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**The morphology of the aedeagus as a basic feature for the
determination of the males of the genus *Eupithecia* CURTIS, 1825
(Lepidoptera, Geometridae)**

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Abstract

The genus *Eupithecia* CURTIS, 1825 was divided into five groups according to the morphology of the aedeagus (phallus), especially of the cornuti. The aedeagus of each species was photographed as a whole, and then, separately, the vesicae after extraction from aedeagus as well. The technique of extraction is described in detail. The shape of the cornuti of the individual groups was carefully observed and compared. The study covers the Central European and some Southern European species, totally 85 species, and was produced as an assisting device for the determination of males of the genus *Eupithecia*.

Key words: Lepidoptera, Geometridae, *Eupithecia*, European species, Taxonomy, Male genitalia, Aedeagus, Variability.

Zusammenfassung

Die Gattung *Eupithecia* CURTIS 1825 wird nach der Morphologie des Aedoeagus (Phallus), besonders der Cornuti, in fünf Gruppen eingeteilt. Der Aedoeagus jeder Art

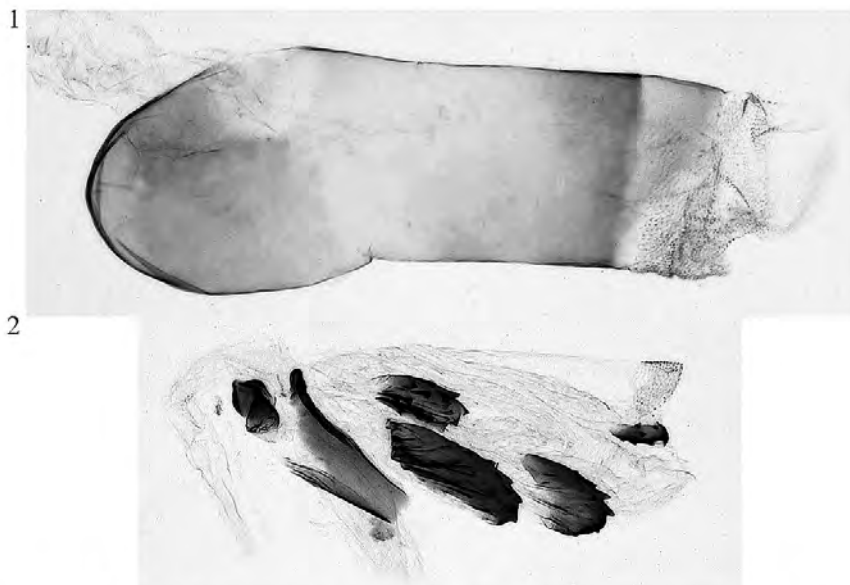
wurde photographiert, zunächst in seiner Gesamtheit, und dann die Vesicae nach ihrer Extraktion aus dem Aedeagus. Die Form der Cornuti bei den einzelnen Gruppen wurde sorgfältig ermittelt und verglichen. Die Arbeit umfasst die mitteleuropäischen und teilweise südeuropäischen Arten, insgesamt 85 Arten, und ist konzipiert als Hilfsmittel für die Determination der Männchen der Gattung *Eupithecia*.

Introduction

The most frequently used criterion for the determination of male specimens of the genus *Eupithecia* is the morphology of the aedeagus or the vesica. The variably shaped, membranous vesica contains pronounced sclerotized formations, the cornuti, of – according to species – different size and shape (WEIGT, 1987, 1988, 1990, 1991, 1993, MIRONOV, 2003, BOLTE, 1990). So far, the physiological function of the cornuti has not been defined (CORDERO, 2010). The terminology of the aedeagus is unstable, depending on the opinions of different authors studying this genitalia part in the course of the last one hundred years (EYER, 1924, FÄNGER & NAUMANN, 1998). For this contribution, however, the terminological problems are of no relevance. It is designed as determination device like our former communications (KUBÍN & PROCHÁZKA, 2012 –a, 2012 – b).

Materials and methods

85 species of the genus *Eupithecia* were used (Tab.1). The survey of localities and names of collectors of the used specimens are presented in a separate chapter. After preparation in hot solution of NaOH and intense washing in water, the aedeagi were mechanically separated from the genitalic bodies. The extraction of the vesicae was performed after the transfer of the aedeagi on electrophoresis strips (products of the firm Oxoid), saturated with water, the slipping of material on smooth glass being thus prevented. The aedeagi were seized with a micro forceps in the region of the caecum and the vesica extracted with a second forceps in caudal direction. This process was not easy to perform in some species. In most cases, the caudal part of aedeagus had to be violated moderately in order to make the extraction of the vesica easier. If the walls of the aedeagus were damaged, it was necessary to remove its remains from the vesica individually with a forceps (Figs. 1 and 2).



Figs. 1 - 2. **Both figures are *E. satyrata*.** 1. Aedeagus after extraction of vesica.
2. Vesica after extraction from aedeagus.

Before fixation with 70% alcohol (60'), aedeagi and vesicae were cleared with a clearing solution (15 – 30') (Otčenášek 1990); microscopically supervised. After a short transfer into absolute alcohol, the preparations were embedded in Euparal. The size of the aedeagus was measured with an ocular scale with the accurateness of 0,1 mm. The actual size of aedeagus is shown in the upper corner of the photographs of each aedeagus. The preparations were photographed in a light microscope (obj. 4x or 10x) using the digital camera CMOS 530 (3 MP).

The preparations of *E. pantellata*, *E. phoeniceata*, *E. ultimaria*, and *E. cauchiata* have been deposited in the collection of Senckenberg Naturhistorische Sammlungen of Dresden Museum für Tierkunde in Dresden, Germany, of *E. pulchelata* and *E. pygmeata* in the National Museum, Prague, Czech Republic, the rest of the preparations in the private collection of the first author.

Tab. 1. List of used species in alphabetical order

Species / Groups	Groups	Aedeagus Fig	Vesica Fig
<i>E. abbreviata</i> STEPHENS, 1831	2	12	13
<i>E. abietaria</i> (GOEZE, 1781)	2	14	15
<i>E. absinthiata</i> (CLERCK, 1759)	3	84	85
<i>E. actaeata</i> WALDERDORFF, 1869	2	16	17

