Freina (MWM). Weitere F4-Tiere mit gleichen Daten: 5♂, 5♀ ZSM, 16♂, 10♀, cult. et coll. Buchsbaum, ZSM, 20♂, 10♀ cult. et coll. Hager (Wuppertal); 15♂, 12♀ cult. et coll. Pensotti (Mailand); 15♂, 11♀ cult. et coll. Piatkowski (Hanau). 7♂, 6♀ N-Oman, Jabal-Akhdar-Südausläufer, ca. 28 km E Al Nizwa, 10 km E Izki, ca. 600 m, 04.04.2005, leg. et coll. de Freina (MWM); 17♂, 12♀ N-Oman, Jabal Nakhl-Gebirge, ca. 16 km N Nakhl, Unteres Wadi Mistal, ca. 600 m, 08.–09.4.2005, leg. et coll. de Freina (MWM); 7♂, 6♀, N-Oman, 18 km W Barka, Küstenbereich bei Ras al Sawadi, 0–10m, 01.–08.4.2006, leg. et coll. de Freina (MWM), davon 1♀ genital untersucht (Gen.Präp. de Fr. 2006/57); 18♂, 16♀, N-Oman, Jabal al Akhdar SO-Ausläufer, Umg. Birkat al Mawz, Eingang Wadi al Muaydin, ca. 700 m, 04.04.2005, leg. et coll. de Freina (MWM); 22♂, 11♀, NO-Oman, Jabalal Akhdar, SO-Ausläufer, 10 km WNW Birkat Al Mawz, ca. 650 m, 04.04.2005, leg. et coll. de Freina; 16♂, 12♀, NO-Oman, Jabal Akhdar-Südausläufer, ca. 20 km NW Nizwa, Umg. Tanuf, Eingang Wadi Tanuf, ca. 850 m, 05.4.2005, leg. et coll. de Freina (MWM); 9♂, 3♀, Sultanat Oman, Tanuf, 630 m, N 23°03'08" E 57°27'27", V.2005, e. o. cult. Berger (MWM); 1♀, Nizwa 15 km North, 600 m, 11.2.2007, leg. Major, coll. Pensotti (Mailand); 1♂, S-Iran, Hormozgan Prov., Beshagerd [Bashākerd] Mts., 26°34' N 57°54' E, 900 m, 25.3.–05.04.2000, leg. Siniaev & Plutenko, ex coll. Schintlmeister (MWM) (Gen.Präp. de Fr. 2006/58); 1♀, Kerman, Senderk, 31.05.1977, leg. Sojak, ex coll. Krušek (MWM); 1♂, Kerman, 30 km SSW Jiroft [= Sabzvārān], Mohamadabad, Maskún, 18.05.1977, leg. Sojak, ex coll. Krušek (MWM).

Beschreibung (Fig. 1–9). Holotypus ♂ Vorderflügelänge 18 mm, Paratypen ♂ 16–22 mm, durchschnittlich 18 mm. Fühler schwarzgrau bis schwarz, filiform, Fühlergliederzahl 45; Vorderbein ohne, mittleres Bein mit einem, Hinterbein mit zwei Paaren kurzer, gedrungener Tibialspornen, Coxa, Femur und Tibia aller Beine an der Außenseite schwarz, innen rosabraun, die Tarsen schwarz; Thorax rosa ocker, Zeichnung von Kopf und Dorsum samtschwarz; Abdomen dorsal bis mediodorsal zinnoberrot, lateroventral dunkel lilabraun bis schwarzbraun, ventral rußig schwarz, das erste Abdominalsegment auffällig zitronengelb behaart, das Abdominalende lateral mit zwei schwarzgrauen, die Coremataöffnungen überdeckenden Haarbüscheln; Abdominalsegmente mediodorsal mit schwarzem, fein gelb umrandetem Fleck, der des letzten Segments länglich mit deutlicher gelboranger Umrandung; mediolateral und medioventral sitzen weitere schwarze Punktfleckenreihen. Vorderflügelgrundfarbe hell zimtfarben, postbasal bis

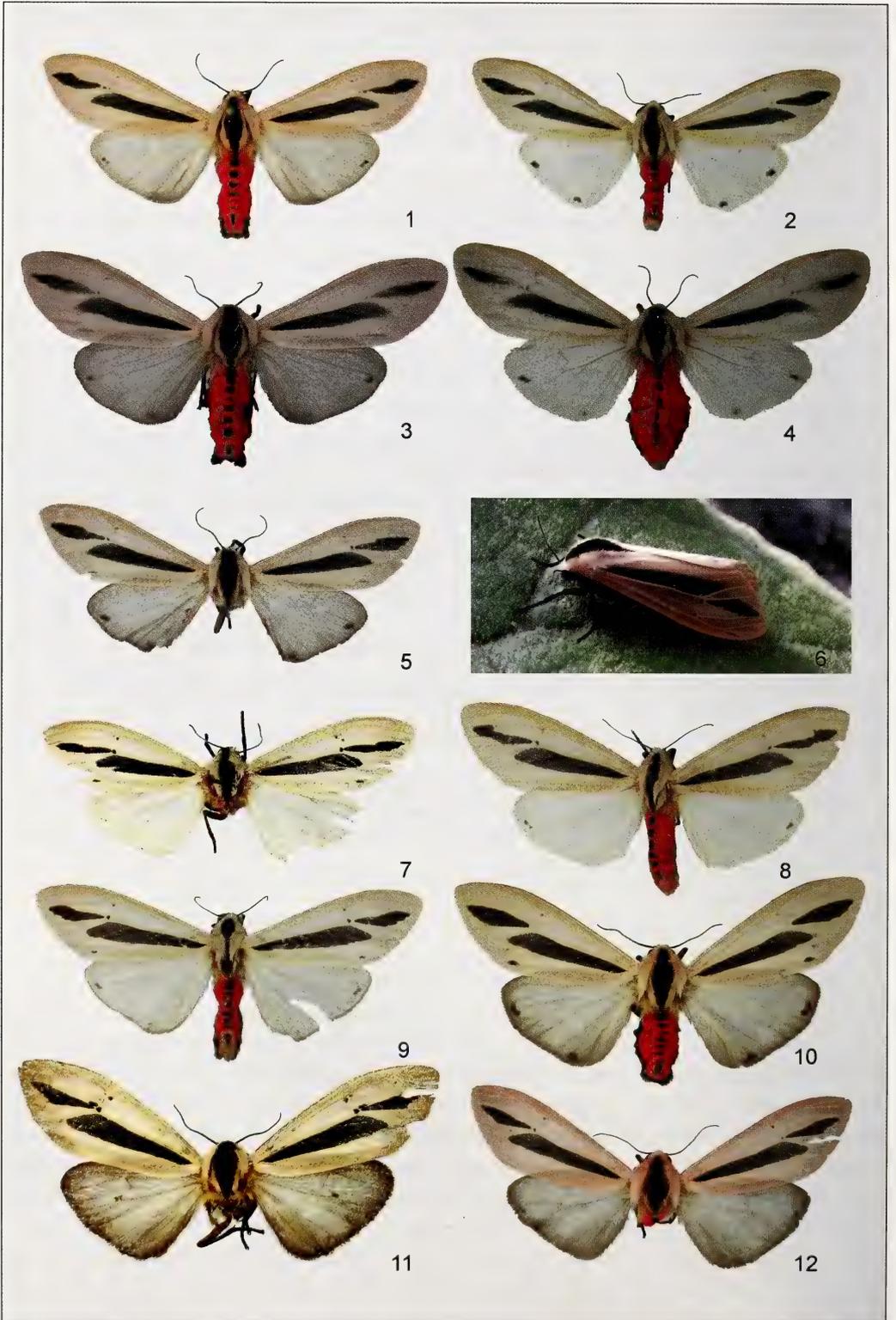
zur Zelle unterhalb der Mediane ein schwarzer, zur Zell hin erweiterter Keilfleck, dahinter in den oberen beiden Medianfeldern ein schwarzer, von der Zelle ausgehend bis vor den Außenrand ein zweiter, kürzerer schwarzer Streifen, an den äußeren Enden der Diskodalader zwei fein rosa eingefasste schwarze Punktflecken. Hinterflügel glasig rußig grau, subapikal und meist auch am Tornus je ein feiner schwarzer Fleck, der Saum dunkler rußig schwarz. Unterseite beider Flügelpaare rußig schwarz, Vflgl. mit schwacher Transparenz der oberseitigen Strichzeichnung.

Weibchen. Vorderflügelänge 19 mm, Paratypen 18–22,5 mm, durchschnittlich 20,5 mm. Geschlechtsdimorphismus nicht sehr auffällig, Fühler wie beim Männchen filiform, die Flügelunterseiten jedoch deutlich heller als beim Männchen. Vorderflügelgrundfarbe lichter, mehr ockerfarben, Hinterflügel glasig weiß, die weibliche Unterseite beider Flügelpaare weiß mit deutlicheren schwarzen Submarginalflecken; Abdomen ventral licht grau mit deutlichen schwarzen Fleckenreihen, das Abdominalende um die Papilla analis hell ocker.

Variabilität. Die Art variiert habituell nur unwesentlich. Die beiden Längswische nähern sich gelegentlich an, die feinen Diskalflecken im Vflgl. können sowohl fehlen als auch in der Anzahl zwischen einem und drei Flecken (selten) variieren, der Tornus gelegentlich mit feinem, dunklen Fleck. Die Submarginalflecken im Hflgl. können bei beiden Geschlechtern fehlen, aber auch schwach bis sehr prominent entwickelt sein. In beiden Geschlechtern betragen die Größenunterschiede die bis zu einem Drittel ihrer Körpergröße. Bei Generationen der kühleren und feuchteren Jahreszeit (Dezember bis April) ist der Geschlechtsdimorphismus deutlicher ausgeprägt, die Farbunterschiede sind deutlicher. Tiere der Sommergenerationen sind größer und in der Grundfarbe geringfügig blasser (vgl. Fig. 1, 2 mit 3, 4). Aus in Mitteleuropa durchgeführten Zuchten hervorgegangene Tiere neigen zum Luxurieren. Die Vorderflügelgrundfarbe der iranischen Tieren ist heller als bei der Nominatunterart, mehr gelbocker bis sandfarben, die Hinterflügel sind in beiden Geschlechtern mehr weiß, der Apikalfleck bei beiden Geschlechtern punktförmig oder fehlend, die mediodorsale Thorakalzeichnung insgesamt feiner.

♂ **Genitalien** (Fig. 19–23, 28, 29). [Gen.Präp. de Fr. 2006/50, 51, 52, 53, 54, 58, 68 (letzteres ♂♀ in Kopula)] Uncus schnabelförmig, apikal leicht gekrümmt, etwa doppelt so lang wie das flache Tegumen; Valven lang, schlank, das distale Drittel schwach nach innen gekrümmt, praeapikal an der Innenseite mit kürzerem zahnartigem Processus; Juxta flaschenförmig, an der Basis annähernd rund, als sklerotisiertes Band bis zur tuba analis reichend; Vinculum breit vau-förmig, Saccus gerundet, schwach sklerotisiert; Phallus etwa um $\frac{1}{4}$ länger als die Valven, das Coecum nur unwesentlich breiter als das kufenförmig gebogene distale Ende; Vesica massiv, partim verknorpelt, etwas länger als die halbe Länge des Phallus, mit vier unterschiedlich massiven, deutlich getrennten Spiculaegruppen; Spiculae mittellang, stiftähnlich, stark sklerotisiert, die der prominentesten Gruppe longitudinal angeordnet, die der kleinsten aus lediglich zwei Nadeln bestehend.

♀ **Genitalien** (Fig. 23, 35, 36). [Gen.Präp. de Fr. 2006/55, 57, 66, 68 (letzteres ♂♀ in Kopula)] Corpus bursae länglich rund mit zwei kleineren ovalen, paarweise angeordneten, fein strukturierten Signa; appendix bursae auffällig massiv, kugelig, mit



sieben kräftigen, krallenförmigen Spiculae; ductus seminalis lang, distal sackförmig; Antrum sehr lang (von der Länge des Phallus), bandförmig, verwunden und stark sklerotisiert; ductus bursae am distalen Ende mit zwei Gruppen Spiculae, deren auffälligere aus longitudinal angeordneten feinen Nadeln besteht, während sich die andere aus wenigen, aber größeren Nadeln zusammensetzt; lamella antevaginalis sehr kräftig, trichterförmig, ostium bursae halbkreisförmig, die posterior apophyses von der Länge der papillae analis.

Coremata des 8. Sternits (Fig. 24–27, 30). Die Coremata bestehen aus einem Paar vergleichsweise kleiner, paarweise angeordneter, in unausgestülptem (luftleerem) Zustand knopfartig eingestülpten Schläuchen, denen distal jeweils ein um ein vielfaches längerer Haarschleier anhaftet. Ausgestülpt erreichen die Coremata etwa die 10fache Länge. Sie sind schlauchartig bei distaler Verengung und über die Gesamtlänge mit hautigen, Zahnkränzen ähnlichen Strukturen besetzt. Das 8. Sternit ist halbkreisförmig.

Diagnose (Fig. 31–34, 37). Für die Differentialdiagnose wurden von *C. gangis* die folgenden Tiere genital untersucht (und die Genitalabbildung von *C. gangis* bei Goodger & Hampson (1995) und Dubatolov (2006) herangezogen):

1♂ **Nepal**, Trisuli valley, 820 m, 3 km N Betrawati, at the Trisuli bridge, 85°11'E 27°59'N, 25.9.1995, leg. B. Herczig & G. M. Lászió (MWM): Gen.Präp. de Fr. 2006/59; 1♂ valley of Tamea Kosi river, 5 km S of Piguti, 950 m, 8/9.X.1995, leg. L. Németh (MWM): Gen.Präp. deFr 2006/60); 1♂ **India**, Assam, Kaziranga Wildlife res., 27°06'N 93°56' E, 200 m, 2.–3.7.1997, leg. Sinjaev (MWM): Gen.Präp. de Fr. 2006/69; 1♀ Assam, Nameri National Park, 40 km N Tepzur, 150 m, 27°20'N 93°15' E, 24.7.–2.8.1997, leg. Sinjaev & Murzin (MWM): Gen.Präp. de Fr. 2006/70; 1♂ **China**, Yünnan, Xishuangbanna Dai, auton. Pref., Puwen, 30 km SSW Simao, 900 m, 22°30'N 100°02' E, 16.3.–10.4.2000, leg. Brechlin's einh. Coll. (MWM): Gen.Präp. de Fr. 2006/61; 1♀ Yünnan, Lincang distr., 10 km W Yunxiang, Daxing 120 km S Dali, 1200 m, 24°30'N 100°01' E, 16.3.–10.4.2000, leg. Brechlin's einh. Coll. (MWM): Gen.Präp. de Fr. 2006/62.

Cretonotos omanirana sp. n. ist in erster Linie durch die Form der Coremata und charakteristischer Strukturen des weiblichen Genitals zu unterscheiden. Habituell ist sie nicht auffällig von *C. gangis* verschieden. Mehrheitlich ist die Färbung von Thorax und Vorderflügel oberseitig nicht zimtrosa wie bei dieser, sondern mehr rosa ocker, die Unterseite der Flügel ist heller, die zitronengelbe Behaarung des ersten Abdominalsegment ist markanter, die gelbe Fleckumrandung des distalen Abdominalflecks ist betonter. Im Bau des männlichen Genitals unterscheiden sich beide Arten nicht auffällig, jedoch konstant. *C. omanirana* besitzt proximal schlankere Valven, der praeapikale Processus

Fig. 1–12. Adulte *Cretonotos* Tiere. **1–9.** *C. omanirana omanirana* sp. n. **10–12.** *C. gangis* (Linnaeus, 1764). **1.** Holotypus ♂. N-Oman, Westl. Hajar-Gebirge, Oase (Wadi) Al Abyadah, 04.–07.4.2006. **2.** Paratypus ♀. N-Oman, Jabal Nakhl-Gebirge, Oase Nakhl 30.–31.3.2006. **3.** Paratypus ♂, Fundort wie Holotypus, ex ovo F1, 08.–25.6.2006. **4.** Paratypus ♀, gleiche Daten wie Fig. 3. **5.** Paratypus ♂, gleiche Daten wie Holotypus (Gen.Präp. deFR 2006/50, Fig. 19, 20 24). **6.** Paratypus ♀, Fundort wie Fig. 2, jedoch 12.12.2006 (alle Tiere leg. bzw. cult. de Freina). **7.** Paratypus ♂. Iran, Hormozgan Prov., Beshagerd Mts., 900 m, 25.03.–05.4.2000, leg. Siniaev & Plutenko (Gen.Präp. deFr 2006/58). **8.** Paratypus ♀. Iran, Kerman, Senderk, 31.05.1977, leg. Sojak. **9.** Paratypus ♂, Iran, Kerman, 30 km SSW Jiroft, Mohamadabad, Maskún, 18.05.1977, leg. Sojak. **10.** ♂. Nepal, Trisuli valley, 820 m, 3 km N Betrawati, at the Trisuli bridge, 85°11'E 27°59'N, 25.9.1995, leg. Herczig & Lászió. **11.** ♂. Nepal, valley of Tamea Kosi river, 5 km S of Piguti, 950 m, 8/9.10.1995, leg. Németh (Gen.Präp. deFr 2006/60). **12.** ♂. Gleiche Daten wie Fig. 10 (Gen.Präp. deFr 2006/59) (alle Tiere und Präparate MWM).