Species / Groups	Groups	Aedeagus Fig	Vesica Fig
<i>E. alliaria</i> STAUDINGER, 1870	5	118	119
<i>E. analoga</i> DJAKONOV, 1926	2	18	19
<i>E. assimilata</i> DOUBLEDAY, 1856	3	86	87
<i>E. breviculata</i> (DONZEL, 1837)	5	120	121
<i>E. cauchiata</i> (DUPONCHEL, 1831)	3	88	89
<i>E. centaureata</i> (DENIS & SCHIFFERMÜLLER, 1775)	2	20	21
<i>E. cocciferata</i> MILLIÈRE, 1864	2	22	23
<i>E. cretacea</i> (PACKARD, 1874)	5	122	123
<i>E. denotata</i> (HÜBNER, 1813)	2	24	25
<i>E. denticulata</i> (TREITSCHKE, 1828)	5	124	125
<i>E. dissertata</i> (PÜNGELER, 1905)	2	26	27
<i>E. distinctaria</i> HERRICH-SCHÄFFER, 1848	4	112	113
<i>E. dodoneata</i> GUENÉE, 1857	2	28	29
<i>E. egenaria</i> HERRICH-SCHÄFFER, 1848	2	30	31
<i>E. ericeata</i> (RAMBUR, 1833)	2	32	33
<i>E. exigua</i> (HÜBNER, 1813)	5	126	127
<i>E. expallidata</i> DOUBLEDAY, 1856	3	90	91
<i>E. extraversaria</i> HERRICH-SCHÄFFER, 1852	5	128	129
<i>E. extremata</i> (FABRICIUS, 1787)	5	130	131
<i>E. gelidata</i> MÖSCHLER, 1860	2	34	35
<i>E. gemellata</i> HERRICH-SCHÄFFER, 1861	5	132	133
<i>E. graphata</i> (TREITSCHKE, 1828)	5	134	135
<i>E. gueneata</i> MILLIÈRE, 1862	5	136	137
<i>E. haworthiata</i> DOUBLEDAY, 1856	4	114	115
<i>E. icterata</i> (VILLERS, 1789)	5	138	139
<i>E. immundata</i> (LIENIG & ZELLER, 1846)	3	92	93
<i>E. impurata</i> (HÜBNER, 1813)	3	94	95
<i>E. indigata</i> (HÜBNER, 1813)	3	96	97
<i>E. innotata</i> (HUFNAGEL, 1767)	5	140	141
<i>E. insigniata</i> (HÜBNER, 1790)	5	142	143
<i>E. intricata</i> (ZETTERSTEDT, 1839)	3	98	99
<i>E. inturbata</i> (HÜBNER, 1817)	4	116	117
<i>E. irriguata</i> (HÜBNER, 1813)	3	100	101
<i>E. lanceata</i> (HÜBNER, 1825)	2	36	37

Species / Groups	Groups	Aedeagus Fig	Vesica Fig
<i>E. laquaearia</i> HERRICH-SCHÄFFER, 1848	1	8	0
<i>E. lariciata</i> (FREYER, 1841)	2	38	39
<i>E. linariata</i> (DENIS & SCHIFFERMÜLLER, 1775)	1	9	0
<i>E. millefoliata</i> RÖSSLER, 1866	5	144	145
<i>E. nanata</i> (HÜBNER, 1813)	5	146	147
<i>E. ochridata</i> SCHÜTZE & PINKER, 1968	5	148	149
<i>E. orana</i> (DIETZE, 1910)	2	40	41
<i>E. orphnata</i> W. PETERSEN, 1909	2	42	43
<i>E. oxycedrata</i> (RAMBUR, 1833)	2	44	45
<i>E. pantellata</i> MILLIÈRE, 1875	2	46	47
<i>E. pauxillaria</i> BOISDUVAL, 1840	2	48	49
<i>E. phoeniceata</i> (RAMBUR, 1834)	2	50	51
<i>E. pimpinellata</i> (HÜBNER, 1813)	2	52	53
<i>E. plumbeolata</i> (HAWORTH, 1809)	2	54	55
<i>E. pulchellata</i> STEPHENS, 1831	1	10	0
<i>E. pusillata</i> (DENIS & SCHIFFERMÜLLER, 1775)	2	56	57
<i>E. pygmaeata</i> (HÜBNER, 1799)	2	58	59
<i>E. pyreneata</i> MABILLE, 1871	1	11	0
<i>E. quercetica</i> PROUT, 1938	2	60	61
<i>E. reisserata</i> PINCER, 1976	5	150	151
<i>E. santolinata</i> MABILLE, 1871	5	152	153
<i>E. satyrata</i> (HÜBNER, 1813)	3	102	103
<i>E. scalptata</i> CHRISTOPH, 1885	5	154	155
<i>E. schiefereri</i> BOHATSCH, 1893	2	62	63
<i>E. scopariata</i> (RAMBUR, 1833)	2	64	65
<i>E. selinata</i> HERRICH-SCHÄFFER, 1861	2	66	67
<i>E. semigraphata</i> BRUAND, 1850	5	156	157
<i>E. silenata</i> ASSMANN, 1848	5	158	159
<i>E. silenicolata</i> MABILLE, 1867	2	68	69
<i>E. simplicciata</i> (HAWORTH, 1809)	5	160	161
<i>E. sinuosaria</i> (EVERSMANN, 1848)	2	70	71
<i>E. spissilineata</i> (METZNER, 1846)	5	162	163
<i>E. subfuscata</i> (HAWORTH, 1809)	2	72	73
<i>E. subumbrata</i> (DENIS & SCHIFFERMÜLLER, 1775)	3	104	105

Species / Groups	Groups	Aedeagus Fig	Vesica Fig
<i>E. succenturiata</i> (LINNAEUS, 1758)	3	106	107
<i>E. tantillaria</i> BOISDUVAL, 1840	2	74	75
<i>E. tenuiata</i> (HÜBNER, 1813)	5	164	165
<i>E. tripunctaria</i> HERRICH-SCHÄFFER, 1852	2	76	77
<i>E. trisignaria</i> HERRICH-SCHÄFFER, 1848	5	166	167
<i>E. ultimaria</i> BOISDUVAL, 1840	5	168	169
<i>E. undata</i> (FREYER, 1840)	2	78	79
<i>E. unedonata</i> (MABILLE, 1868)	5	170	171
<i>E. valerianata</i> (HÜBNER, 1813)	3	108	109
<i>E. venosata</i> (FABRICIUS, 1787)	2	80	81
<i>E. veratraria</i> HERRICH-SCHÄFFER, 1850	5	172	173
<i>E. virgaureata</i> DOUBLEDAY, 1861	2	82	83
<i>E. vulgata</i> (HAWORTH, 1809)	3	110	111

Results

According to the shape of cornuti, all 85 species of the genus *Eupithecia* were subdivided into 5 characteristic groups (Tab. 3). The percentual occurrence of species is presented in Tab. 2.

Tab. 2: Percentual occurrence of species in individual groups

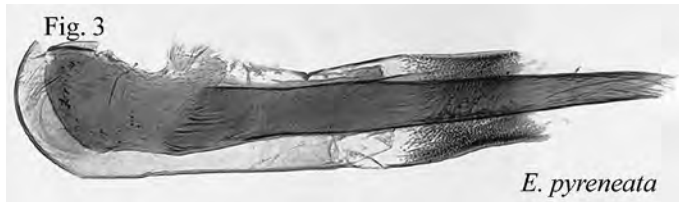
Group	1	2	3	4	5
Percentage of occurrence	4,7	42,4	16,5	3,5	32,9

The extraction of the vesicae made a more precise consideration of the shape of cornuti possible. This operation was most important in species with a low possibility of distinction in the morphology of the aedeagus as a whole. The use of a larger magnification (obj. 10x) proved effective.

The study of the variability of the distribution of cornuti showed a relative constancy of significant marks, that is why it did not influence the definitive determination. See *E. subumbrata* showing a negligible variability regardless of the position of the aedeagus in the preparation (Figs. 174 – 180). In the course of the examination of the species *E. gemellata*, *E. satyrata* and some others, the position of the aedeagus proved notably relevant (Figs. 181 – 192). The actual size of the aedeagus varies between 1,9 and 2,3 mm.

Tab. 3: Survey of the 5 groups of the genus *Eupithecia*

Group 1. Aedeagus without cornuti.



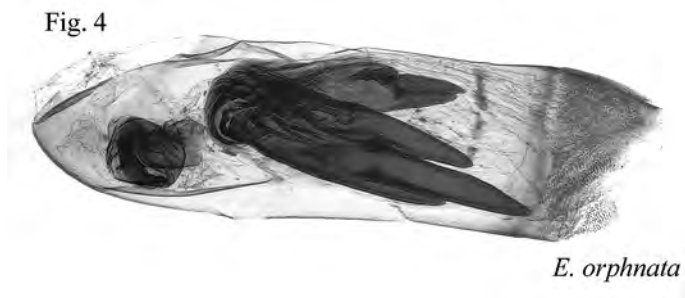
E. laquaearia HERRICH-SCHÄFFER, 1848

E. linariata (DENIS & SCHIFFERMÜLLER, 1775)

E. pulchellata STEPHENS, 1831

E. pyreneata MABILLE, 1871

Group 2. Cornuti are elongated with sharp and simple caudal ends.



E. abbreviata STEPHENS, 1831

E. abietaria (GOEZE, 1781)

E. actaeata WALDERDORFF, 1869

E. analoga DJAKONOV, 1926

E. centaureata (DENIS & SCHIFFERMÜLLER, 1775)

E. cocciferata MILLIÈRE, 1864

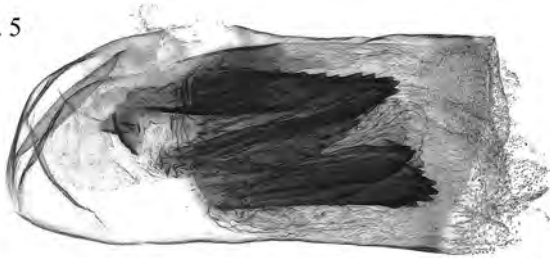
E. denotata (HÜBNER, 1813)

E. dissertata (PÜNGELER, 1905)

- E. dodoneata* GUENÉE, 1857
E. egenaria HERRICH-SCHÄFFER, 1848
E. ericeata (RAMBUR, 1833)
E. gelidata MÖSCHLER, 1860
E. lanceta (HÜBNER, 1825)
E. lariciata (FREYER, 1841)
E. orana (DIETZE, 1910)
E. orphnata W. PETERSEN, 1909
E. oxycedrata (RAMBUR, 1833)
E. pantellata MILLIÈRE, 1875
E. pauxillaria BOISDUVAL, 1840
E. phoeniceata (RAMBUR, 1834)
E. pimpinellata (HÜBNER, 1813)
E. plumbeolata (HAWORTH, 1809)
E. pusillata (DENIS & SCHIFFERMÜLLER, 1775)
E. pygmaeata (HÜBNER, 1799)
E. quercetica PROUT, 1938
E. schiefereri BOHATSCH, 1893
E. scopariata (RAMBUR, 1833)
E. selinata HERRICH-SCHÄFFER, 1861
E. silenicolata MABILLE, 1867
E. sinuosaria (EVERSMANN, 1848)
E. subfuscata (HAWORTH, 1809)
E. tantillaria BOISDUVAL, 1840
E. tripunctaria HERRICH-SCHÄFFER, 1852
E. undata (FREYER, 1840)
E. venosata (FABRICIUS, 1787)
E. virgaureata DOUBLEDAY, 1861

Group 3. Cornuti are dentate on the caudal margin.

Fig. 5

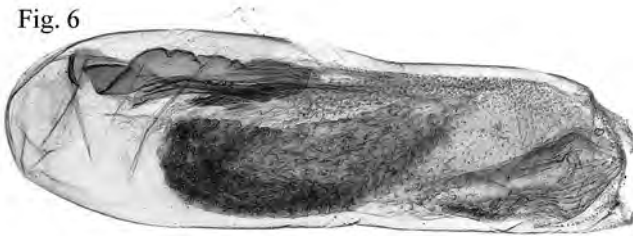


E. immundata

- E. absinthiata* (CLERCK, 1759)
- E. assimilata* DOUBLEDAY, 1856
- E. cauchiata* (DUPONCHEL, 1831)
- E. expallidata* DOUBLEDAY, 1856
- E. immundata* (LIENIG & ZELLER, 1846)
- E. impurata*.(HÜBNER, 1813)
- E. indigata* (HÜBNER, 1813)
- E. intricata* (ZETTERSTEDT, 1839)
- E. irriguata* (HÜBNER, 1813)
- E. satyrata* (HÜBNER, 1813)
- E. subumbrata* (DENIS & SCHIFFERMÜLLER, 1775)
- E. succenturiata* (LINNAEUS, 1758)
- E. valerianata* (HÜBNER, 1813)
- E. vulgata* (HAWORTH, 1809)

Group 4. Aedeagus without visible cornuti. Vesica contains only more or less sclerotised spines of different shape.

Fig. 6



E. distinctaria

E. distinctaria HERRICH-SCHÄFFER, 1848

E. haworthiata DOUBLEDAY, 1856

E. inturbata (HÜBNER, 1817)

Group 5. Aedeagus contains a mixture of all types of cornuti.