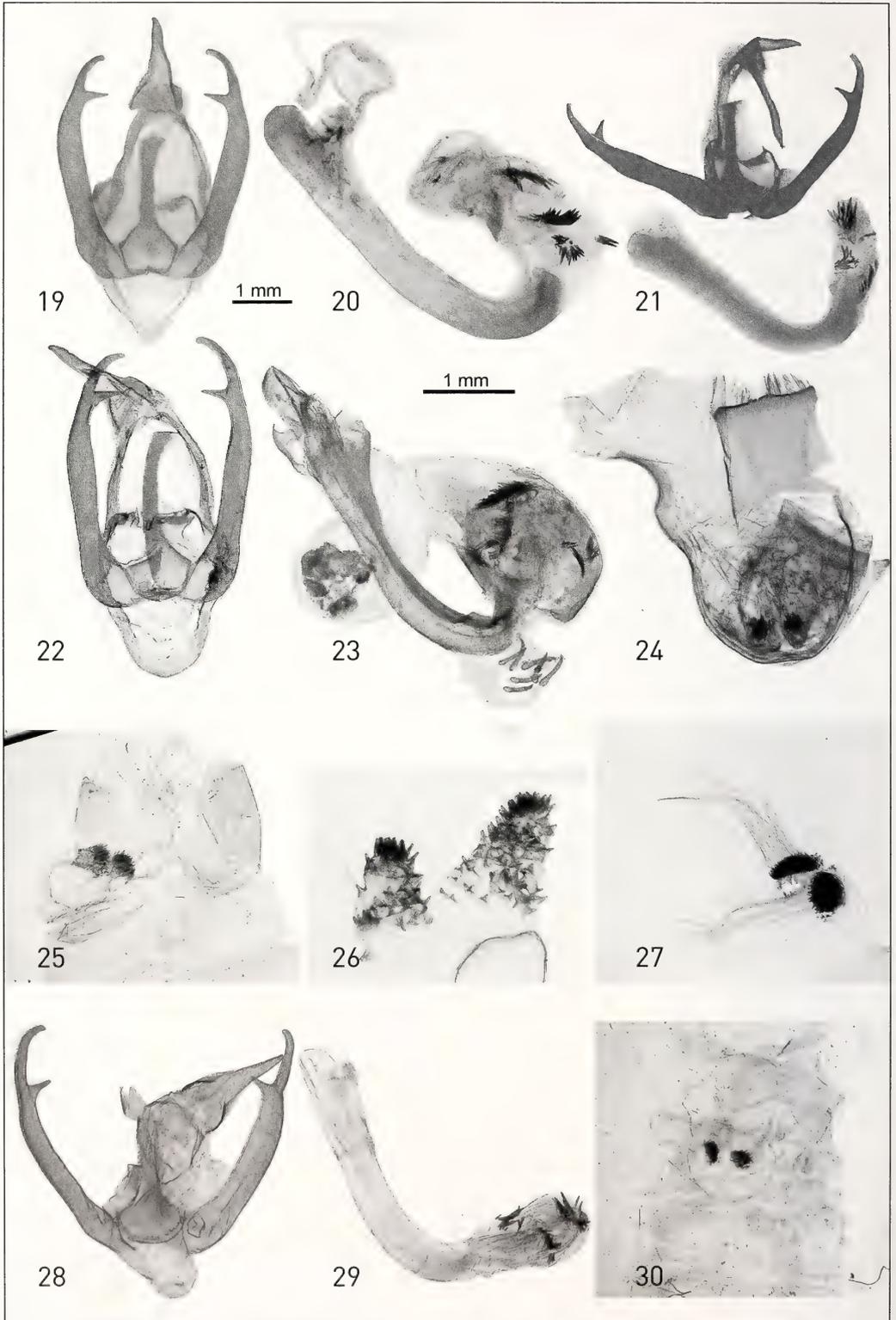
Fig. 13–18. *Cretonotos omanirana* sp. n. **13.** Lebensraum Nordoman, Oase Nakhl. **14.** Lebensraum Nordoman, NW Nizwa, Umg. Tanuf, Eingang Wadi Tanuf. **15.** L1-Raupe (F1), Originalgröße 0,6 mm. **16.** L2-Raupe (F2), Originalgröße 1,1 mm. **17.** Erwachsene Raupe, typische Farbvariante, natürliche Größe. **18.** Erwachsene Raupen, rot- und gelbgefleckte Variante (unten).

steht in deutlicherem, fast rechtem Winkel von der Valve ab, der apikale Finger ab dem Processusansatz ist kürzer. Die Juxta ist an der Basis weniger kugelförmig und am Übergang zum posterioren Band deutlich abgeschrägt. Der Phallus von *C. omanirana* ist distal stärker gekrümmt, die Vesica besitzt vier klar voneinander getrennte

Spiculaegruppen, während diese bei *C. gangis* nur unwesentlich voneinander abgesetzt sind. Holloway (1988) spricht von „three fields of numerous moderate, long spines“, es dürften jedoch vier Gruppen Spiculae sein, was allerdings aufgrund der undeutlichen Abstände schwer zu diagnostizieren ist (siehe Fig. 31 und 33). Auch die Abbildungen bei Goodger & Watson (1995: 37, fig. 100) und Dubatolov (2006: 146, fig. 27) sprechen für vier Gruppen an Spiculae. Unverkennbare Artmerkmale sind die auffälligen Unterschiede in der Struktur der Coremaschläuche. Bei *C. omanirana* bestehen diese aus einem Paar an zwei kleineren Schläuchen, *C. gangis* hat zwei Paar weitaus größere, voluminösere, längere und mit mittellangen aber dichteren Haarschleiern bestückte, paarweise angeordnete Schläuche (Fig. 32, 34). Die weiblichen Genitalien weisen mehrere arttypische Merkmale auf. *C. omanirana* besitzt schlankere papillae analis, das ostium bursae und die lamela antevaginalis sind enger und runder geformt, bei *C. gangis* sind letztere breiter und flacher; ductus bursae bei *C. omanirana* länglich, schlank trichterförmig mit zwei Gruppen Spiculae, bei *C. gangis* breiter und kürzer trichterförmig bei schwach entwickelten Spiculaegruppen; appendix bursae bei *C. omanirana* mit sieben krallenförmigen Spiculae, bei *C. gangis* mit nur zwei Spiculae; Signa bei *C. omanirana* nebeneinander angeordnet, bei *C. gangis* deutlich getrennt.

Verbreitung und Habitat (Fig. 13–14). *C. omanirana* ist in zwei geographisch getrennten Populationen bekannt. Im Oman ist die Art von der nördlichen Küstenebene bis in die Nord- und Südhänge des östlichen Jebel Akhdar-Gebirges verbreitet. Der Fund von Ras al Sawadi bestätigt das Vorkommen bis in Strandnähe, aus der Djebel Akhdar-Region stammt ein Nachweis aus 850 m Höhe. Auf der asiatischen Seite des Persischen Golfs ist *C. omanirana* aus den iranischen Provinzen Kerman und Hormozgan bekannt. Ein Paratypus stammt aus 900 m Höhe. *C. omanirana* ist im halbwüstenreichen Nordoman bisher ausschließlich in oder am Rande von Oasen, in länger wasserführenden Wadis oder in bewässerten Kulturlandschaften der Batinah (nördliche Küstenebene) nachgewiesen. Sie ist thermophil, besiedelt aber in ihren Lebensräumen halbschattige, mehr oder weniger feuchte, kühlere und krautige Nischen. Am Rande von Oasen entwickelt sie sich in der Randvegetation von Bewässerungsgräben. Man kann die Art als Kulturfolger bezeichnen.

Lebensweise (Fig. 15–18). Bei Zuchten erwiesen sich die Raupen als weitgehend polyphag, bevorzugten jedoch Löwenzahn (*Taraxacum*). In ihren angestammten Lebensräumen wurde die Raupe an Gräsern und Fabaceae-Arten (Leguminosae) gefunden. Sie ist extrem überlebenstüchtig und robust. Die bisherigen Zuchtergebnisse zeigen, dass die Entwicklungsdauer einer Generation zwischen 2 und 2½ Monaten liegt. Unter Berücksichtigung der hochsommerlichen Trockenperioden des Nordoman kann man davon ausgehen, dass die Art pro Jahr in vier Generationen auftritt. Hinsichtlich der Geschlechterverteilung fällt der überproportional hohe Anteil an Weibchen auf, der eine hohe Reproduktion der Art garantiert. Der Geschlechterproporz Männchen zu Weibchen beträgt etwa 3 : 2. Die aus im Oman eingesammelten und in Deutschland gezüchteten Raupen stammenden Imagines erwiesen sich als sexuell nahezu inaktiv, so dass in zwei Fällen trotz einer höheren Anzahl an Tieren jeweils nur eine Kopula erfolgte. Dagegen zeigten bereits die F1-Nachkommen trotz kühlerer Temperaturen rege sexuelle Aktivität, die sich bei den F2-Tieren noch steigerte, so dass es zu zahl-



reichen Paarungen kam. Dieses Verhalten deutet auf ein rasches Anpassungsvermögen der Art an neue Lebensbedingungen hin.

Der Paarungsflug setzt gegen 18°Uhr ein, also zu einer Zeit, zu der im Oman bereits die Dämmerung eingesetzt hat, und endet gegen 22° Uhr. Die Kopula dauert in der Regel bis in die Morgenstunden des folgenden Tages. Zwei Tage nach Lösen der Kopula beginnt das Weibchen mit der Eiablage. Die Anzahl der Eier schwankt zwischen 250 und 300, die Eidauer beträgt 10 Tage. Die elfenbeinfarbenen, bereits nach 2 Tagen gelblich verfärbten, runden Eier werden einschichtig geordnet in mehreren Spiegeln abgelegt. Auffällig ist die, gemessen an der Größe der Imagines, unverhältnismäßig kleine Eiform, die der Art eine hohe Reproduktion aufgrund der höheren Eimenge ermöglicht.

Die Eischale bildet die erste Nahrung der geschlüpften Raupe. Die Eiraupe (Fig. 15) ist auberginefarben. Alle Füße einschließlich dem Analpaar, Kopf, Mandibeln, Prothorakalschildchen und Warzen sind schwarzbraun. Die Behaarung ist einfach, borstenartig, ungefiedert, schwarz glänzend. Die singulären Borstenhaare auf der Kopfkapsel und dem Nackenschild sowie die Borsten der dahinter liegenden Warzen sind auffällig lang und entsprechen etwa einem Viertel der Körperlänge. Noch länger sind die Borstenhaare der beiden letzten Abdominalsegmente von etwa ein Drittel der Körperlänge. Die beiden vorderen Thorakalsegmente besitzen laterodorsal je zwei Warzenpaare mit jeweils zwei Borsten, die dahinter liegenden Segmente nur eine. Lateral sitzt jeweils eine massive, sternförmig mit kurzen Borsten besetzte Warze.

Bereits die L2-Raupe (Fig. 16) zeigt die für die Art typische Tracht mit heller Mediodorsallinie und größerem rostbraunen Fleck in der Rückenmitte jedes Segments, der in die Linie eingebunden ist. Die Warzen sind schwarzbraun und mit kräftigen, sternförmig angeordneten Borstenbüscheln besetzt. In ihrem weiteren Wachstum ändert sich das Raupenkleid bis ins letzte Stadium nur noch unbedeutend. Lediglich die mediodorsalen Flecken werden flächiger, das mediodorsale Band wird breiter, der weiße Lateralfleck auf dem zweiten Thorakalsegment vergrößert sich deutlich. Die Warzen bleiben schwarzbraun, die dichten, sternförmigen Borstenbüschel sind im letzten Larvalstadium rötlichbraun.

Die Grundfarbe der erwachsene *C. omanirana*-Raupe variiert zwischen braun und schwarz, die Farbe der Dorsalflecken zwischen gelbocker und rostrot (Fig. 17, 18). Wird die Raupe in humidem Milieu gezogen, entwickelt sich fast ausschließlich die melanistische dunkle Form, bei Trockenheit überwiegt die hellere Variante.

Fig. 19–30. *Cretonotos omanirana* sp. n., ♂ Genital- und Coremata-Strukturen des 8. Sternits. **19, 20.** ♂ Genital mit Phallus (vergrößert), N-Oman, Westl. Hajar-Gebirge, Oase (Wadi) Al Abyadah (Gen.Präp. deFr 2006/50). **21.** ♂ Genital mit Phallus, N-Oman, Jabal Nakhil-Gebirge, Oase Nakhil (Gen. Präp. deFr 2006/54). **22, 23.** ♂ Genital mit Phallus, Fundort wie Fig. 21 (Gen.Präp. deFr 2006/68). Phallus (23) in Kopula mit weiblichem Genital (Maßstab wie Fig. 20). **24–27.** Corematastrukturen. **24, 25.** Coremata in Ruhestellung: Gen.Präp. deFr 2006/50 (wie Fig. 19) und Gen.Präp. deFr 2006/52. **26.** Coremata vergrößert, zu $\frac{3}{4}$ ausgestülpt: Gen.Präp. deFr 2006/51. **27.** Coremata in Ruhestellung, vergrößert: Gen.Präp. deFr 2006/68) (wie Fig. 21). **28–30.** ♂ Genital mit Phallus und Coremata-Struktur des 8. Sternits in Ruhestellung, ♂. Iran, Hormozgan Prov., Beshagerd Mts., 900 m (Gen.Präp. deFr 2006/58).

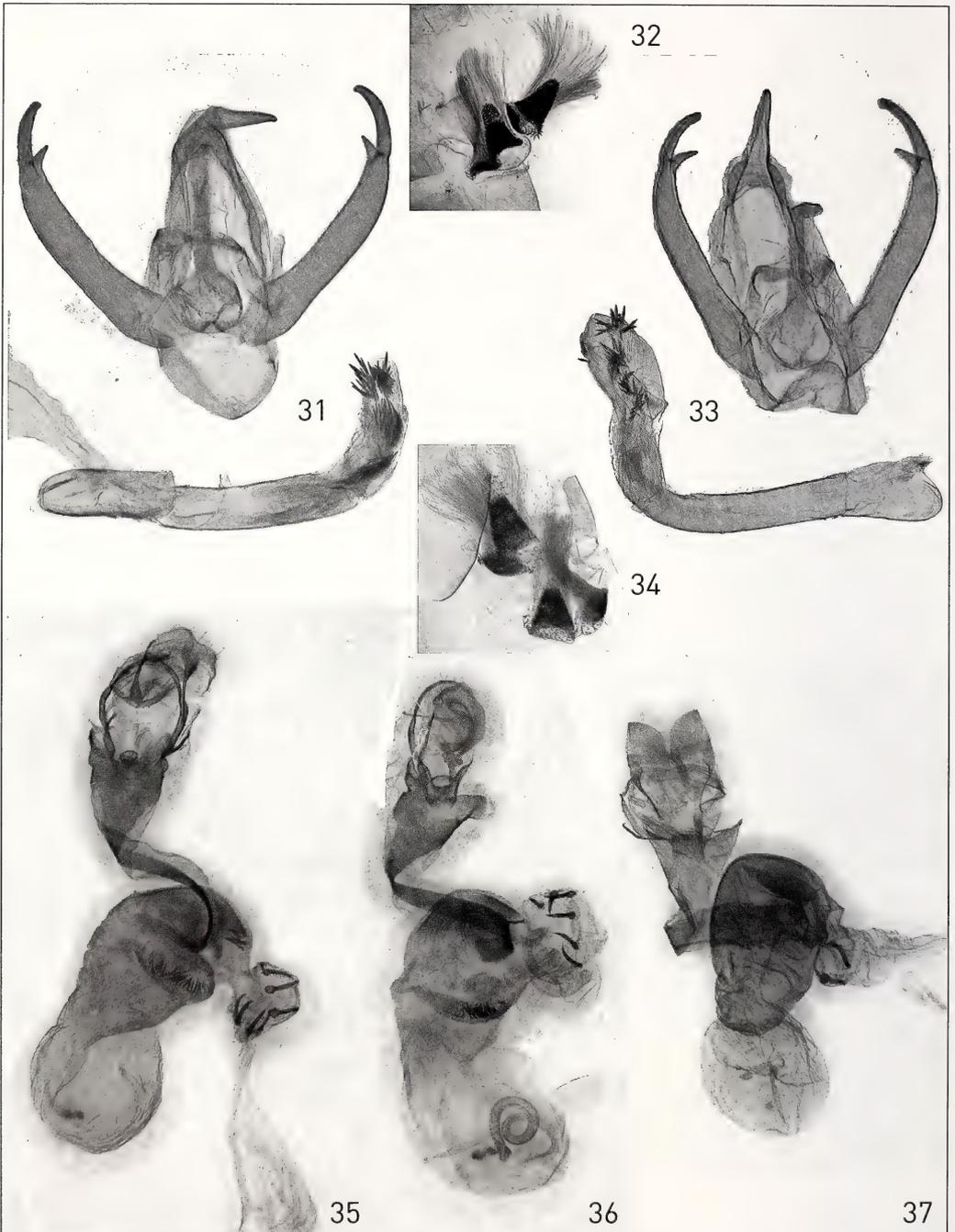


Fig. 31–34. *Cretonotos gangis* (Linnaeus, 1764), ♂ Genital and Coremata-Strukturen des 8. Sternits (in Ruhestellung). **31, 32.** Nepal, Trisuli valley, 820 m, 3 km N Betrawati, at the Trisuli bridge (Gen. Pröp. deFr 2006/59) (Wie Fig. 12). **33, 34.** Nepal, valley of Tamea Kosi river, 5 km S of Piguti, 950 m, 8/9.X.1995 (Gen.Pröp. deFr 2006/60) (Wie Fig. 11).

Fig. 35–37. *Cretonotos* spp., ♀ Genital. **Fig. 35–36.** *C. omanirana* sp. n. **35.** N-Oman, Jabal Nakhl Gebirge, Oase Nakhl (Gen.Pröp. deFr 2006/56). **36.** Wie Fig. 35 (Gen.Pröp. deFr 2006/55). **37.** *C. gangis* (Linnaeus, 1764), China, Prov. W-Yünnan, Lincang distr., 10 km W Yunxiang, Daxing, 120 km S Dali, 1200 m, 16.3.–10.4.2000 (Gen.Pröp. deFr 2006/62).

Die lichtscheue, überwiegend nachtaktive Raupe neigt im Endstadium bei Futtermangel zu kannibalischem Verhalten, wobei sowohl in Häutung befindliche Raupen als auch Puppen gefressen werden. Landwirtschaftlich genutzte Lebensräume der Art werden regelmäßig im Zuge von Bewässerungsmaßnahmen geflutet (siehe Fig. 13). Das dichte Borstenkleid verhindert jedoch ein Ertrinken der Raupen. Zusammengerollt sind sie in der Lage, zeitlich unbegrenzt auf der Wasseroberfläche zu treiben und dank ihrer guten Schwimffähigkeit wieder festen Boden zu erreichen.

Die Verpuppung erfolgt bodennah in einem grauen, relativ dichten, aber transparenten Gespinst. Die Puppe ruht dabei in der Mitte des Gespinstes. Die Raupenhaut wird nicht gänzlich abgestreift, sondern verbleibt, die hinteren beiden Segmente bedeckend, am Abdominalende der Puppe verankert. Die vorderen Abdominalsegmente der frischen rotbraunen Puppe sind zunächst trüb weiß gefleckt. Später dunkelt die Puppe schwarz ein, die Fleckung der Abdominalsegmente bleibt jedoch rötlich transparent, erhalten. Die Lateralpartie der vorderen Abdominalsegmente ist mit feinen Borsten besetzt. Der Kremaster fehlt, wird aber in beiden Geschlechtern durch eine Gruppe Hufnägeln ähnlichen Fortsätzen, etwa 14–18 an der Zahl, ersetzt. Die Puppenruhe variierte bei Zuchten zwischen 18–20 Tagen.

Die Falter schlüpfen am frühen Nachmittag. Sie verhalten sich bis auf die Paarungsaktivität sehr ruhig. Tagsüber verkriechen sie sich in der Vegetation. Frisch geschlüpfte bzw. noch nicht flugfähige Falter scheiden bei Störung zu ihrem Schutz den braunrosa Puppenharn aus, dem ein bitterer Geruch anhaftet. Bei Störung zeigen die Tiere akinetisches Verhalten mit Zusammenklappen der Flügelpaare und Anspreizen der Beine. Dabei legen sie sich seitlich und präsentieren ihr rotes Abdomen bei gleichzeitiger Absonderung eines vermutlich toxischen Tropfen mit stark nikotinähnlichem Geruch. Die Thanatose hält mehrere Minuten an.

Derivatio nominis. Die neue Art ist nach ihrer geographischen Herkunft benannt.

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A revision of the clearwing moth species described by Zukowsky from China with additional notes on Sesiidae species from the Mell collection (Sesiidae)

AXEL KALLIES

The Walter and Eliza Hall Institute of Medical Research, 1G Royal Parade, Melbourne/Parkville, Victoria 3050, Australia; e-mail: kallies@wehi.edu.au

Abstract. In the present paper the Chinese Sesiidae species described by Zukowsky from the Mell collection are reviewed. The following new combinations are introduced: *Glossosphesia melli* (Zukowsky, 1929) comb. n., *Nokona semidiaphana* (Zukowsky, 1929) comb. n., and *Adixoa leucocyanea* (Zukowsky, 1929) comb. n. *Aegeria sangaica* Zukowsky, 1932 is formally established as a synonym of *Toleria abiaeformis* Walker, 1865. Additional Sesiidae records published by Zukowsky (1929) from China are critically analyzed and mostly rejected as the specimens on which these records were based were found to be misidentified. *Melittia inouei* (Arita & Yata, 1987) and *Macroscelesia japona* (Hampson, 1919) are new records for the fauna of China.

Introduction

Examining the Sesiidae collection of the Zoological Museum of the Humboldt University, Berlin, Germany, the author came across a series of clearwing moth specimens, which had not been incorporated into the main collection. The majority of these moths carried only numbers for labels, but some of them had additional hand-written determination labels, which identified them as taxa described by Zukowsky (1929) from southern China. Comparing these specimens and their labels with the published descriptions and the handwriting of Zukowsky, confirmed that these specimens were holotypes of the taxa in question.

In his paper on the clearwing moth species of the Mell collection from southern China Zukowsky (1929) named three species, *Aegeria melli*, *Paranthrene semidiaphana* and *Synanthedon leucocyanea*, and published records of an additional 19 species. Although some specimens listed in the paper are missing from the collection, most of them could be recovered and assigned to records published by Zukowsky (1929). Examination of the specimens revealed, that Zukowsky's taxa are valid species but have to be transferred to other genera. Most of the additional specimens, however, were misidentified and consequently the majority of Zukowsky's faunistic records, some of which were subsequently cited by other researchers (Gaede 1933; Xu & Liu 1993), are rejected here. In addition to the above mentioned type material, another badly damaged specimen could be identified as a type specimen of a further taxon named by Zukowsky, *Aegeria sangaica* Zukowsky, 1932. This taxon is here confirmed to be a synonym of *Toleria abiaeformis* Walker, 1865.

Material and Methods

All material is located in the Zoological Museum of the Humboldt University, Berlin, Germany (ZMHB). Locality data are quoted as on the labels. When original labels

were absent locality data are given in square brackets, [...], according to Zukowsky (1929); new transcriptions of locality data, if available, are provided in round brackets, (...). The following abbreviations were used: ATA – Anterior Transparent Area; ETA – Exterior Transparent Area; PTA – Posterior Transparent Area.

Taxa described by Zukowsky from China

CISSUVORINI

Glossosphecia melli (Zukowsky) comb. n.

(Figs 1, 5)

Aegeria melli Zukowsky, 1929: 34. Type locality: South China, Sin hang.

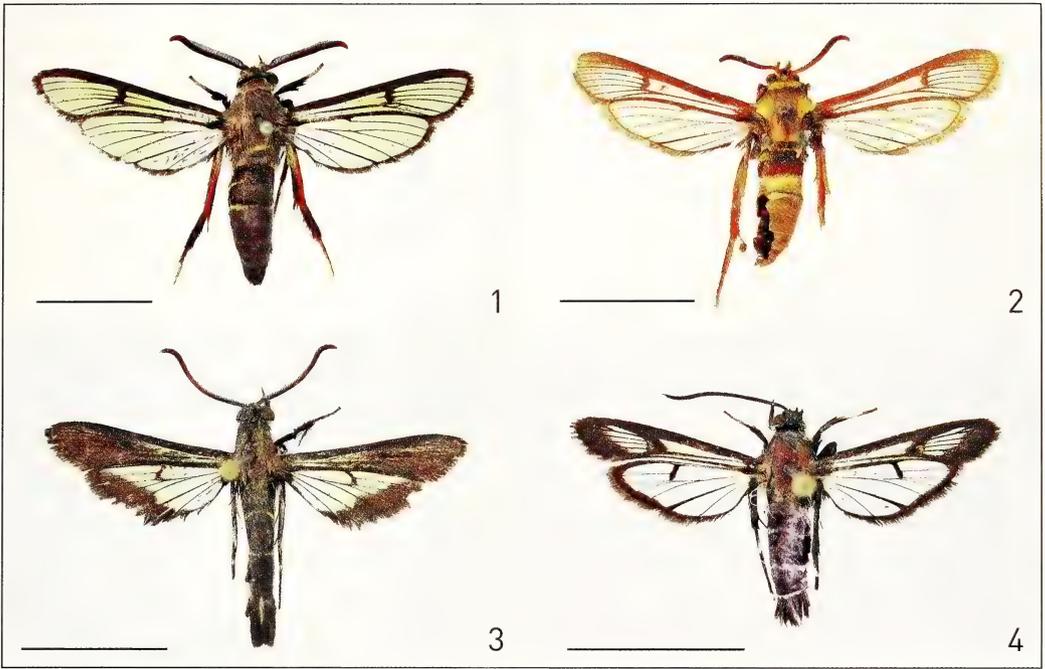
Gaede 1933: 787. Heppner & Duckworth 1981: 32 (*Synanthedon*). Pühringer & Kallies 2004: 29 (*Synanthedon*).

Material. Holotype ♂ [Sin hang] „11. *Aeg. melli*“ / „11.“, gen. prep. AK156.

This species is a typical representative of the genus *Glossosphecia* Hampson 1919. This genus was redefined by Arita & Gorbunov (1998) and besides the species dealt with here it comprises four species, *Glossosphecia contaminata* (Butler, 1878) (the type species), *Glossosphecia romanovi* (Leech, 1889), *Glossosphecia sherpa* (Bartsch, 2003) and *Glossosphecia huoshanensis* (Xu, 1993). *G. melli* seems to be closely related to *G. contaminata*. It differs from the latter by the dark fuscous patagia (bright yellow in *contaminata*) and the abdomen (tergite 4 with a broad and bright yellow band in *contaminata*). *G. huoshanensis* was described from the southern Chinese Huoshan County, Anhui Prov. (Xu 1993) and is possibly a junior synonym of *G. melli*.

Description. Alar expanse 38 mm. Forewing length 16.5 mm. Body length 19 mm. Head. Frons light grey, laterally white; vertex fuscous with fine white scales subdorsally; antenna brown, ventrally orange, unipectinate, ciliate; labial palps with basal segment fuscous, second segment deep yellow with a brown lateral line, apical segment orange-yellow; scapus brown. Legs. Fore coxa yellow with brown margins; fore femur and tibia dark brown, dorsally with long scales, ventrally deep orange; fore tarsus orange; mid and hind coxae yellow; mid and hind femurs yellow in distal portion; mid and hind tibiae ventrally black with yellow patches close to spurs, dorsally dirty orange; basal hind tarsomers with long and rough scaling, dorsally brown-orange, remainder of hind tarsus brown, ventrally yellow-orange. Forewing. Transparent with a rusty shine; discal spot narrow, with a long and narrow projection into ATA; costal margin and discal spot with individual orange scales; ETA with 6 cells, partly covered with minute, semitransparent scales; apical area not developed. Hindwing. Discal spot very small; transparent cells in distal portion of the wing with minute, semitransparent scales. Abdomen. Dark fuscous, tergites 1–3 with narrow yellow posterior margins, tergite 4 with yellow scales at anterior margin, sternites 2–7 with pale yellow posterior margins, anal tuft fuscous, apically pale yellow.

Distribution. The position of the type locality could not be verified. It is likely to be a place in the Guangdong Province where most of Mell's material was collected.



Figs 1–4. Sesiiidae types from the Mell collection (all in MNHB). **1.** *Glossospehia melli* comb. n., holotype, male. **2.** *Toleria abiaeformis*, female (syntype of *Aegeria sangaica*). **3.** *Nokona semidiaphana* comb. n., holotype, male. **4.** *Adixoa leucocyanea* comb. n., holotype, female. Scale bars 10 mm.

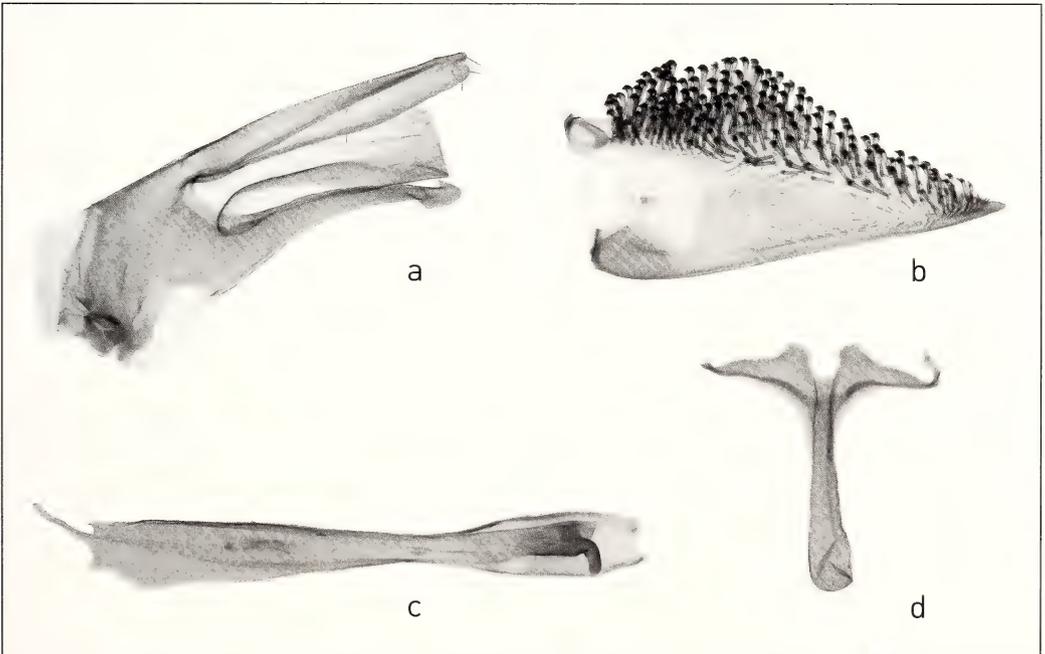


Fig. 5. *Glossospehia melli*, holotype, male genitalia. **a.** uncus-tegumen, lateral. **b.** right valva, ventral. **c.** phallus, lateral. **d.** saccus, ventral.

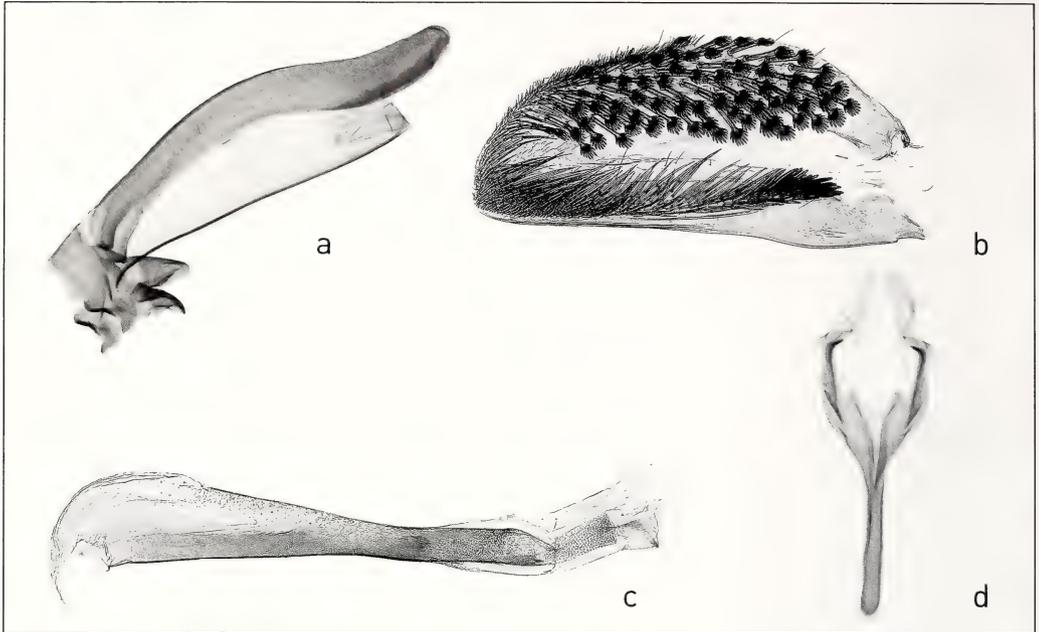


Fig. 6. *Nokona semidiaphana*, holotype, male genitalia. **a.** uncus-tegumen, lateral. **b.** left valva, ventral. **c.** phallus, lateral. **d.** saccus, ventral.

Habitat and Bionomics. Unknown; the specimen was collected ‘on a leaf in a forest’ (Zukowsky 1929).

Remarks. Generic combinations of some of the above mentioned species were established during the course of this work but have been formally published earlier (Pühringer & Kallies 2004).

Toleria abiaeformis Walker, 1865

(Fig. 2)

= *Aegeria sangaica* Zukowsky, 1932: 316. Type locality: Shanghai.

Heppner & Duckworth 1981: 28 (Sesia). Špatenka et al. 1999: 115. Pühringer & Kallies 2004: 12.

Material. 1♂ (syntype, Fig. 2). “Shanghai (China), Juni 1918., (H. Höne)” / “det. Zukowsky” / “Type, H. Höne, 11.1.19, *Aegeria sangaica* Höne?”

Aegeria sangaica Zukowsky, 1932 and *Sphecia sinensis* Walker, 1865 were both considered synonyms of *Toleria abiaeformis* Walker, 1865 although the type material of Zukowsky’s taxon had not been traced (Špatenka et al. 1999). Arita & Gorbunov (1998) resurrected *sinensis* from synonymy and assigned it to the re-established generic name *Chimaerosphecia* Strand, 1916; however, without establishing the identity of *Aegeria sangaica*. Examination of a syntype of *sangaica* confirms that this taxon is a junior subjective synonym of *Toleria abiaeformis*.

The genus *Toleria* in the present view contains only two valid species, *T. abiaeformis* and the very similar *T. ilana* Arita & Gorbunov, 2001. The structures of the female genitalia are only insufficiently known. The genus *Chimaerosphecia* Strand, 1916 on the other hand is known from females only. It was redefined and separated from *Toleria*

Walker, 1865 by Arita & Gorbunov (1998) on the grounds of small differences in the venation and labial palpus. Apart from the type species, *Ch. aegerides* Strand, 1916, from Taiwan, it contains another two species, *Ch. sinensis* Walker, 1865 from Hong Kong and *Ch. colochelyna* Bryk, 1947 from Kiangsu, Southern China. The validity of the genus *Chimaerosphecia* is considered doubtful by the present author and more material, in particular clearly conspecific males and females, is needed to establish the identity of the genus.