Fig. 7



E. millefoliata

E. alliaria STAUDINGER, 1870

E. breviculata (DONZEL, 1837)

E. cretacea (PACKARD, 1874)

E. denticulata (TREITSCHKE, 1828)

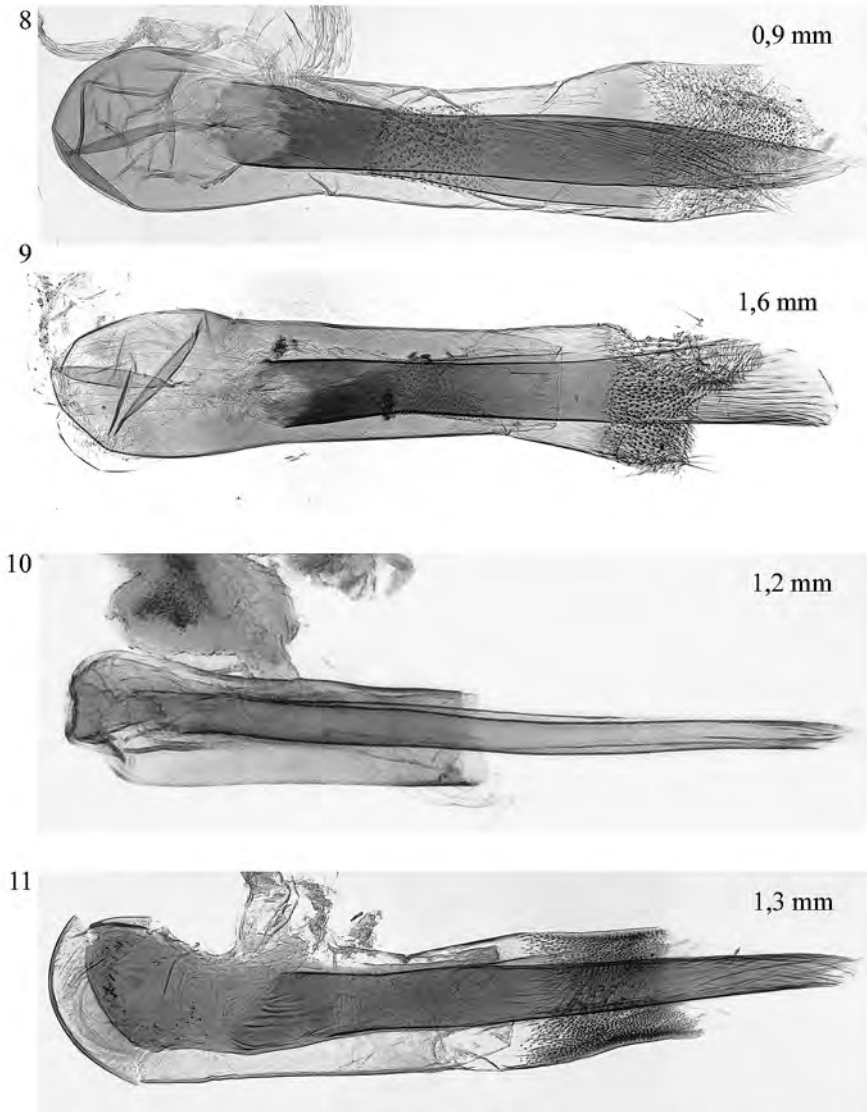
E. exigua (HÜBNER, 1813)

- E. extraversaria* HERRICH-SCHÄFFER, 1852
E. extremata (FABRICIUS, 1787)
E. gemellata HERRICH-SCHÄFFER, 1861
E. graphata (TREITSCHKE, 1828)
E. gueneata MILLIÈRE, 1862
E. icterata (VILLERS, 1789)
E. innotata (HUFNAGEL, 1767)
E. insigniata (HÜBNER, 1790)
E. millefoliata RÖSSLER, 1866
E. nanata (HÜBNER, 1813)
E. ochridata SCHÜTZE & PINKER, 1968
E. reisserata PINCEK, 1976
E. santolinata MABILLE, 1871
E. scalptata CHRISTOPH, 1885
E. semigraphata BRUAND, 1850
E. silenata ASSMANN, 1848
E. simpliciata (HAWORTH, 1809)
E. spissilineata (METZNER, 1846)
E. tenuiata (HÜBNER, 1813)
E. trisignaria HERRICH-SCHÄFFER, 1848
E. ultimaria BOISDUVAL, 1840
E. unedonata (MABILLE, 1868)
E. veratraria HERRICH-SCHÄFFER, 1850

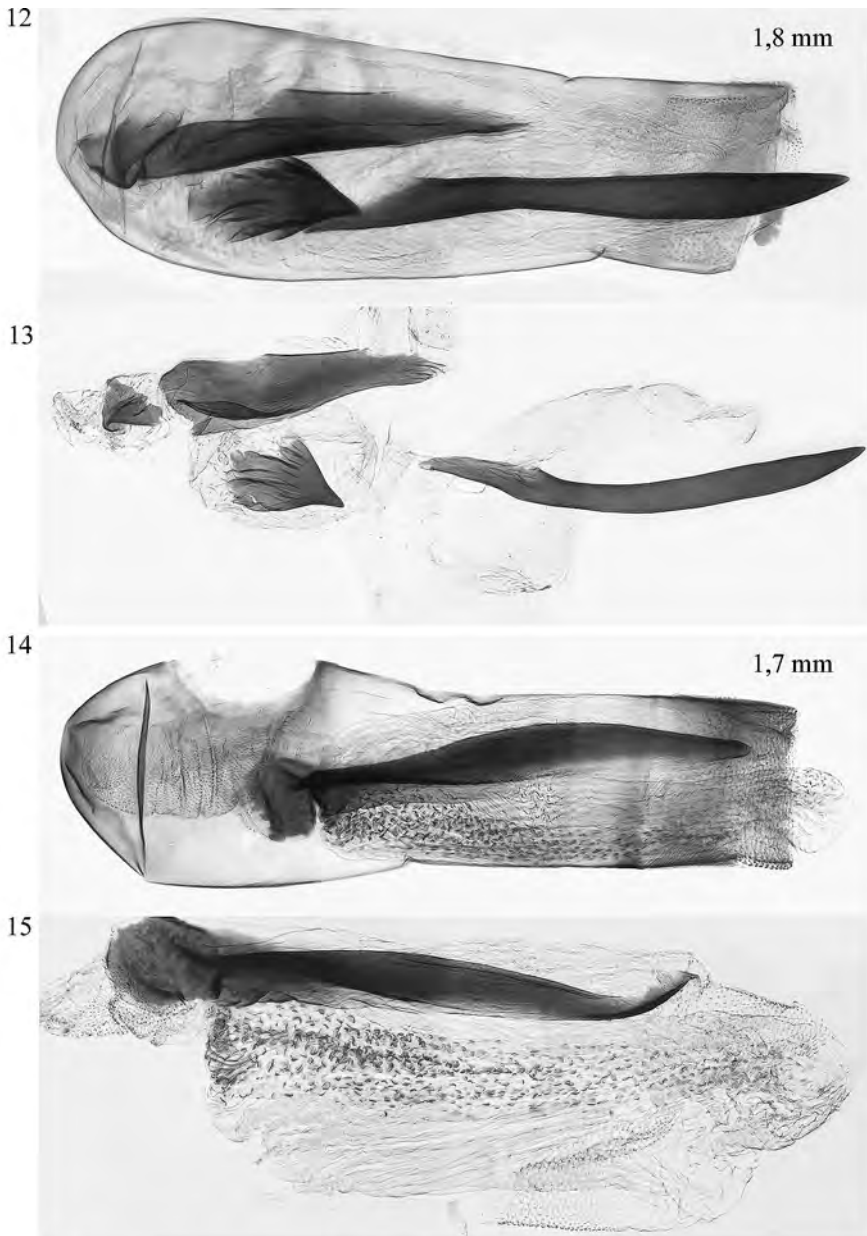
List of localities and collectors of the treated species

E. abbreviata, Bohemia, Družec, Kubín V.; *E. abietaria*, Bohemia, Šumava - Nová Pec, Kubín V.; *E. absinthiata*, Bohemia, Družec, Kubín V.; *E. actaeata*, Bohemia, Červená n. Vltavou, Novák I.; *E. alliaria*, Slovakia, Slov. Kras - Vidová, Liška J.; *E. analoga*, Bohemia, Šumava - Jelení Vrchy, Kubín V.; *E. assimilata*, Bohemia, Družec, Kubín V.; *E. breviculata*, Greece, Parga, Procházka J.; *E. cauchiata*, France, Novák I.; *E. centaureata*, Bohemia, Družec, Kubín V.; *E. cocciferata*, France, Gourdon, Skyva J.; *E. cretacea*, Italy, Alpes Maritimes, Dvořák M.; *E. denotata*, Bohemia, Družec, Kubín V.; *E. denticulata*, Greece, Smolikas, Skyva J.; *E. dissertata*, Slovakia, Velká Fatra, Liška J.; *E. distinctaria*, Bohemia, Krkonoše - Černý důl, Skyva J.; *E. dodoneata*, Bohemia, Družec, Kubín V.; *E. egenaria*, Bohemia, Písek, Novák I.; *E. ericeata*, Slovakia, Medovarce, Skyva J.; *E. exigua*, Bohemia, Družec, Kubín V.; *E. expallidata*, Bohemia, Krkonoše - Lánov, Skyva J.; *E. extraversaria*, Bohemia, Družec, Kubín V.; *E. extremata*, Greece, Pelopones, Kubín V.; *E. gelidata*, Bohemia, Červené Blato, Jaroš J.; *E.*

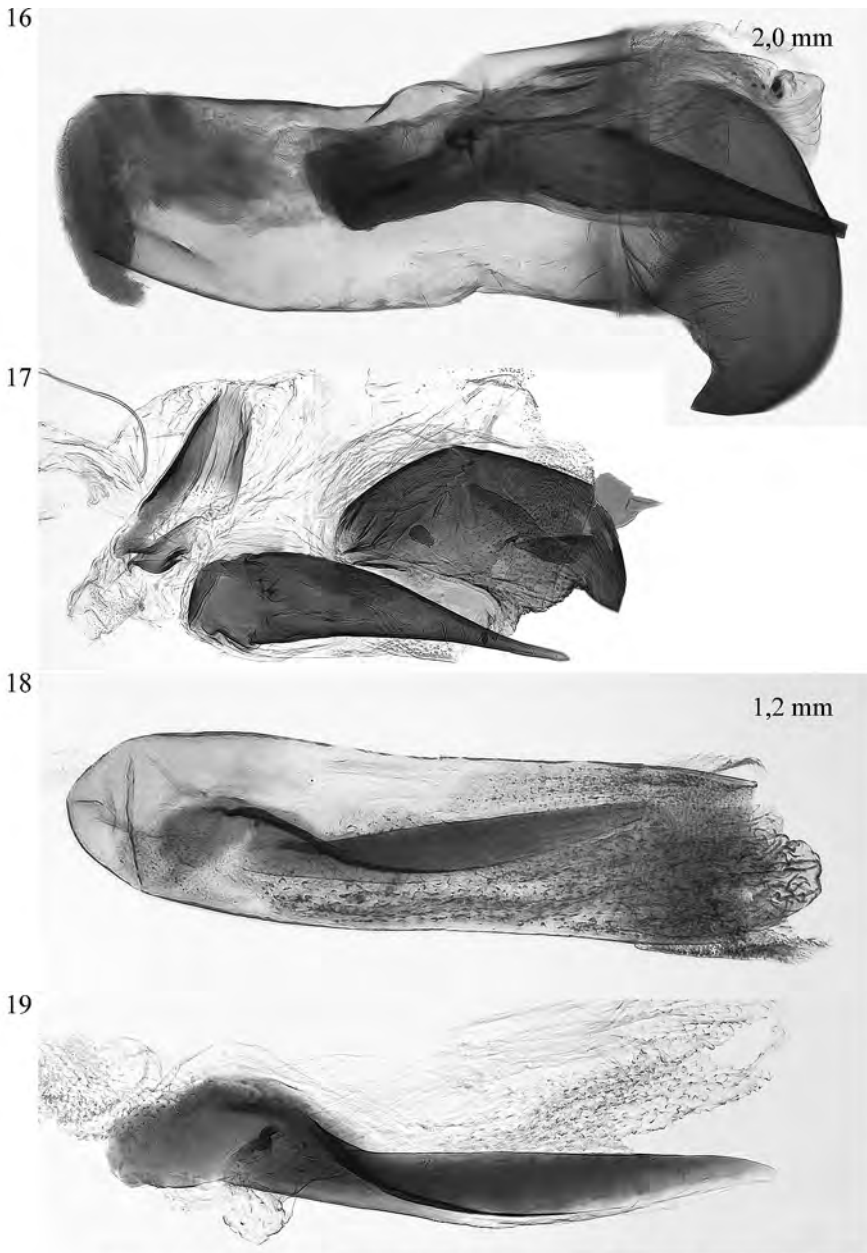
gemellata, Spain, Palomera, Procházka J.; *E. graphata*, Hungary, Csákberény, Skyva J.; *E. gueneata*, Hungary, Várpalota, Vodrlind B.; *E. haworthiata*, Bohemia, Družec, Kubín V.; *E. icterata*, Bohemia, Družec, Kubín V.; *E. immundata*, Bohemia, Řevničov, Procházka J.; *E. impurata*, Slovenia, Julské Alpy - Vršič, Skyva J.; *E. indigata*, Bohemia, Družec, Kubín V.; *E. innotata*, Bohemia, Družec, Kubín V.; *E. insigniata*, Bohemia, Družec, Kubín V.; *E. intricata*, Bohemia, Družec, Kubín V.; *E. inturbata*, Bohemia, Teptín, Číla P.; *E. irriguata*, Greece, Pelopones, Skyva J.; *E. lanceata*, Bohemia, Družec, Kubín V.; *E. laquaearia*, Spain, Ejulve, Procházka J.; *E. lariciata*, Bohemia, Družec, Kubín V.; *E. liniariata*, Bohemia, Družec, Kubín V.; *E. millefoliata*, Bohemia, Družec, Kubín V.; *E. nanata*, Bohemia, Červené Blato, Jaroš J.; *E. ochridata*, Bohemia, Praha, Novák I.; *E. orana*, Spain, Andalusia- Almeria, Dvořák M.; *E. orphnata*, Moravia, Podyjí - Šobes, Marek J.; *E. oxycedrata*, Greece, Pelopones, Skyva J.; *E. pantellata*, Spain, Aliaga, Procházka J.; *E. pauxillaria*, Italy, Ligurské Alpy, Skyva J.; *E. phoeniceata*, Greece, Pelopones, Skyva J.; *E. pimpinellata*, Bohemia, Družec, Kubín V.; *E. plumbeolata*, Bohemia, Družec, Kubín V.; *E. pulchellata*, Bohemia, Jizerské hory - Bukovec, NM Praha; *E. pusillata*, Bohemia, Družec, Kubín V.; *E. pygmaeata*, Moravia, Lednice, NM Praha; *E. pyreneata*, Bohemia, Brná n. Labem, Novák I.; *E. quercetica*, Greece, Pelopones, Skyva J.; *E. reisserata*, Greece, Pelopones, Skyva J.; *E. santolinata*, Spain, Šumpich J.; *E. satyrata*, Bohemia, Družec, Kubín V.; *E. scalptata*, Greece, Diakofto, Procházka J.; *E. scopariata*, France, Cogolin, Petrů M.; *E. selinata*, Bohemia, Krkonoše - Dvoračky, Novák I.; *E. semigraphata*, Croatia, Murter, Kubín V.; *E. schiefereri*, Greece, Pelopones, Skyva J.; *E. silenata*, Bohemia, Lány, Kubín V.; *E. silenicolata*, Greece, Leptokaria, Skyva J.; *E. simpliciata*, Bohemia, Družec, Kubín V.; *E. sinuosaria*, Bohemia, Družec, Kubín V.; *E. spissilineata*, Greece, Pelopones, Skyva J.; *E. subfuscata*, Bohemia, Družec, Kubín V. *E. subumbrata*, Bohemia, Šumava - Jelení Vrchy, Kubín V.; *E. succenturiata*, Bohemia, Družec, Kubín V.; *E. tantillaria*, Bohemia, Družec, Kubín V.; *E. tenuiata*, Bohemia, Družec, Kubín V.; *E. tripunctaria*, Bohemia, Družec, Kubín V.; *E. trisignaria*, Bohemia, Družec, Kubín V.; *E. ultimaria*, Italy, Portogruaro - Brussa, Skyva J.; *E. undata*, Italy, Ortler Gruppe - Passo di Stelvio, Skyva J.; *E. unedonata*, Spain, Andalusia- Almeria, Dvořák M.; *E. valerianata*, Slovakia, NM Praha *E. venosata*, Bohemia, Šumava - Jelení Vrchy, Kubín V. *E. veratraria*, Bohemia, Novohradské Hory, Jaroš J.; *E. virgaureata*, Bohemia, Družec, Kubín V.; *E. vulgata*, Bohemia, Družec, Kubín V.