Remarks. Zukowsky (1932) mentioned three type specimens from the Höne collection (today in Zoologisches Forschungsinstitut und Museum Alexander König, Bonn, Germany), all from Shanghai, one of which was found in the ZMHB. This specimen consequently is a syntype. The designation of the lectotype is avoided here as the present specimen is badly damaged by frass with major parts of the genitalia destroyed. If additional syntypes can be found in other parts of the Höne collection one should be selected as lectotype. The biology of the species of *Toleria* is not known; however, the larvae of a species of the closely related genus *Chimaerosphecia*, *Ch. sinensis*, were collected in the trunks of *Ormosia pachycarpa* (Fabaceae) at Ma On Chan, Hong Kong, in May and adults emerged in early June (Kendrick 2001).

PARANTHRENINI

Nokona semidiaphana (Zukowsky) comb. n.

(Figs 3, 6, 7)

Paranthrene semidiaphana Zukowsky, 1929: 36. Type locality: Mahn tsi shan.

Gaede 1933: 794. Heppner & Duckworth 1981: 24. Liu & Shen 1992: 728. Pühringer & Kallies 2004: 21.

Material. Holotype ♂ “24. *P. semidiaphana*” / “24” [Mahn tsi shan 25.vii.1915] (Guangdon Prov, E Nanling, between rivers Si Kiang and Yangste), gen. prep. AK157. Additional material: 1♂ „China Canton, 9.1910, Mell S.V.“; 1♀ [Mahn tsi shan, 900 m, 31.vii.1915]; 1♀ [Lin-ping, 700 m, NO Kwangtung, 14.vii.1920].

This species is a typical representative of the genus *Nokona* Matsumura, 1931. It differs from most congeners by the conspicuously broad and dark margins of the hindwings. Broadened hindwing margins are known from some other species of *Nokona* such as *N. powondrae* (Dalla Torre, 1925) and *N. inexpectata* Arita & Gorbunov, 2001, both from Taiwan. These species, however, have distinctly different markings on the abdomen (comp. Arita & Gorbunov 2001) and significantly different genitalia (valva long and tapered, saccus short in the species compared; valva shorter, saccus long and narrow in *N. semidiaphana*).

Apart from the holotype of this species, the Mell collection contains an additional three specimens, which are here considered as belonging to *N. semidiaphana*. These specimens were misidentified by Zukowsky (1929) as *Paranthrene davidi* Le Cerf, 1917 and *Paranthrene cupreivitta* (Hampson, 1893), respectively.

Description. Alar expanse 29 mm. Forewing length 13 mm. Body length 17 mm. Head. Frons black, laterally white to grey; labial palpus black, yellow ventrally and medially; vertex black; pericephalic scales white. Thorax. Black; with a yellow patch below forewings; patagia with individual yellow scales laterally. Legs. Fore leg black;

mid coxa black (remaining parts of mid leg broken off); hind coxa yellow; hind femur with posterior margin white; hind tibia black with white lateral patch, yellow at posterior end, medially mainly white; hind tarsus black, basal tarsomer white at distal end. Forewing. Almost entirely opaque brown. Hindwing. Transparent, with a broad brown margin. Abdomen. Black, tergite 1 with individual yellow scales at posterior margin; tergites 2 and 4 with narrow yellow posterior margins; in tergite 4 broadened towards lateral; sternite 4 broad yellow in posterior half; anal tuft triangular, black, ventro-medial with some yellow scales; outer surface of valvae with white scales.

Distribution. Known from the Guangdong Province, China.

Habitat and Bionomics. Most records are from July, one specimen was collected in September.

***Adixoa leucocyanea* (Zukowsky) comb. n.**

(Figs 4, 6)

Synanthedon leucocyanea Zukowsky, 1929: 36. Type locality: Lung tao shan.

Gaede 1933: 781. Heppner & Duckworth 1981: 31. Pühringer & Kallies 2004: 29.

Material. 1♀ (holotype) "29. *S. leucocyanea*" / "29." [Lung tao shan, 19.vii.1917] (Guangdong Prov., Mt. Longtou, ca 230 km N Guangzhou), gen. prep. AK191.

This species belongs to the tribe Paranthrenini and is here assigned to the genus *Adixoa* Hampson, 1893. This association, however, remains tentative until more material, in particular males, is known. The genus *Adixoa* is insufficiently known. So far only the male of *Adixoa trizonata* (Hampson, 1900) has been examined in detail (Gorbunov & Arita 1995). The female genitalia of *A. leucocyanea* are unique amongst the Sesiidae in their formation of the ostium bursae and the most distal parts of the ductus (strongly sclerotized, curved and protruding from the sclerite). This structure distinguishes *A. leucocyanea* readily from all other known Paranthrenini and may prove to be an autapomorphy of the genus *Adixoa*. Habitually *A. leucocyanea* differs from other known species of *Adixoa* by the coloration of the abdomen (black, with white markings; with yellow markings in all other species).

Description. Alar expanse 24 mm. Forewing length 10 mm. Body length 10.5 mm. Head. Frons light grey, laterally white; labial palps grey, ventrally with some white scales, relatively long and upcurved, almost reaching the scapus; vertex black, antenna black, scapus white ventrally; pericephalic scales black, laterally white. Thorax. Black; patagia crème laterally. Legs. Fore coxa crème, basally with a white spot, distally black; fore leg black, dorsally partly white; basal tarsomer with a white distal margin; mid and hind tibiae with a white spot ventrally; spurs black, medial side white; basal and subbasal tarsomers distally white. Forewing. With well-developed transparent areas; discal spot broad, near the cubitus protruding into the ATA, with yellow scales in distal portion; ETA consisting of 5 large cells and an additional small cell between R4 and R5; PTA reaching the discal spot, with some yellow scales in distal portion; apical area almost as wide as ETA. Hindwing. Discal spot well-developed, relatively broad and straight; outer margin well-developed, about as broad as the fringe. Black; tergites 2, 4, 6 each with a narrow white distal band; sternite 1 white in distal half; sternite 3 with a

narrow, sternites 4 and 5 with broad white distal bands; sternite 6 with only some white scales; anal tuft black, with white scales dorso-laterally.

Distribution. Known only from the Guangdong Province, China.

Habitat and Bionomics. Unknown. The type specimen was found ‘on a leaf in a forest, in July’ (Zukowsky 1929).

Additional Sesiidae records from the Mell collection

The following species were identified from the material of the Mell collection.

***Trichocerota melli* Kallies & Arita, 2001**

Material. 1♂, 1♀ „Canton (China), Westfluss, Ting-Wu-San, 28.vi.1910, Mell S.G.” (Guangdong Prov.).

Two specimens in the Mell collection were misidentified as *Trichocertota brachythyra* Hampson, 1919 (Zukowsky 1929); later these specimens became part of the type series of *T. melli* (comp. Kallies & Arita 2001).

***Trichocerota tricolor* Kallies & Arita, 2001**

Material. 1♂, 1♀ [Tsha yuen shan, 19.v.1915].

Two specimens in the Mell collection were misidentified as *Trichocerota dizona* Hampson, 1919 (Zukowsky 1929); later these specimens became paratypes of *T. tricolor* (comp. Kallies & Arita 2001).

***Caudicornia tonkinensis* Kallies & Arita, 2001**

Three specimens of this species in the Mell collection, marked only with “22”, could not be assigned to any published records. Presumably these specimens were collected by Mell in southern China.

***Melittia inouei* (Arita & Yata, 1987)**

Material. 1♂ [South China, Gao fung, 9.vi.1917, leg. Mell], gen. prep. AK188.

This species has been known only from Japan and Korea (Špatenka et al. 1999; Arita et al. 2004) and thus, the specimen listed here represents a new record for China. The specimen in the Mell collection was misidentified as “*M. bombyliiformis* Cramer” (Zukowsky 1929). The exact position of the collecting locality could not be established.

***Macrosclesia japona* (Hampson, 1919)**

Material. 1♀ [South China, Gao fung, 9.vi.1917, leg. Mell], gen. prep. AK184.

This species was known only from Japan and Korea (Špatenka et al. 1999; Arita et al. 2004). The specimen in the Mell collection was identified by Zukowsky (1929) correctly as *M. eurytion* sensu Bartel, 1912 (= *japona* Hampson, 1919). A second specimen, supposedly a male, mentioned by Zukowsky (1929) was not found in the collection. The exact position of the collection locality could not be established.



Fig. 7. Female genitalia. **a.** *Adixoa leucocyanea*, holotype. **b.** *Nokona semidiaphana* (?).

***Cyanosesia tonkinensis* Gorbunov & Arita, 1995**

Material. 1♂ [China, Shui yün shan, 2.vi.1917, coll. Mell] (probably Guangdong Province, Shaoguang City, Ongyuen County, 18 km ENE of Fongwan, 900 m, mountain forest), gen. prep. AK187.

This specimen was misidentified by Zukowsky (1929) as *Paranthrene trizonata* Hampson, 1900 but its identity was established as *Cyanosesia tonkinensis* later (Kallies 2003).

***Nokona iridina* (Bryk, 1947)**

Material. 1♀ [Kanton]; 1♀ „Canton (China), Westfluss, Ting-Wu-San, Mell S.G.“; 1M [Lung tao shan, 3.v.1918].

The specimens in the Mell collection were misidentified by Zukowsky (1929) as *Paranthrene bicincta* and *Paranthrene pernix*, respectively. Here they are regarded as *N. iridina* although the status of this taxon in respect to *Nokona bicincta* (Walker, 1865) needs validation. Gorbunov & Arita (2001) regarded *iridina* a distinct species while Špatenka et al. (1999) considered it a synonym of *bicincta*.

***Nokona regale* (Butler, 1878)**

Material. 1♀ [Lung tao shan].

The single specimen present in the Mell collection was correctly identified as *Paranthrene regale* (Zukowsky 1929).

Appendix

Zukowsky (1929) recorded a number of Sesiidae taxa as new for the Chinese fauna. Many of these records, however, have to be considered doubtful with respect to the known distribution of the species concerned. The true identity of some specimens present in the collection, as listed above, could be established here, but others were found to represent unnamed species or their identity remains elusive due to the poor

condition of the material. On the grounds of lacking material, records of the following species as given by Zukowsky (1929) are here rejected: *Paranthrenopsis polishana* (Strand, 1916); *Trichocerota brachythyra* Hampson, 1919; *Trichocerota cupreipennis* (Walker, 1865); *Oligophlebia cristata* Le Cerf, 1916; *Toleria abiaeformis* Walker, 1865; *M. chalciformis* (Fabricius, 1793) (as “*M. bombylififormis* Cramer”); *Nokona bicincta* Walker, 1865 (as *Paranthrene*); *Nokona pernix* (Leech, 1889) (as *Paranthrene*); *Nokona davidi* (Le Cerf, 1917) (as *Paranthrene*); *Paranthrene cupreivitta* (Hampson, 1893); *Adixoa trizonata* (Hampson, 1900) (as *Paranthrene*); *Pseudosesia limpida* (Le Cerf, 1916) (as *Paranthrene*); *Ichneumenoptera auripes* Hampson, 1893; *Synanthedon subauratus* Le Cerf, 1916, *Synanthedon unocingulata* Bartel, 1912; *Synanthedon concavifascia* Le Cerf, 1916.

Acknowledgments

I wish to express my cordial thanks to Wolfram Mey (ZMHB) for his permission to examine material under his care and to Daniel Bartsch, Stuttgart, for providing some of the photographs reproduced here.

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Rediscovery of *Sciopetris melitensis* Rebel, 1919 and description of its morphology and life history (Psychidae)

PETER HÄTTENSCHWILER¹, PAUL SAMMUT² & MICHAEL ZERAFA³

¹ Seeblickstrasse 4, 8610 Uster, Switzerland; e-mail: peter.haettenschwiler@dativo.ch

² 137, 'Fawkner/2', Dingli Road, Rabat, RBT 9023, Malta; e-mail: farfett@onvol.net

³ 16 'Agape', Triq L-Imag hazel, Naxxar, NXR 02, Malta; e-mail: family_zerafa@hotmail.com

Abstract. The original description of *Sciopetris melitensis* Rebel, 1919 is based on a strongly damaged male collected in 1915 by Adolf Andres at the former Verdala Barracks, Bormla. The species was re-described by Amsel (1955) based on four badly damaged males collected at Gharghur in 1953. Since then only these specimens are known in the literature. After a lapse of over 50 years the species was rediscovered and breeding from eggs succeeded. Based on this material, males, females, eggs, larvae, pupae and bag as well as the life history are described and compared with the other species of the genus.

Zusammenfassung. Die Originalbeschreibung von *Sciopetris melitensis* Rebel, 1919 basiert auf einem stark beschädigten Männchen, das 1915 von Adolf Andres in den damaligen Verdala Barracks Bormla gefangen wurde. Die Art wurde von Amsel (1955) aufgrund von vier, in Gharghur 1953 gesammelten, sehr schlecht erhaltenen Männchen nachbeschrieben. Seit dem sind nur diese Männchen in der Literatur bekannt. Nach einer Unterbrechung von über 50 Jahren wurde die Art wieder gefunden und es gelang die Zucht aus dem Ei. Basierend auf diesem Material werden Männchen, Weibchen, Ei, Larve, Puppe und Sack sowie die Entwicklung beschrieben und mit den anderen Arten der Gattung verglichen.

Résumé. La description de *Sciopetris melitensis* Rebel, 1919 est basée sur un mâle fortement endommagé, capturé par Adolf Andres en 1915 à Verdala Barracks, Bormla. Amsel l'a re-décrit de quatre mâles en très mauvais état, capturés à Gharghur en 1953. Depuis, seulement ces cinq exemplaires ont été mentionnés dans la littérature. Après une interruption de plus de 50 ans l'espèce a été retrouvée et élevée à partir de l'œuf. Des informations additionnelles sont données pour le mâle, la femelle, la larve, le fourreau et le développement de l'espèce, qui est comparée avec les autres espèces du genre.

Introduction

Today the genus *Sciopetris* Meyrick, 1891 incorporates six species: the type species *M. technica* Meyrick, 1891 described from Algeria, *M. amseli* Sieder, 1959 from Afghanistan, *M. melitensis* Rebel, 1919 from Malta, *M. pretiosa* (Stainton, 1872) from Morocco, *M. hartigi* Sieder, 1976 from Sardinia and *M. karsholti* Hättenschwiler, 1996 from Tunisia. All are small species and mostly insufficiently known. For most of the species only the male is known while female, larva, bag, and life history remain undescribed. The bag and life history are known only for *S. hartigi*. Several species are only known from a very limited area as are the islands of Sardinia and Malta. The description of the genus *Sciopetris* is based on three males that were collected by Meyrick "from sheltered rock-faces in Algeria". The genus and its type species *M. technica* are described very briefly:

"Head rough-haired; ocelli present; tongue absent. Antennae two-thirds, in males filiform, clothed with rather long pubescence (2), basal joint moderate, stout, with well developed pecten. Labial palpi rather short, porrected or drooping, with loose projecting hair-scales. Maxillary palpi obsolete. Posterior tibiae with appressed scales. Fore-wing with vein 1 furcate, 2 from two-thirds of cell, 7 absent, 10 absent, 11 from before middle of cell. Hind-wings under one, elongate-ovate, cilia 1; vein 3 remote from 4, 4 and 5 from a point or stalked, 6 and 7 parallel. (female probably apterous)."

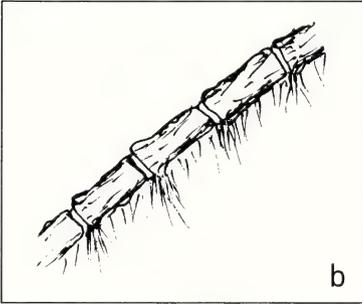
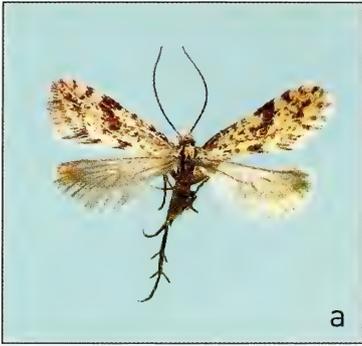


Fig. 1. *S. melitensis* male. **a.** Malta, Bormla, 23.i.2006, Zerafa leg. (photo by M. Zerafa), **b.** antenna.

From this we can understand that there are eight veins from the discoidal cell on the forewing and six on the hindwing, that m_{2+3} are stalked, that ocelli are present, and that the antennae reach $2/3$ of the wing-length and are filiform. The wing venation in several of the species is not constant and in some the ocelli are absent. The species also show variations in other identification criteria. In the descriptions of the various species, due to the limited number of specimens available, only a few of the identification criteria could be compared.

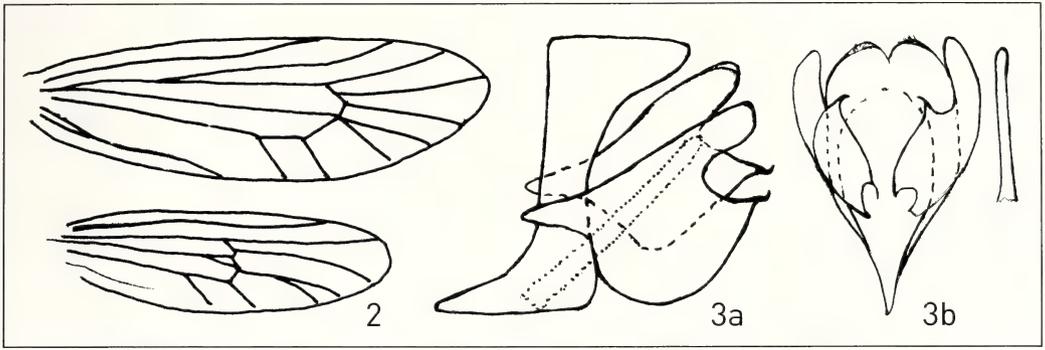
In this study we shall concentrate on *S. melitensis*, the species from Malta (Fig. 1a), knowing that also here there are differences between our findings on the one side and facts, assumptions, and descriptions in earlier studies on the other hand. However, we are convinced that the species we have at hand is identical with the single, damaged male Rebel described in 1919.