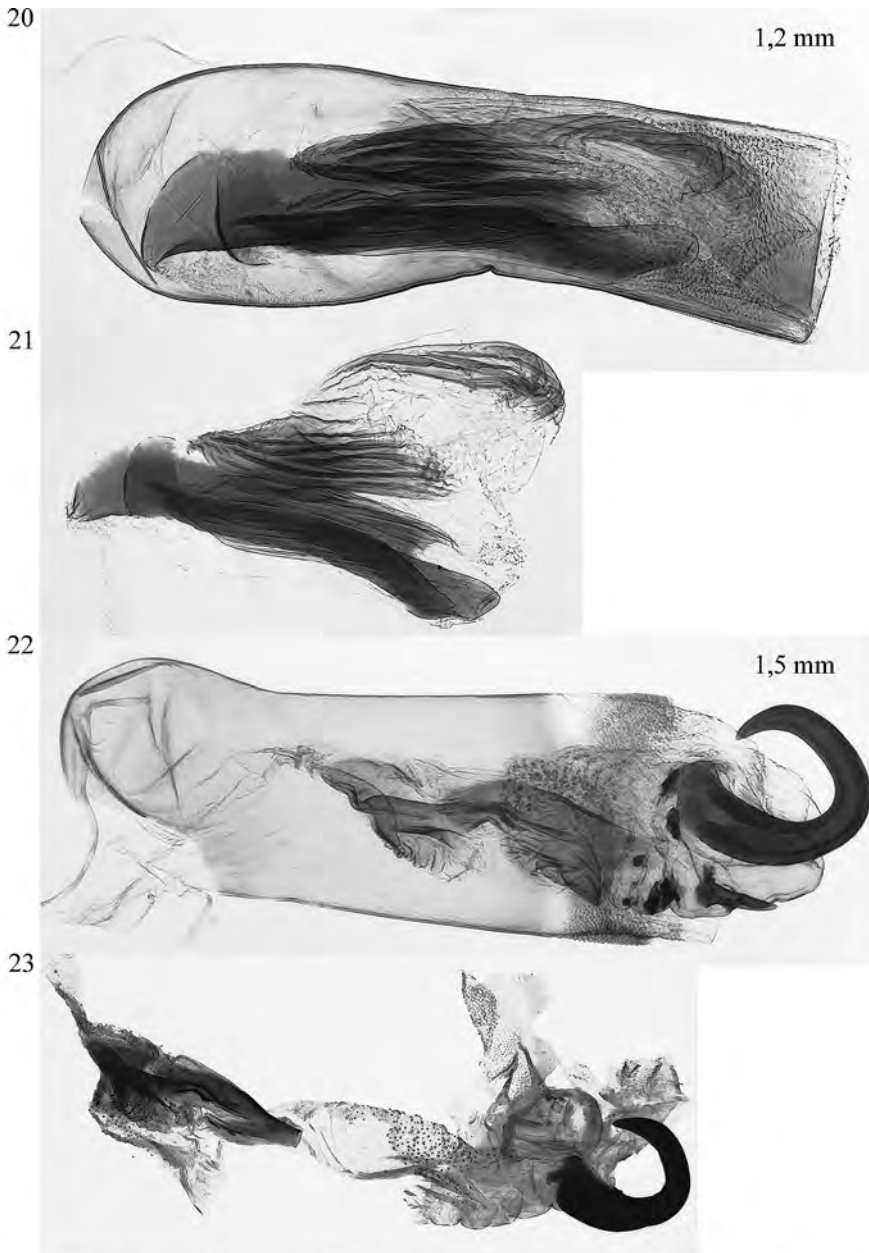
Figs. 8-11. **Group 1.** 8. *E. laquaearia*. 9. *E. linariata*. 10. *E. pulchelata*.
11. *E. pyreneata*.



Figs. 12 - 15. **Group 2.** 12 - 13. *E. abbreviata*. 14 - 15. *E. abietaria*.



Figs. 16 - 19. **Group 2.** 16 - 17. *E. actaeata*. 18 - 19. *E. analoga*.