“A single male specimen, only partly in a good condition, of this very small new species was collected by Adolf Andres, a war prisoner on the Island of Malta. This probably happened in February 1915 and was mentioned (Andres 1916), already under the name suggested by me (i.l.)”. (This historical note was written in the German language by Rebel).

written in the German language by Rebel).

Sciopetris melitensis species has been listed with little or no additional information by other authors in various Lepidoptera faunistic lists (Sieder 1959; De Lucca 1965: 514; Sammut 1984a: 65; 1984b: 10; 1985: 304; Sammut & Valletta 1989: 98; Sauter & Hättenschwiler 1999: 77). Recently Sammut (1989: 129; 2000: 42) translated to Maltese all the known information regarding this species. However, all these references regard the only two captures of *S. melitensis* known at that time. Since then many professional and amateur entomologists have been searching for this little species without success. It took over 50 years until one of us, Michael Zerafa, took two male specimens and found a 6–8 mm long bag that contained eggs. He took it home and after a few days, very small larvae were crawling out of the little bag and started to build a miniature bag of their own. He reared them successfully through the summer and in January and February of the next year adults, males and females, were hatching out of the bags and were mating and laying their eggs. From these eggs more specimens were reared by us and the life history could be observed and the species was studied. In the following lines we give a better and more complete description of the male, female, egg, larva, pupa, bag, and life history.

The genus *Sciopetris* belongs to the Taleporiini Tutt, 1900 (Psychidae: Taleporiinae). Taleporiini can be recognized by the short epiphysis and 6 veins from discoidal cell in hindwing. Characteristics for *Sciopetris* are: (1) forewing with 8 veins off the discoidal



Figs 2–3. 2. Wing venation of male *S. melitensis*. 3. Male genitalia of *S. melitensis*, a. lateral view, b. ventral view.

cell and without accessory cell; (2) males with ocelli (but also present in *Bankesia*, *Pseudobankesia*, *Taleporia*); (3) antenna with an antero-ventral half-circle of bristles (Fig. 1b) (Sauter & Hättenschwiler 1999).

Redescription of *Sciopetris melitensis* Rebel, 1919 from Malta

Material. The following description is based on 21 males, 9 females, 6 larvae, some of which were mounted on slides, and approximately 50 bags, all from the same location: Malta, Bormla, leg. M. Zerafa, reared ex. ova, or males collected in the field. One bag was collected at Manikata, also by Zerafa, and from it the parasite emerged. The specimens are deposited in the collections of the authors.

Description. Male. Wings narrow and long. Average wingspan 9.6 mm ($n = 21$; smallest 8.2 mm, largest 11.2 mm; wingspan of *S. hartigi* and *S. amseli* 11 mm, *S. technica*: 10–11 mm). Bred specimens are on an average slightly smaller than wild collected males. Forewing with 8 veins off the discoidal cell, without accessory cell (Fig. 2). Colour whitish with brown scales forming variable dots and small brown areas (Fig. 1a). Hindwing with 6 veins off the cell, with an intercalated cell, veins m_2+m_3 stalked, no connection between radial ramus and sub-costal (the original description gives incomplete data on the wings due to the strong damage on the holotype; Sieder 1959 also did not remove the wing scales of the only available specimen when describing *S. amseli* and therefore the actual venation of this species remains unknown; Hättenschwiler 1996 studied and published the wing venation of *S. karsholti*, and it differs in some aspects from that of *S. melitensis*). Scales of forewings wide, class 4–5 (Sauter 1956), on hindwings class 1–3, whitish in colour. Head without ocelli. Labial palps with 3 segments, bent forward. Antenna long, $\frac{2}{3}$ to $\frac{3}{4}$ of wing length, the 27–36 segments with scattered ventral bristles which stand at base of segments nearer together and forming kind of a ventral half-ring (Fig. 1b). Scapus and 3–4 basal segments coated with whitish scales. Eyes round and large; distance between eyes nearly twice that of eye diameter. Head and body covered with long whitish hairs. Forelegs with epiphysis; midlegs with one pair and hindlegs with two pairs of tibial spurs. Male genitalia (Fig. 3): saccus triangular. Valva about as long as tegumen. Sacculus with pointed thorn. Phallus long, straight.

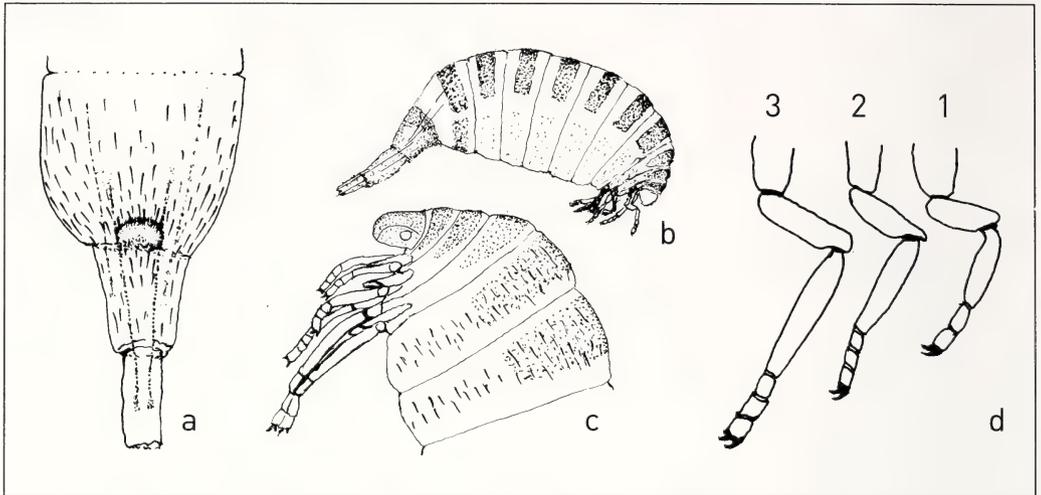


Fig. 4. Female of *S. melitensis*, **a.** genitalia in ventral view, **b.** side view, **c.** enlarged head part, **d.** 1 foreleg, 2 midleg, 3 hindleg enlarged.

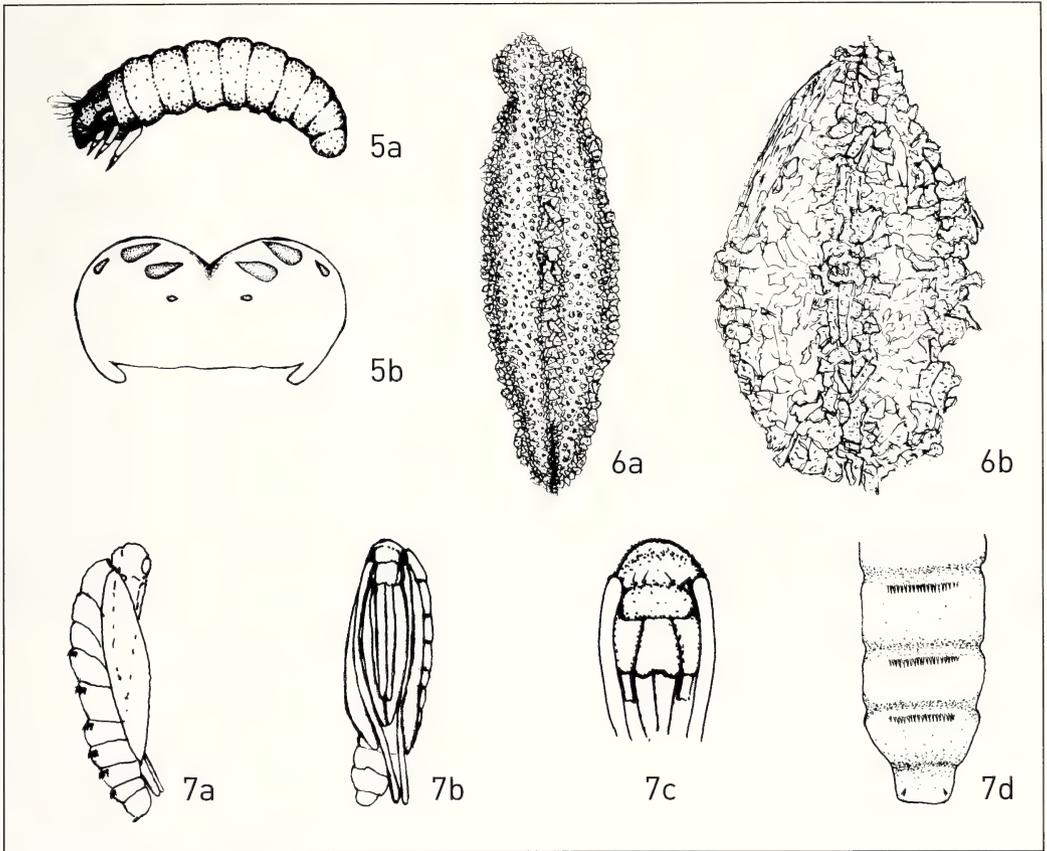
Female (Fig. 4). Wingless, 3–4 mm long (excluding ovipositor), and about 1.5 mm in diameter, cylindrical. Head and thoracic segments dorsally and laterally sclerotized, dark brown. Head small, eyes miniature, antenna reduced. Legs long, tarsi mostly with 4 segments, first about as long as 2–4 together (Fig. 4d); some specimens only have three tarsal segments, 2 short and 1 long. Abdominal segments 1–7 whitish to pale yellow, with light brown dorsal plates (Fig. 4b). Segment 8 with full circle of golden abdominal hair tuft; genital opening ventral, between segments 8 and 9 (Fig. 4a); ovipositor telescopic.

Egg. Yellowish when fresh, slightly oval, 0.35–0.45 mm long, without any markings or sculpture. The colour changes with the life history of the larva to dark grey. In two of the bags opened we counted 65 and 71 eggs respectively. The body of one dead female contained 49 fully developed eggs.

Larva (Fig. 5a). Whitish to pale yellow; head dark; thoracic segments 1–3 with dark brown markings and stripes; length 3.5–4.5 mm, diameter approx. 1 mm. (Fig. 5b). Ventral side of labrum with four pairs of setae. Tineidae have 3 pairs only (Davis 1978).

Bag (Figs 6a–b). Triangular in cross section. Female bags range from 6.6–8.2 mm in length and male bags from 5.3–6.8 mm. About 2 mm wide. Opening of female bags decorated with debris of dried leaves and lichens. Silk structure with coating of sand and miniature stones; often partly, or even completely covered with organic matter like bits of plant and wood tissue and also minute parts of dead insects.

Pupa (Fig. 7). Male pupa 3–4 mm long, 0.8–1.2 mm in diameter. Sclerotized exuvia very delicate and fragile; light brown skeleton thinner than in other genera of Taleporiini. Abdominal segments (Fig. 7a) equipped with row of thorns facing backwards on each segment anteriorly. Sheaths of appendices arranged as usual; long antennal sheaths reaching rear end of pupa. Thorax-head plate (Fig. 7c) with two pairs of bristles.



Figs 5–7. *Sciopetris melitensis*. 5. Larva, **a.** lateral view, **b.** ventral side of labrum with 4 pairs of setae. 6. Bags, **a.** bag with only silk and sand, **b.** bag, upper side completely covered with plant material, only the ventral side showing the silken basic construction. 7. Male pupa after hatching, **a.** lateral view, **b.** ventral view, **c.** details of thorax-head plate, and **d.** abdomen with dorsal rows of thorns facing backwards, apical two thorns facing forward.

Female exuvia even thinner than in male; reduced to soft skin which is pushed backwards rather than being crawled out of. After hatching, exuvia remaining as flat package in bottom of bag.

Life history. *Larva.* The young larvae hatch from after 2–4 weeks in their mother’s bag and hurry to get out. Their first action is to build a miniature bag with silk and often with minute plant material taken from the mother’s bag or elsewhere. During their whole life the larvae maintain, repair, and enlarge their bag to accommodate their increasing size, but they never leave it. The bag is kept long enough and wide enough so that the larva can turn around within it. To enlarge the bag, the larva bites it open along one of the three selvages and inserts a small section of silk and also little bits of foreign matter. This procedure is done along one selvaige after the other until the inside room is again wide enough for the grown larva to turn around inside the bag. The larvae mainly feed on the moss *Tortula muralis* Hedwig, 1801, but we observed also that dead insects, found on the moss, are eaten.

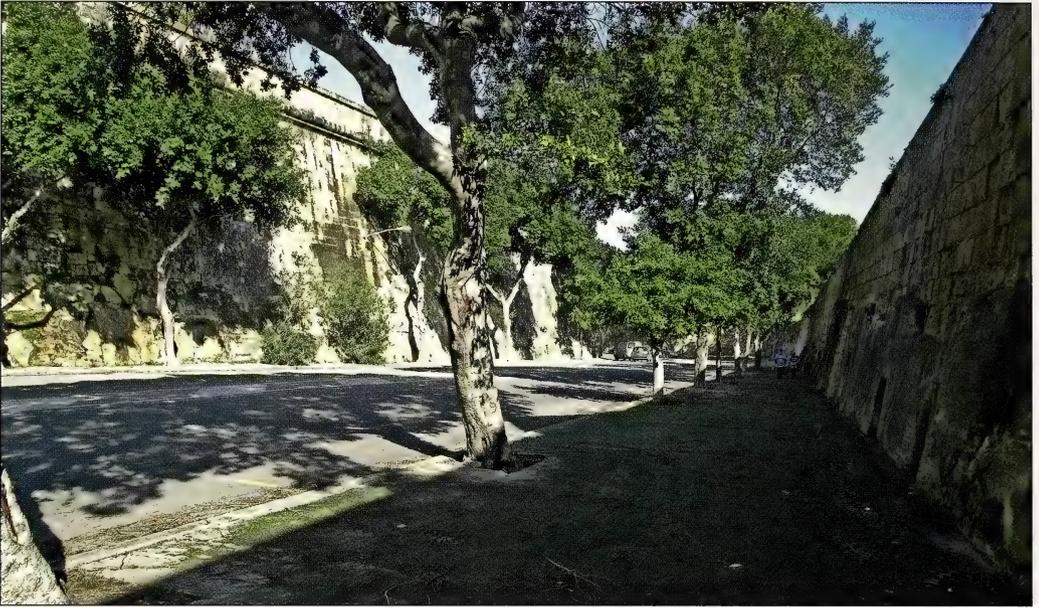


Fig. 8. Biotope; a shady street with moss covered rocks and walls (photo by P. Sammut).

During the warm and dry summer a diapause is observed for some 2–3 months. In autumn this diapause ends and the larvae eat again for some weeks and prepare for pupation. For most of the time the larvae hide in the moss, where many also pupate.

P u p a . The dorsal abdominal thorns would help the pupa to work itself out of the bag by bending the abdomen up and down and finding hold in the wall of the bag. This behavior is normal with both sexes in all genera of the Naryciinae and Taleporiinae. However, according to our observations *S. melitensis* does not partly work the pupa out of the bag prior to hatching and the rows of thorns on the pupae can be interpreted as a relict (Fig. 7a, d), The two thorns on the last segment facing forward probably help the pupa in preventing it from falling out of the bag when preparing for hatching.

A d u l t . Mating occurs early in the morning. The female hatches at dawn and waits outside of her bag with the ovipositor widely extended, calling for a partner with her pheromone. The male hatches at dusk and dries its wings. It remains on or near the bag until the next morning. When the pheromone of a female reaches the male it follows the scent against the airflow to find the waiting female. Mating lasts only a few minutes. Immediately after, the female starts laying about 50–70 eggs into the bag beside the pupal exuvia and rubs off her abdominal hairs to place them between the eggs for cushioning and insulation. When finished, the female “walks” away and dies. The sex ratio is balanced. The species has one generation per year which begins approximately with egg laying in January or February, and lasts a full year with a diapause of 2 to 3 months in the summer.

P a r a s i t e s . The only parasitoid known emerged from a bag collected in Manikata. It was a male wasp of the genus *Gelis* Thunberg, 1827 (Ichneumonidae, Cryptinae). The biomass of the larva is practically identical with that of the wasp.



Fig. 8. Biotope; a shady street with moss covered rocks and walls (photo by P. Sammut).

Habitat (Figs 8–9). This species is known only from Malta, and it is the only *Sciopteris* known on the Maltese archipelago, where it was found on mossy rocks and stone walls colonized mostly by *Tortula muralis* Hedwig, 1801 (Pottiaceae). Besides the type locality, it is also known from Gharghur (Amsel 1953) and Manikata. The situation of the collecting localities is shown on the map (Fig. 10).

Etymology: The name *melitensis*, meaning “Maltese” or “of Malta” is derived from the old name of the Island of Malta – Melita.

Discussion

With the exception of *S. melitensis*, from none of the other five species in the genus are all stages known and many identification criteria remain unknown. In the following table the published data are compiled. One can observe important criteria, such as the presence or absence of ocelli and the presence or absence of an intercalated cell in the hindwing. Such important criteria often serve to separate genera, but in the case of the genus *Sciopteris*, too many questions remain unanswered. For this reason we do not split the genus and accept it in its present, heterogeneous state until more is known of the species in question. In fact, the species *S. melitensis*, re-described in this paper, differs from the general description of the genus by the absence of ocelli and the presence of an intercalated cell in the hindwing. However, we are convinced that the species reviewed here is the species found by Adolf Andres in 1915 and partly described by Rebel in 1919.

Tab. 1. Summary of known data for all *Sciopetris* species. Blank areas indicate "unknown".

	<i>technica</i> Meyrick, 1891	<i>amseli</i> Sieder, 1959	<i>melitensis</i> Rebel, 1919	<i>pretiosa</i> (Stainton, 1872)	<i>hartigi</i> Sieder, 1976	<i>karsholti</i> Hättenschwiler, 1996
source of info	original description	original description	actual studies	original description	original description, study of paratype (*)	original description
number of males known	3	1	21	1	5	25
flying season	April	May	January–February	April	February–March	May
type locality	Algeria, Philippeville	Afghanistan, Kashka, 1800 m	Malta, near sea level	Morocco, Marshen	Sardinia	Tunisia, 35 km off sea coast
wingspan (mm)	10–11	11	8.2–11.2	5 lines = 10.6	11	9.5–10
forewing veins off discoidal cell	8		8		8	8
forewing scales (Sauter 1956)		5	4–5		4	4–5
hindwing veins off discoidal cell	6, m2+m3 often stalked		6, with intercalated cell m2+m3 stalked		6	5, with intercalated cell
hindwing scales (Sauter 1956)	hair scales	narrower than on forewing	1–3		„hairlike“ 1–2	2–3
ocelli	present		missing		present (*)	missing
antenna segments		28	27–36		approx. 35	29
eyes distance : eye height			2 x		approx. 2 x (*)	1.2–1.5 x
epiphysis on foreleg		missing	present		present	present
phallus		short, curved	thin, long, straight		short, curved	long, nearly straight
female size (mm)			length 3–4 diameter 1.5		length 2.5 diameter 1.5	
bag length (mm)			triangular; male 5.3–6.8; female 6.5–8		triangular; 7–8 (*)	

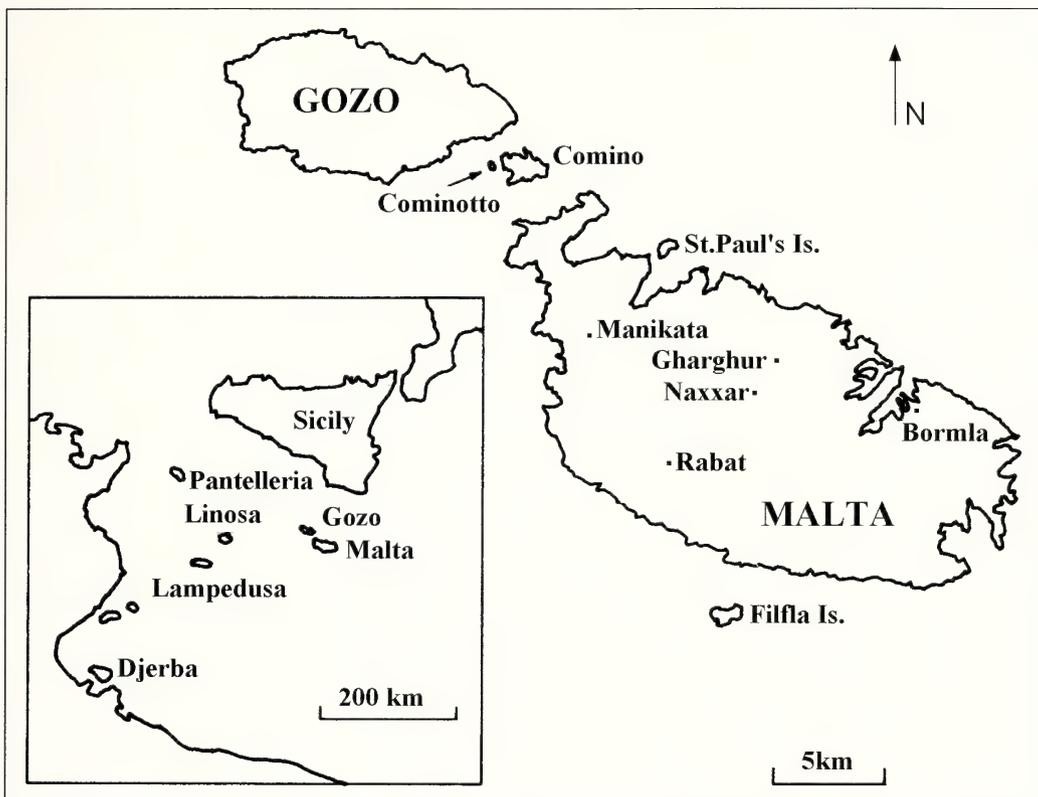


Fig. 10. Map with the collecting localities of *S. melitensis* on the island Malta and position of the Maltese Archipelago in the Mediterranean Sea.

Acknowledgements

We are thankful for the help we obtained from various people, Prof. Dr. Willi Sauter for checking and discussing the manuscript, Dr. Martin Schwarz for his help in determining the parasitoid wasp, Dr. Gaden Robinson for his help in gathering the required literature, and not least, our thanks also go to Ruth Hättenschwiler for taking care of the nursery of these most interesting larvae.

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Prays peregrina sp. n. (Yponomeutidae) a presumed adventive species in Greater London

DAVID AGASSIZ

The Natural History Museum, Cromwell Road, London SW7 5BD; e-mail: d.agassiz@nhm.ac.uk

Résumé. *Prays peregrina* sp. n. is described from scattered localities in Greater London. The possible origin of this species is discussed.

Introduction

In the autumn of 2005 two British lepidopterists: Colin Plant and Philip Sterling contacted me about a mystery yponomeutid of which a specimen had been taken in West London. Shortly afterwards a second specimen was reported which appeared to belong to the same species. Over the following months further specimens were reported. I searched through the collections of the Natural History Museum (BMNH) but was unable to find an exact match for the specimens. A male was dissected which seemed to confirm that the species belonged to the genus *Prays*. Pictures of adult and genitalia were circulated to entomologists in Europe and Australia, but none could suggest an identity. Moriuti (1977) described six new species from Japan but it resembles none of these. When a seventh specimen was reported in 2006 I made a further search of the BMNH collections and found that *P. curulis* Meyrick seemed to be the nearest species, a male had been dissected by Moriuti but there were some differences in the genitalia. It therefore seemed necessary to describe the species as new.

A summary of recorded specimens is as follows:

Date	locality	British grid	sex	recorder
15.viii.2003	Parliament Hill	TQ2785	♂	Ray Softly
19.vi.2005	Chelsea Physic Garden	TQ2778	♀	Tim Freed
6.ix.2005	Wood Green	TQ1585	♂	Marcel Ashby
5.x.2005	Greenford	TQ3189	♀	David Howdon
28.vii.2006	Wood Green	TQ1585	♂	Marcel Ashby
6.ix.2006	Orpington	TQ4667	?	Martin Jordan
16.ix.2006	Orpington	TQ4667	?	Martin Jordan
18.x.2006	Barnet	TQ2596	♀	Rachel Terry
24.vi.2007	Wembley	TQ1884	♀	Geoff Geiger
10.vii.2007	Wimbledon	TQ2670	♀	Vlad Proklov
24.viii.2007	Wetlands Centre	TQ2276	♀	Martin Honey
5.ix.2007	Chessington	TQ1864	♂	Jim Porter
8.ix.2007	Wimbledon	TQ2670	♀	Vlad Proklov
14.ix.2007	Sidcup	TQ4772	1♂+1♀	David Macklin
2.x.2007	Wimbledon	TQ2670	♂	Vlad Proklov

The distribution of these records is shown in Fig. 5

Prays peregrina* sp. n.*Figs 1–4**

Material. Holotype: ♀ '5th Oct. 2005 D. Howdon | Melville Ave, Greenford, | Middx.' 'BM genitalia slide No. 31468.' a red circled holotype label and 'Prays peregrina Agassiz det D. Agassiz, 2007. Deposited in BMNH. – Paratypes: 1♂ Alexandra Road, Middlesex, London N8, 5.ix.2005; BM genitalia slide No. 31467, BMNH; 1♂ Parliament Hill, London NW3, 15.viii.2003, R. Softly, coll. C. W. Plant; 1♂ London N8 28.vii.2006, M. Ashby, coll. R. Terry; 1♀ Chelsea Physic Garden, SW, 19.vi.2005, T. H. Freed, coll. T. H. Freed; 1♀ Barnet, 18.x.2006, R. Terry, coll. R. Terry.

Description of the adult (Figs 1–2). Wingspan 14 mm. Head pale grey, labial palpus white, segment 3 longer than segment 2, tuft of white hairs arising from base; antenna just over half wing length, weakly annulate pale fuscous and white; pair of white tufts behind head. Thorax dark fuscous. Forewing white with scattering of dark fuscous dots, dark fuscous mark arising from middle of dorsum in shape of curved triangle, dark fuscous tornal spot, terminal cilia concolorous with adjacent wing. Hindwing uniform pale grey, small hyaline patch above vein CuP near base. Underside of all wings fuscous. Legs white, forelegs fuscous above. Abdomen white.

The species is similar to *Prays curulis* Meyrick, but differs in lacking partial fascia from middle of dorsum, and having more pronounced tornal spot.

Male genitalia (Figs 3, 3a) Socii strong with tips drawn out to a point, gnathos forming an arched rod, valva with sacculus forming a small point, saccus long and slender. Phallus curved with a cluster of 2 large and 3–4 smaller cornuti. Differs from *P. curulis* in the more uniform socii, longer and narrower saccus and the stronger and fewer cornuti in the phallus.

Female genitalia (Fig. 4) Ostium wide, ductus bursae strong and straight, slightly longer than ostial chamber, corpus bursae ovate, signum small sclerotised plate with two prongs.

Distribution. All known specimens from Greater London (Fig. 5). The native range of the species is unknown, suspected to be in Asia, specimens of the closely related *P. curulis*, described by Meyrick (1914), in the Natural History Museum are from northern India and Nepal.

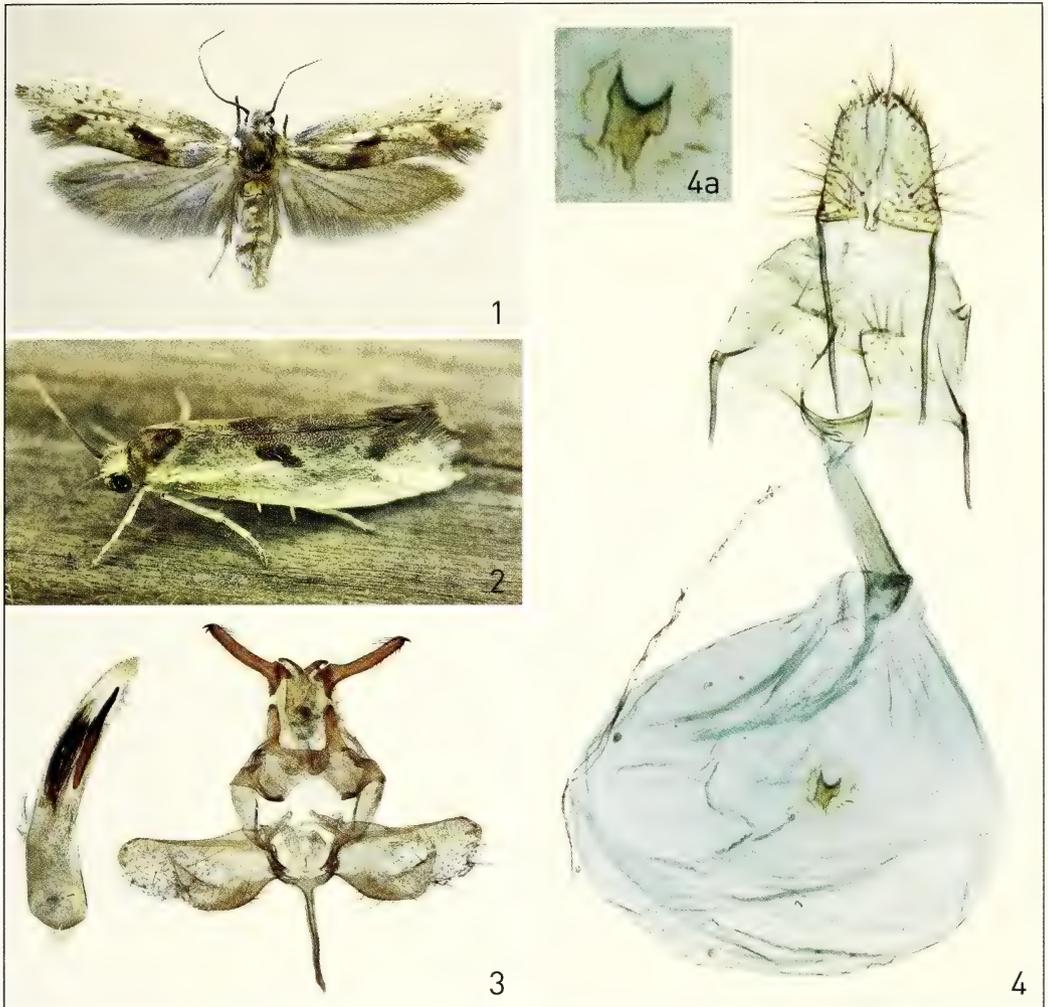
Life History unknown.

Etymology. The name is taken from the Latin word meaning "that comes from foreign parts"

Discussion

The origin of these specimens remains a matter of speculation. Either they must be breeding locally or else emerging from imported plant material or foodstuffs. If the former were the case one would expect a local population to build up, and therefore the scattered nature of the records suggests that they are repeatedly imported. The lack of records from any other city or country is surprising, as well as the fact that there is no mention of such a *Prays* species in the economic literature. It is also puzzling that there are no records prior to 2003.

The genus *Prays* Hübner contains over 40 described species predominantly from the Old World; there are 23 species from Asia, 8 from Australia, 4 from Europe, 3 from Africa, and the remainder from certain oceanic islands or South America. Foodplants used are Oleaceae (*Fraxinus*, *Juglans*, *Ligustrum*, *Olea*), Rutaceae (*Citrus*), Caprifoliaceae



Figs 1–4. 1. Set specimen of *P. peregrina* (photo Rachel Terry). 2. Live specimen of *P. peregrina* (photo Martin Jordan). 3. Male genitalia, with phallus on the left (photo Rachel Terry). 4. Female genitalia, 4a signum enlarged.

(*Viburnum*) and a few other families. Larvae are known to feed on fruits and in shoots of the host plant as well as the leaves. The specimen taken in Chelsea Physic Garden was a female and a spermatophore in the corpus bursae indicated that it had paired with a male, so several specimens must have emerged at about the same time.

It seems most likely that the specimens have been imported as larvae or pupae in some foodstuff from Asia, but this is purely conjecture, the span of dates of capture from June to October suggests either that the species is continuously brooded and repeatedly imported, or it may have become locally established.

Malumphy (2007) listed various arthropod species intercepted on *Citrus hystrix* which has only recently been imported from Indonesia, since this belongs to an appropriate family it should be explored as a possible host plant.

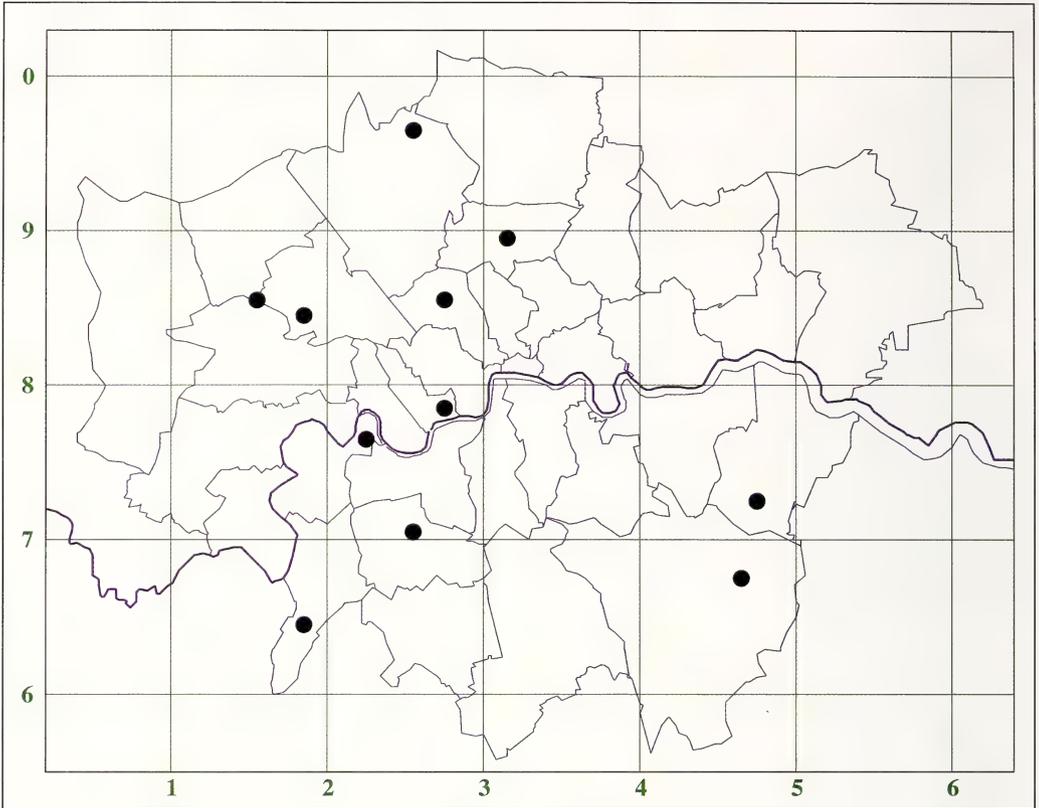


Fig. 5. Map of Greater London showing distribution of records of *P. peregrina* (Dmap).