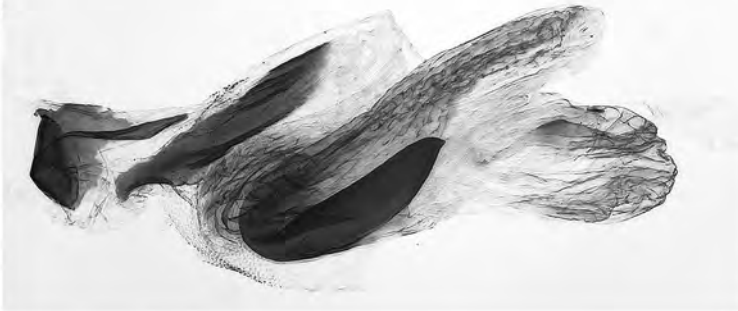


Figs. 20 - 23. **Group 2.** 20 - 21. *E. centaureata*. 22 - 23. *E. cocciferata*.

24



25



26

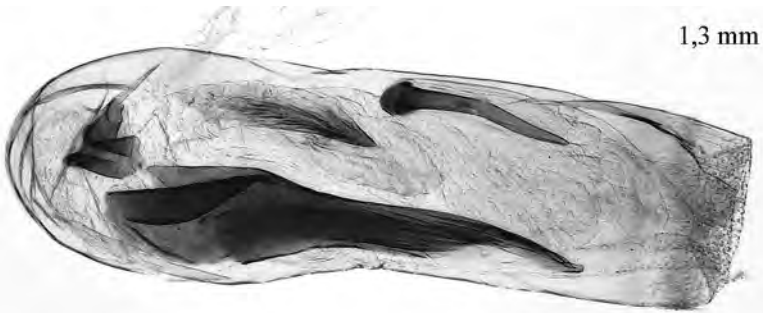


27



Figs. 24 - 27. Group 2. 24 - 25. *E. denotata*. 26 - 27. *E. dissertata*.

28

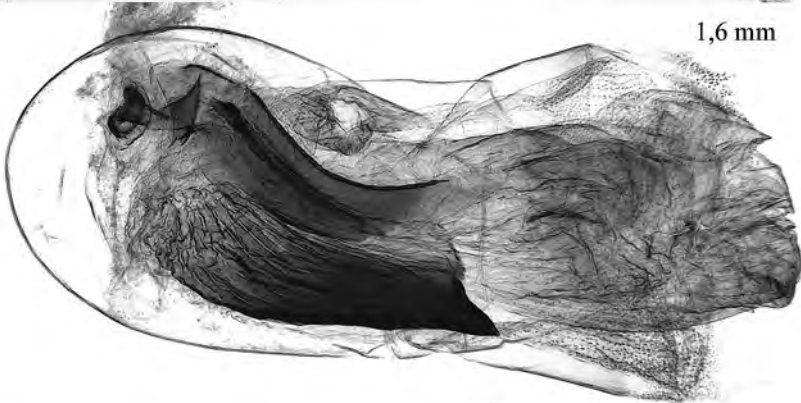


1,3 mm

29



30



1,6 mm

31



Figs. 28 - 31. **Group 2.** 28 - 29. *E. dodoneata*. 30 - 31. *E. egenaria*.

32



33



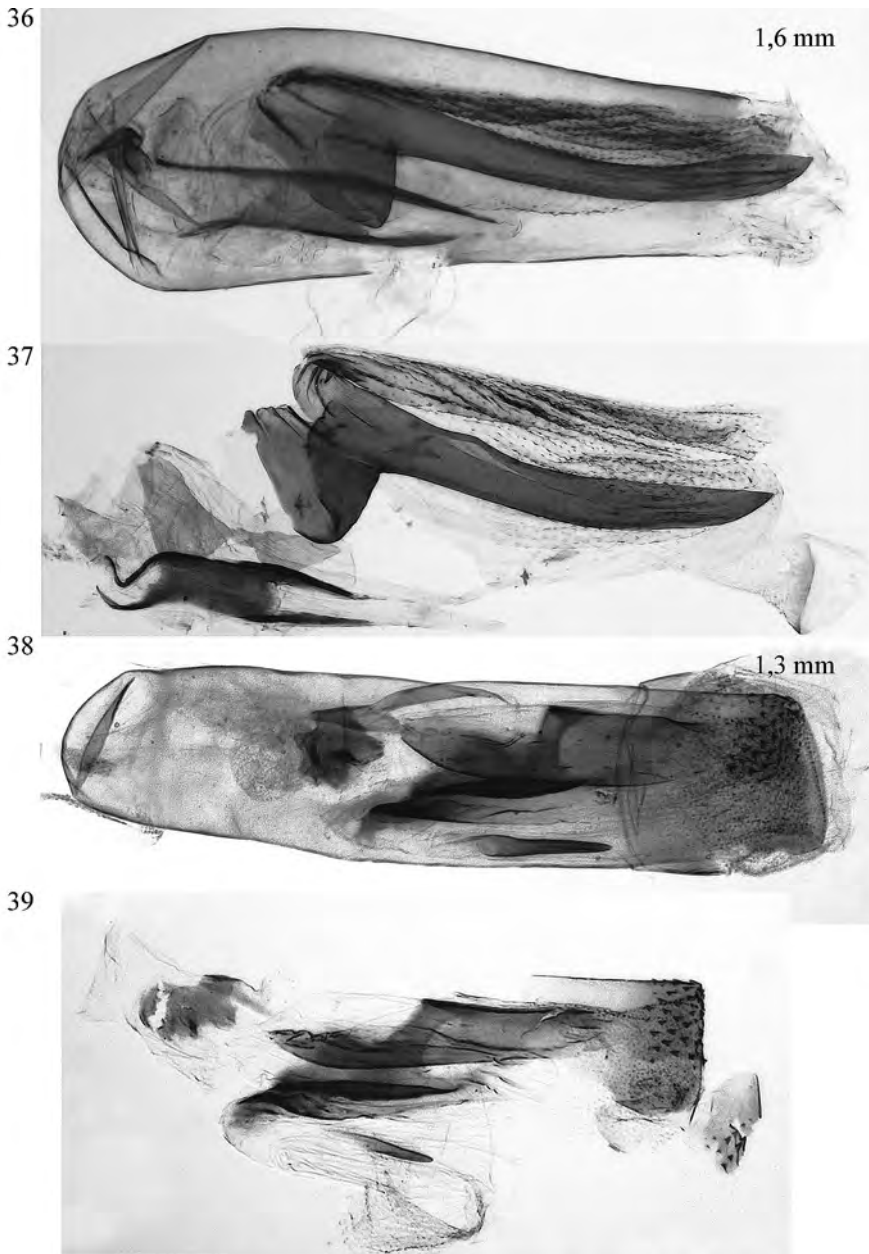
34



35



Figs. 32 - 35. **Group 2.** 32 - 33. *E. ericeata*. 34 - 35. *E. gelidata*.