Acknowledgements

The recorders of all specimens cited are thanked for their willing collaboration and assistance, Dr Klaus Sattler has given advice and encouragement. Thanks to Rachel Terry for making the preparation and photographing the male genitalia, the distribution map was generated using Dmap.

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Dyspessa aphrodite sp. n. from Greece (Cossidae)

ROMAN V. YAKOVLEV¹ & THOMAS J. WITT²

¹ ul. Chkalova, 57–81, Barnaul, 656049, Russia; e-mail: yakovlev_r@mail.ru

² Tengstr.33, 80796 München, Germany; e-mail: thomas@witt-thomas.com

Abstract. *Dyspessa aphrodite* Yakovlev & Witt, sp. n. is described from Greece and compared with *Dyspessa emilia* (Staudinger, 1878), with which it has been confused. Therefore, *D. emilia* must be removed from the European list of Cossidae.

Introduction

Our knowledge of European Cossidae is considered satisfactory. After the revisions of Daniel (1955–1965) several comprehensive papers and books have been published with new data on the distribution and systematics of the European carpenter moths (de Freina & Witt 1990; Karsholt & Razowski 1996; Yakovlev 2005). However, while examining material in the Thomas Witt entomological museum (MWM) the authors surprisingly found a series of an intriguing carpenter moth of the genus *Dyspessa* Hübner, 1820 originating from Greece (Peloponnes, Mega Spileon). These moths had been wrongly identified as *Dyspessa emilia* (Staudinger, 1878) and were mentioned as such for the first time for the fauna of Greece by de Freina & Witt (1990: 31–32, pl. 4 figs 10–12), and later by Karsholt & Razowski (1996). A detailed examination of these specimens revealed that they represent a species new to science and its description is given below. As a result, *Dyspessa emilia* (Staudinger, 1878) has to be deleted from the list of European Cossidae and must be replaced by *Dyspessa aphrodite* Yakovlev & Witt, sp. n.

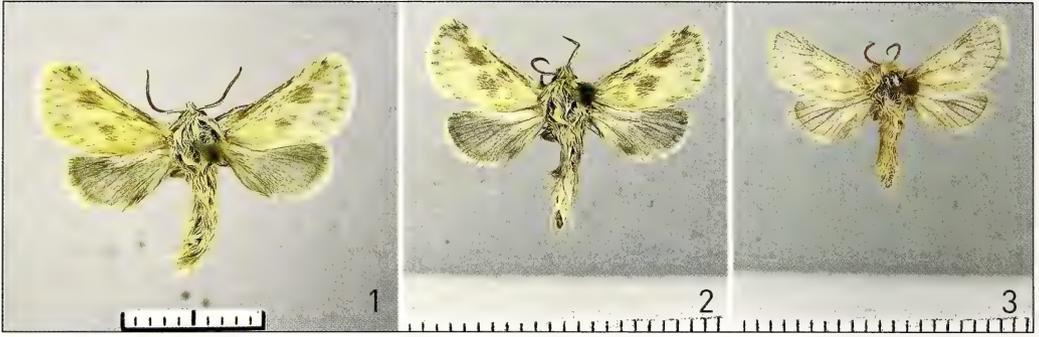
Dyspessa aphrodite sp. n.

Figs 1–3, 7, 9

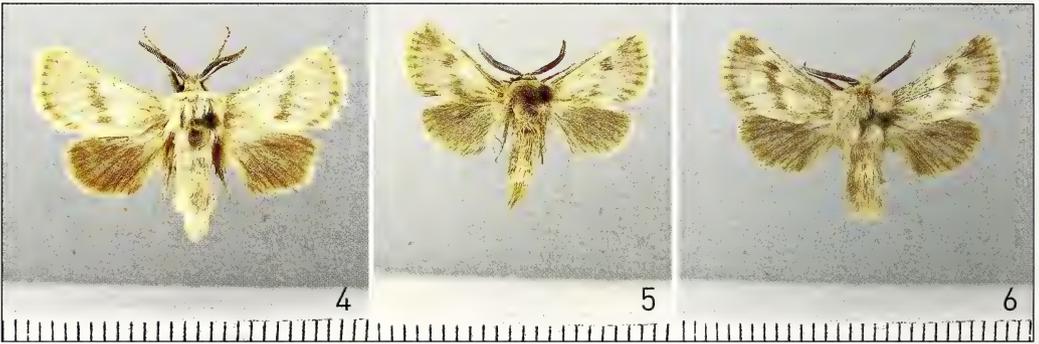
Material. Holotype-♂: “Greece | Peloponnes | Mega Spileon | 6.vi.1981 | Mühle leg.”, “Holotypus | *Dyspessa aphrodite* | Yakovlev & Witt”, MWM. – Paratypes: 7♂, same data (GenPr.11821, 11822) MWM. Add separators between lines of labels and add Holotype label and others if applicable.

Description. Forewing length 9–10 mm. Antenna bipectinate, medially with processes becoming 1.5 times longer than segment diameter, space between processes as wide as processus breadth. Forewing pale yellow with small dark spot in discal zone in area of cubital veins, relatively large brown spot in postdiscal zone in radial area (at discal cell apex), and weakly expressed brown spot at apex. Two paratypes miss these spots. Fringe mostly yellow, but basally dark at tips of radial veins. Hindwing greyish yellow with pale yellow fringe.

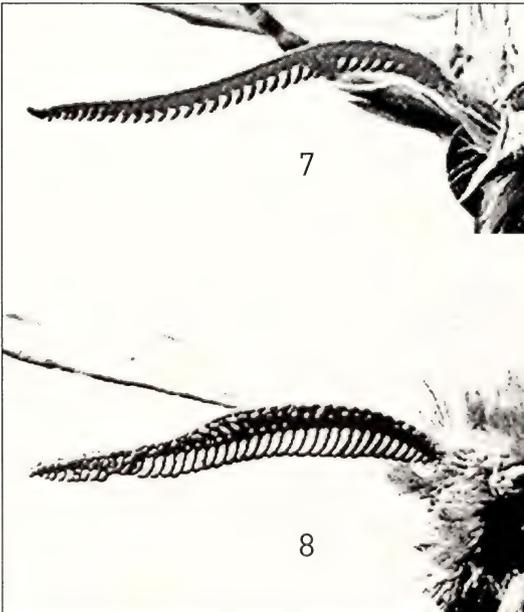
Male genitalia (Fig. 9). Uncus triangular with a beak-like pointed apex. Gnathos arms thin and long, gnathos small. Valva trapezoid with almost rectangular distal margin, also with small crest on costal margin; distal end membranous. Arms of transtilla forming wide triangles. Saccus small, rounded. Juxta small. Phallus curved, thin and tapering to apex; vesica opening occupying half of its length.



Figs 1–3. *Dysspessa aphrodite* Yakovlev & Witt, sp. n. (MWM). 1. Holotype. 2–3. Paratypes.



Figs 4–6. *Dysspessa emilia* (Staudinger, 1878), males from Turkey, (MWM). 4. Anatolia, 25 km south of Sivas, 1500 m, 24–26.vii.1978, leg. W. Thomas. 5–6. Ak.-Ch.-Tschiftlik, 19–20.vii.1928, coll. v. Bartha.



Diagnosis. The new species is close to *Dysspessa emilia* (Staudinger, 1878) (Figs 4–6, 8, 10) from which it differs by the following characters: The antennal processus in *D. emilia* is much longer; it is 2.5–3 times longer than the antennal diameter while in *D. aphrodite* it is not longer than 1.5 times this diameter. The forewing is much wider than in *D. emilia*. The basal parts of the forewing fringe are dark only at the distal end of the radial veins in *D. aphrodite*, whereas it is dark at the distal end of all veins in

Figs 7–8. Antennae of male *Dysspessa* specimens. 7. *D. aphrodite* Yakovlev & Witt, sp. n., paratype. 8. *D. emilia* (Staudinger, 1878).

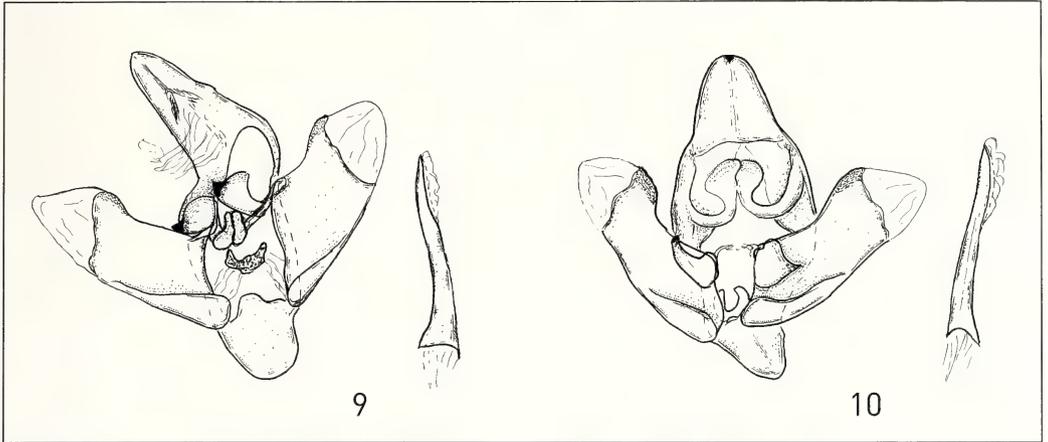


Fig. 9–10. Male genitalia *Dyspessa aphrodite*. **9.** *Dyspessa aphrodite* Yakovlev & Witt, sp. n. **10.** *Dyspessa emilia* (Staudinger, 1878).

D. emilia. In forewing pattern, the spots of the postdiscal row are approximately equal in size in *D. emilia*. In the new species the spot in the radial area is larger than the others, which are shifted into the discal zone. The male genitalia practically do not differ, except for the somewhat more expressed processus on the costal margin of the valva in *Dyspessa emilia*. However, our analysis of very large material in genus *Dyspessa* showed very weak interspecific differences in genitalia structure.

Etymology. In Greek mythology Aphrodite is the goddess of love and beauty.

Distribution. Known only from the type locality.

Remark. The absence of forewing dark spots on two paratypes may be due to wear or individual variation.

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Taxonomic notes on *Acossus* Dyar and *Parahypopta* Daniel (Cossidae)

ROMAN V. YAKOVLEV

ul. Chkalova, 57–81, Barnaul, 656049, Russia; e-mail: yakovlev_r@mail.ru

Abstract. While studying material of Cossidae from North America it was found that *Acossus* Dyar, 1905 is a synonym of *Lamellocossus* Daniel, 1956, **syn. n.** Thus, the following combinations are made: *Acossus terebra* ([Denis & Schiffermüller], 1775) **comb. n.** and *Acossus viktor* (Yakovlev, 2004) **comb. n.** Genus *Acossus* includes five species and is Holarctic in distribution. The type and topotypical specimens of *Parahypopta caestrum radoti* (Homberg, 1911) were investigated. Distinct features of pattern and morphology differentiate it from *Parahypopta caestrum* (Hübner, 1804). *Parahypopta radoti* (Homberg, 1911) **stat. n.** proves to be a distinct species.

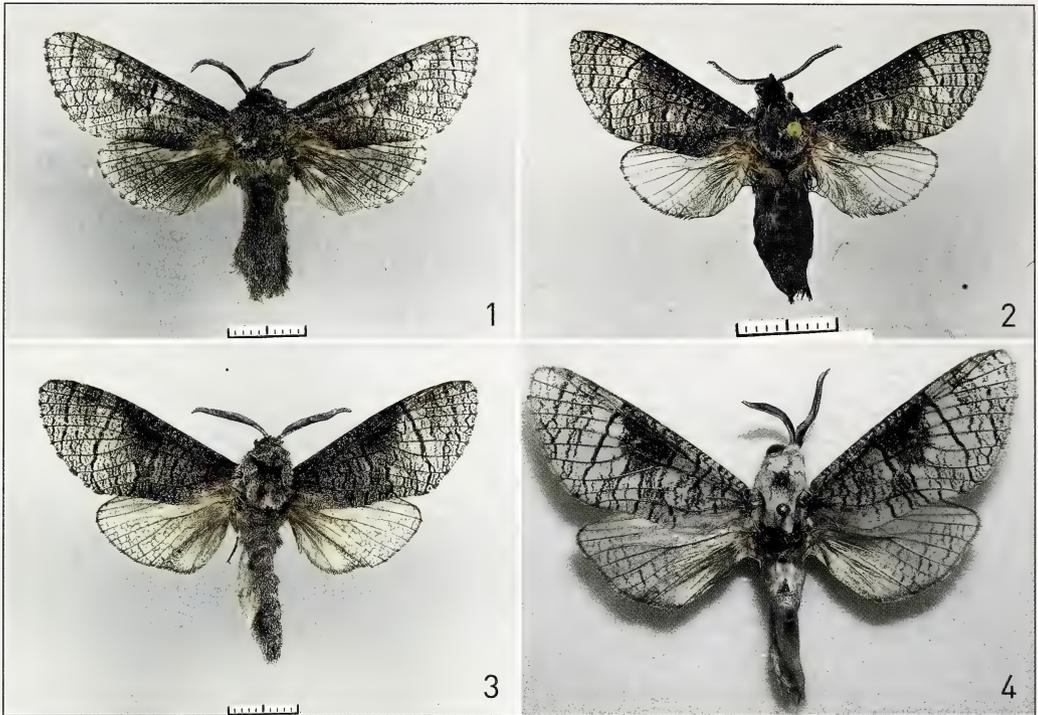
1. *Acossus* Dyar, 1905

Type species: *Cossus undosus* Lintner, 1878

Genus *Acossus* was described by Dyar (1905) for the North American *Cossus undosus* Lintner, 1878 and since 1905 the name was used only for representatives of the Nearctic fauna. Ureta (1957) described from Chile *Acossus comadioides* from Chile, a name that was later synonymised with *Rhizocossus munroei* Clench, 1957 (Gentili 1985). Half a century after the description of *Acossus*, Daniel (1956) described the genus *Lamellocossus*, to exclude *Bombyx terebra* Denis et Schiffermüller, 1775 from *Cossus* Fabricius, 1793 with which it had been associated. As the main diagnostic character, Daniel mostly used the antennal structure of the male. *Bombyx terebra* clearly differs in this character from the type species *Cossus cossus* (Linnaeus, 1756), because of its bipectinate antenna. Later, Russian authors (Zagulyaev 1978; Chistyakov 1999; Yakovlev 2004) soundly stressed the differences between *Cossus* and *Lamellocossus*. A new species, *Lamellocossus viktor* Yakovlev, 2004 was described from the *terebra*-group; it inhabits the arid regions of South Tuva (the northern part of the Great Lake Hollow, at Lake Tere-Khol' and the Tes Khem River) and should occur also in northern Mongolia.

While studying material of the private collections by Thomas Witt (Munich) and Armin Hauenstein (Untermünkheim) and after an assessment of the literature I found that *Acossus undosus* and *A. centerensis* (Lintner, 1877) specimens from Canada presented striking external similarities with *Lamellocossus* specimens. My examination of the genitalia of both North American species showed them to be nearly identical with those of *Lamellocossus terebra*. The external traits, antenna and male genitalia structure leave no doubt that *L. terebra* and *L. viktor* belong to *Acossus*, which is thus Holarctic in range. Hitherto, the only known Holarctic taxon of Cossidae was *Zeuzera pyrina* (Linnaeus, 1761) (Hodges, 1983), which, however, quite probably was introduced to North America by man.

Diagnosis: Medium-sized, gray-colored moths. Antenna bipectinate, each segment with two long processes. Thorax and abdomen with dense pubescence of gray hairy scales. Fore wing gray, somewhat darker at base, with wavy streaky pattern through-



Figs 1–4. Adults of *Arossus*. **1.** *A. undosus*, male, Canada, British Columbia, Hazelton, 30 km N Kispiox River, Resort, 400 m, 3.08.–10.08.1999, leg. S. Ortner, Museum Witt, München. **2.** *A. centerensis*, male, Canada, British Columbia, Interior Caribou Mountains, Lake Canim, 900 m, 26.07.–3.08.1997 coll. Hauenstein, Untermünkheim. **3.** *A. terebra*, male, Russia, W. Altai Mts. [Altaiiskii Krai Region, Zmeinogorskii district], 5 km south of Samarka, 800 m, 25–26.07.1993, leg. Z. Varga, Museum Witt, München. **4.** *A. viktor*, holotype, Zoological Institute, St. Petersburg.

out; fringe checkered. Hindwing somewhat lighter gray, often with an expressed wavy streaky pattern.

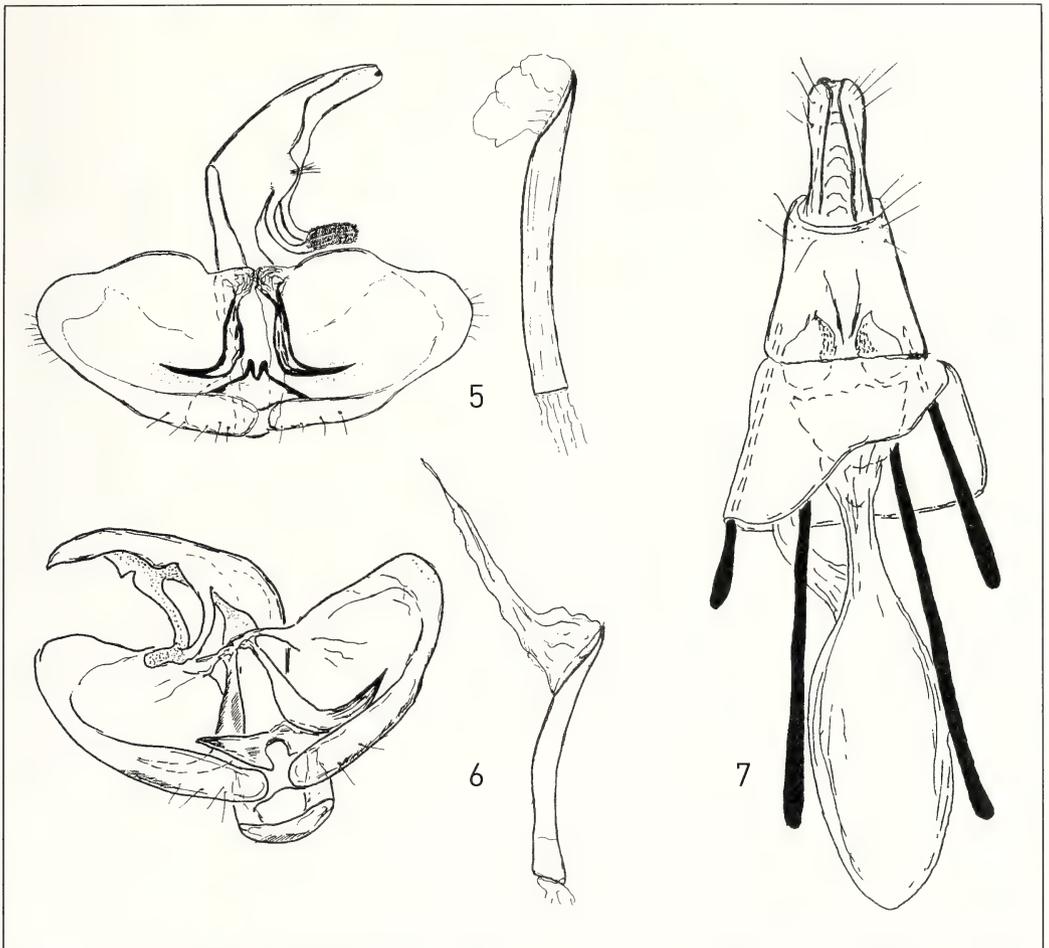
Male genitalia. Uncus long, beak-like; gnathos arms long and quite thick, quite large at point of fusion, covered with fine spinules. Valva broad, cup-like, swollen, with convex costal margin. Arms of transtilla strongly sclerotised, hook-shaped, pointed. Juxta small, strongly sclerotised; saccus weakly expressed. Phallus weakly curved, relatively thick and long; vesica opening dorso-apical, at about one third of phallus length.

Female genitalia. Oviscapt short. Apophyses posteriores very long; papillae anales elongate and smoothly rounded apically; anthrum immersed; ductus bursae wide membranous; bursa ellipsoid, without signa; ductus seminalis from base of bursa base near connection of ductus bursae.

Diversity. The genus includes five species:

Arossus undosus (Lintner, 1878: 243) (*Cossus*) (Figs 1, 5), occurring in Canada and the USA (Barnes & McDunnough 1911; Schoorl 1990).

Arossus populi (Walker, 1856: 1515) (*Cossus*), occurring in Canada and the USA (Barnes & McDunnough 1911; Schoorl 1990).



Figs 5–7. Genitalia of *Acoscus*. 5. *A. undosus*, male. 6. *A. terebra*, male (Chistyakov 1999). 7. *A. terebra*, female (Chistyakov 1999).

Acoscus centerensis (Lintner, 1877: 129) (*Cossus*) (Fig. 2) occurring in Canada and the USA (Barnes & McDunnough 1911; Schoorl 1990).

Acoscus terebra (Denis & Schiffermüller, 1775: 60) (*Bombyx*) **comb. n.** (Figs 3, 6–7) occurring in Eurasia (Israel, Turkey, northern Spain, middle and southern Europe, southern Sweden, Finland, Baltic States, Ukraine, central part of European Russia, Caucasus, southern Siberia including the Altai and Sayan Mts. to S. Yakutia, southern part of Far East, Korea, Heilongjiang, Jilin, inner Mongolia (de Freina & Witt 1990; Hua et al. 1990; Yakovlev 2004).

Acoscus viktor (Yakovlev, 2004), (*Lamellocoscus*) **comb. n.** (Fig. 4) occurring in Russia, southern Siberia, southern part of Tuva Republic.

Note. *Fania connectus* Barnes et McDunnough, 1916, formerly treated in *Acoscus*, has been transferred to *Fania* Barnes, McDunnough, 1911 (Schoorl 1990), which is followed here.

Remarks. *Acoscus* belongs to Cossinae Leach, 1815, is similar to the Palearctic *Cossus*, *Gobibatyr* Yakovlev, 2004 (type species: *Cossus colossus* Staudinger, 1887) and the North American *Prionoxystus* Grote, 1882 (type species: *Cossus robiniae* Peck, 1818).



Fig. 8. *Parahypopta radoti*, lectotype. Fig. 9. Labels of the lectotype of *Parahypopta radoti* (Homberg, 1911).

2. *Parahypopta radoti* (Homberg, 1911) stat. n.

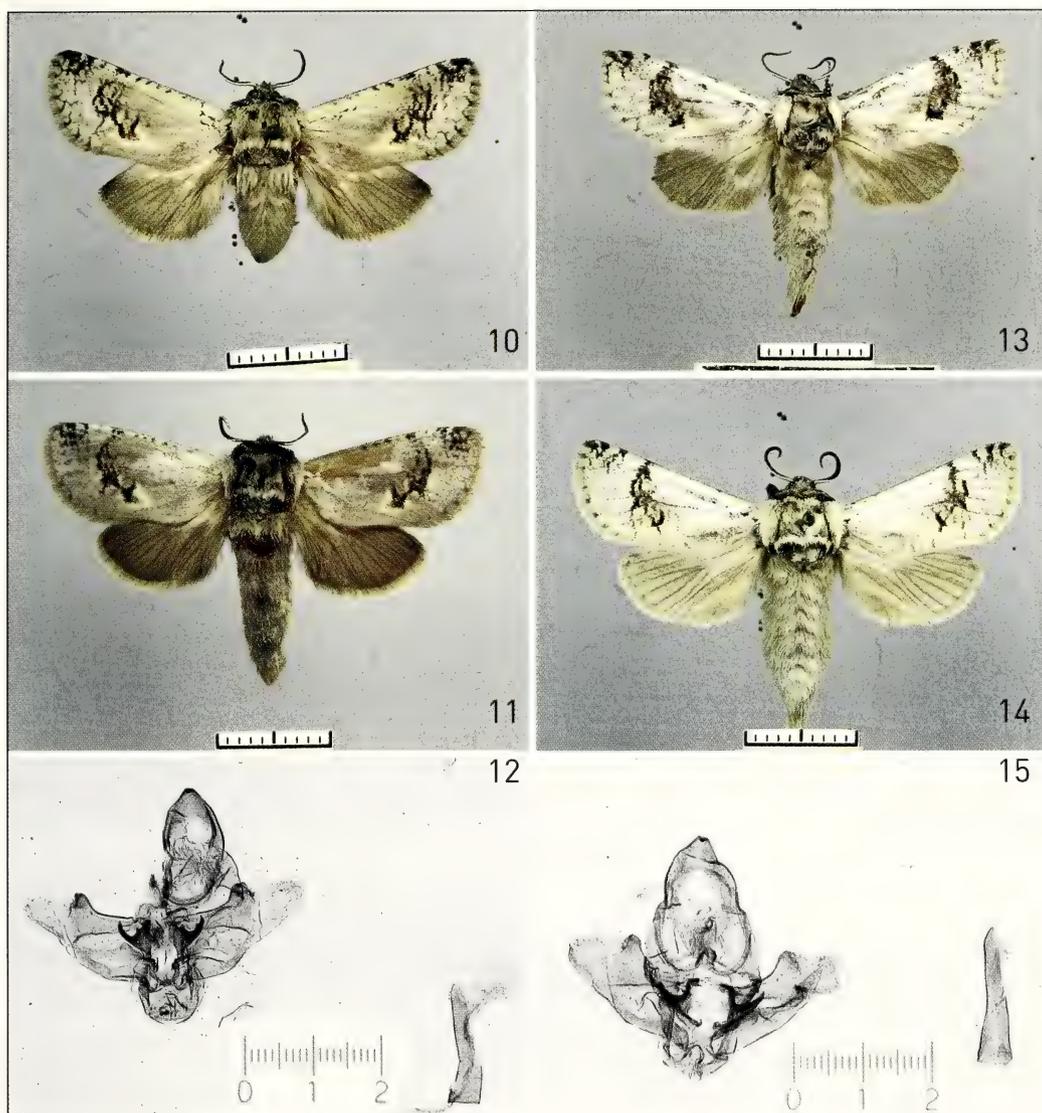
Figs 8–12

Hypopta radoti Homberg, 1911. Type locality: France, Alpes-Maritimes, Cannes.

Hypopta caestrum radoti Homberg, 1911: 143–144. Type locality: France, Alpes-Maritimes, Cannes.

Homberg (1911) briefly described *Hypopta caestrum radoti*, pointing out the dark pattern of the specimens, collected at Cannes (Alpes-Maritimes). Seitz (1912: 424) and Dalla Torre (1923: 22) considered this taxon as a subspecies of *Parahypopta caestrum*. Daniel (1961: 161–162) wrote that *Parahypopta radoti* is «eine Zustandsform oder Mutation, die im Bereich einer engen Population einmal die vorherrschende Form werden kann», thus not considering these moths as a valid taxon. Leraut (1980: 52) mentioned *Parahypopta radoti* Homberg, 1911 as a junior synonym of *Parahypopta caestrum* (Hübner, 1804). De Freina & Witt (1990: 22) adopted the opinion of the previous authors and noted that “Neben den bei Cossiden üblichen Größendifferenzen einzelner Populationen zeigt sich ... auch schiefergrau verdunkelte Individuen, die innerhalb jeder Population mehr oder weniger häufig auftreten können: f. *radoti* Homberg, 1911”. This taxon was not been mentioned in the comprehensive list of the lepidopteran fauna of Europe by Karsholt & Razowski (1996). In the Muséum National d’Histoire Naturelle Paris (MNHN), I investigated the lectotype (designated below) of *Hypopta caestrum radoti* and several topotypical specimens, including syntypes. I found that this taxon is a valid species, clearly distinct from *Parahypopta caestrum* (Hübner, 1804) by external characters as well as the male genitalia structure.

Description. Male. Fore wing length 12–13 mm. Fore wing whitish-brown, with a row of small roundish brown spots at costal margin; there are several brown spots partly fused to each other; submarginal area somewhat lighter than the rest of wing area; entire central part of wing occupied by a dark-brown spot in postdiscal area with



Figs 10–15. *Parahypopta* spp. **10.** *P. radoti*, male, Cannes, MNHN. **11.** *P. radoti*, female, Cannes, MNHN. **12.** *P. radoti*, male genitalia. **13.** *P. caestrum*, male, Hungary. **14.** *P. caestrum*, female, Hungary. **15.** *P. caestrum*, male genitalia.

wavy transversal lines; wing basal area without pattern. Fringe checked dark at veins and light between them. Hind wing brown without pattern; with a light-brown fringe. Male genitalia. Uncus triangular, wide, with a membranous zone on its upper surface. Tegumen wide. Gnathos arms very stout and robust, gnathos covered with small spinules, especially dense laterally. Valva broad, distal end membranous and mobile; costal margin with robust trapeze-shaped processus with slightly dentate margin. Arms of transtilla with wide bases and curved and pointed ends. Juxta carina-shaped with broad weakly sclerotized lateral processes, slightly widening apically. Saccus wide,

semicircular. Phallus stout, slightly curved, with slantingly cut at distal end; vesica with opening dorso-apically and occupying about half of phallus length; without cornuti.

Diagnosis. Clearly differs from *P. caestrum* (Figs 13–15) by the much darker wing coloration, the slightly shorter forewing with rounded apex, and details of the male genitalia structure: the somewhat wider juxta, the much more developed processus on the costal margin of the valva, the shorter and less curved arms of transtilla, the curved phallus.

Taxonomical notes. Taking into account the complicated taxonomy within this group, it is necessary to fix the name *Parahypopta radoti* to a specific specimen. Many syntypes of *Hypopta caestrum radoti* are preserved in the Natural History Museum of the Humboldt University of Berlin, the Zoologische Staatssammlung des Bayerischen Staates of Munich and there is one specimen labelled as lectotype at the MNHN Paris. However, according to my own data the lectotype designation has not been published. Thus, to preserve the selection of this specimen, I hereby designate it as the lectotype. The specimen (Fig.8) bears the following labels (Fig.9): (1) Red, rectangular, with ‘Type’ printed typographically; (2) White, rectangular, with ‘Coll. R. Homberg | Muséum Paris’ printed typographically; (3) White, rectangular, with R. Homberg’s hand-writing in black ink ‘Env. Cannes | 1. Juillet 1910 | ex larva. as page | R. Homberg’; (4) White, rectangular, with R. Homberg’s hand-writing in black ink ‘Var. *Radoti*. Hmbg. | Type | Bull. Soc. Ent. France | 12 avril 1911’; (5) White, rectangular, with five lines of text of which the first is typographically printed while the rest are written in black ink by P. Viette’s hand as follows ‘P.E.L. Viette det. 19 | *Hypopta* L. T. | *caestrum* var. | *radoti* Homberg | Bull. Soc. Ent. Fr., | 1911, p. 143’; (6) White, circular, with black margin, with typographically printed ‘LECTO- | TYPE’; (7) White, rectangular, with A. Kondratyev’s hand-writing in black ink ‘gen. prep. | №. 5. | Kondratiev’; (8) Red, rectangular, with the following hand-written text in black ink: ‘LECTOTYPE | *Hypopta caestrum* Hb. | var. *Radoti* Homberg, 1911 | des. R. V. Yakovlev’.

Distribution. Reliably known only from the type locality. A clarification of the range is planned in the course of a revision of the genus *Parahypopta* Daniel, 1961.

Acknowledgements

I am thankful to all who helped me to prepare this work: A. Hauenstein (Untermünkhein), O. Kosterin (Novosibirsk), J. Minet (Paris), T. J. Witt (Munich), and V. Zolotuhin (Ulyanovsk).

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In the Material section of species descriptions, type material should be listed before the remaining material, with the latter set off by a long dash. For primary type specimens, the complete label data should be quoted using single quotation marks ‘...’ for starting and terminating the quotation of one label, a vertical line | for separating different lines of the label, angled brackets <...> for including comments into the quotation (e.g. <sic>), and square brackets [...] for expansions of abbreviations (e.g., Bras[il].) and for the conversion of measurements. Abbreviations of institutional collections should be taken from the list of *Insect and Spider Collections of the World* of the Bishop Museum, Honolulu, Hawaii at <http://hbs.bishopmuseum.org/codens/codens-r-us.html>. For all other specimens, localities should be given in order of increasing precision as shown here:

Material. Holotype ♂, 'Turkey, Hakk.[ari] | 8 km E. of Uludere, | 1200 m, 10.vi.1984', 'Meier leg.', 'coll. MTD Dresden', 'Holotype | *Aus beus* sp. n. ♂ | det. A. Schmidt', MTD. – Paratypes: 7♂, 3♀, same data, but NHMW. 2♂, 1♂, Iraq, Kurdistan, Sersang, 1500 m, Higgins leg., BMNH; 1♂ Kurdistan, Shaqlawa, 2500 ft, 15/24 May 1957, Higgins leg., BMNH.

The list of references must include all and only the sources that are mentioned in the text. They should be arranged in alphabetical order and provide the full journal names. References by two authors or more, but with the same first author should be arranged by year and in alphabetical order of the second, third, etc. author's names within each year. For journals the full titles should be given without any abbreviations. Please use the following examples and pay attention to the format, punctuation, and types of dashes used:

Higgins, L. G. 1950. A descriptive catalogue of the Palaearctic *Euphydryas* (Lepidoptera: Rhopalocera). – Transactions of the Royal entomological Society of London **101**: 435–489.

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.

The references in the text should be cited in chronological order as Higgins (1950) or (Kingsolver 1978; Higgins & Riley 1980a, b), unless explicitly mentioned otherwise.

Illustrations. Tables and figures have to be numbered consecutively using Arabic numerals, e.g., Tab. 1; Tab. 2 or Fig. 1, Fig. 2, etc. All tables and figures must be mentioned in the text and should be referred to as, e.g., Fig. 1; Fig. 1a, b; Figs 1–3, Figs 1, 3; Tab. 1, etc. The legend should start as follows: 'Tab. 1. Title ...' or 'Fig. 1. Title ...' and should be self explanatory without reference to the text. Illustrations should be instructive and produced carefully. Line drawings, graphics, and photographs must be sharp, clear, of high contrast, and submitted in a way suitable for printing without requiring time-consuming reprocessing. Where several photographs are to form one plate, they should be mounted on plates by the authors only if they are of similar contrast. Otherwise, photographs should be submitted separately, so that they can be scanned individually according to contrast. Each figure should be identified on its back by the author's name and the figure number; the top should be indicated. Figures of morphological structures should bear reference scale bars. For digitised illustrations, line drawings have to be scanned at 600 dpi at least, half-tone (grey scale) illustrations at 400 dpi, and colour photographs at 300 dpi, all at 100% of the final printing size.

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For acceptable style and format please examine the most recent issues of the journal.

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