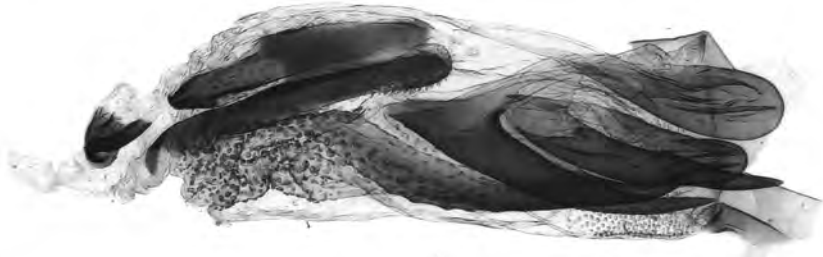
Figs. 36 - 39. Group 2. 36 - 37. *E. lanceata*. 38 - 39. *E. lariciata*.

40

1,4 mm



41



42

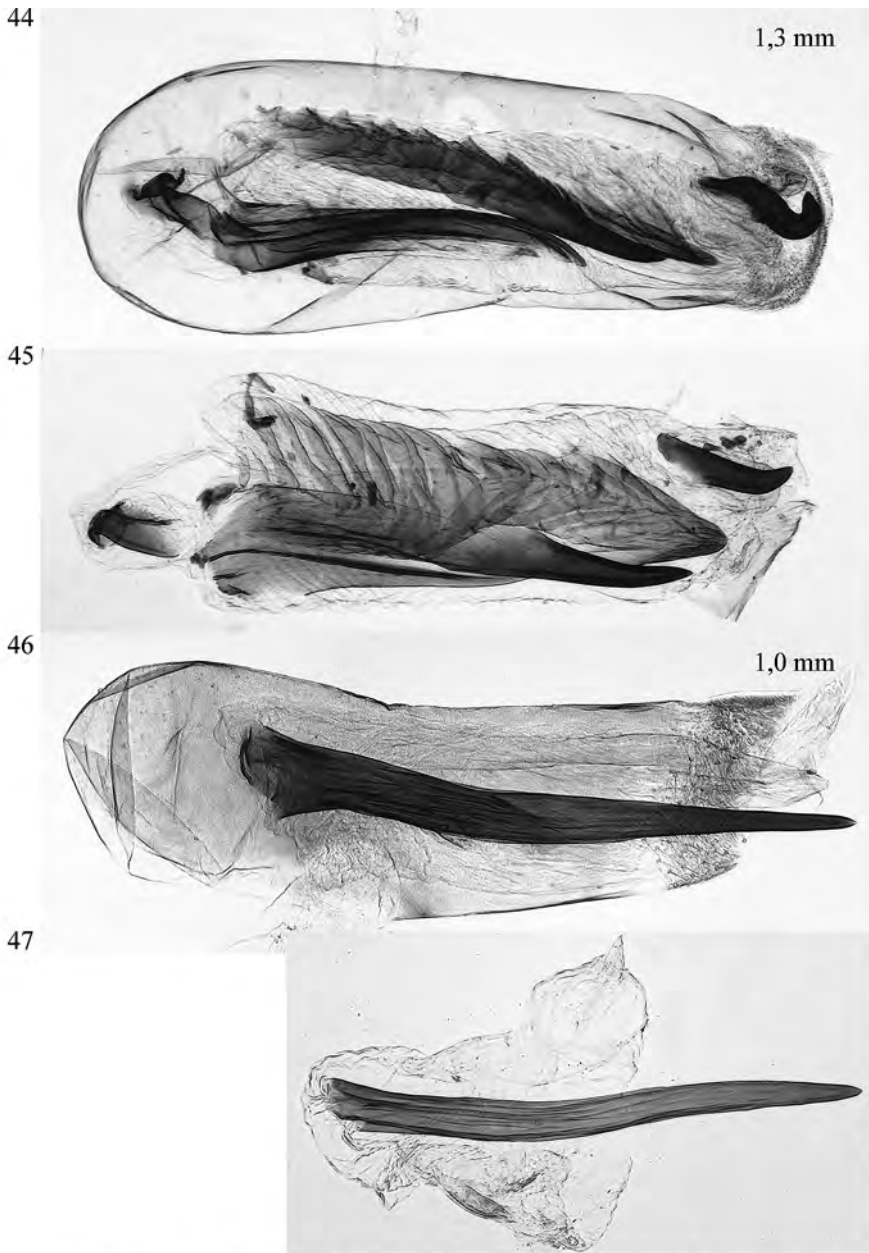
1,6 mm



43

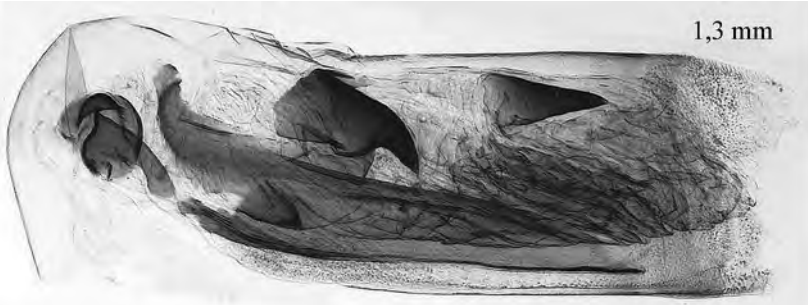


Figs. 40 - 43. Group 2. 40 - 41. *E. orana*. 42 - 43. *E. orphnata*.



Figs. 44 - 47. **Group 2.** 44 - 45. *E. oxycedrata*. 46 - 47. *E. pantellata*.

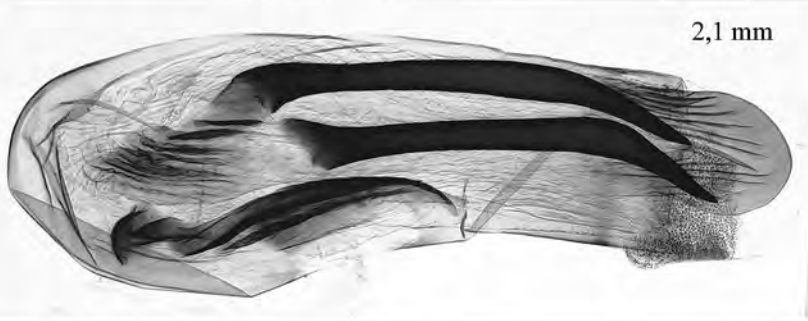
48



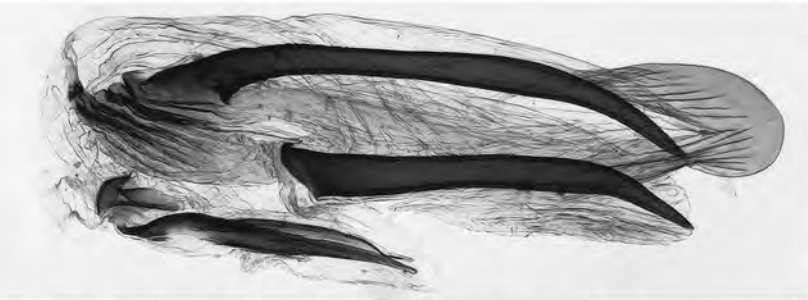
49



50

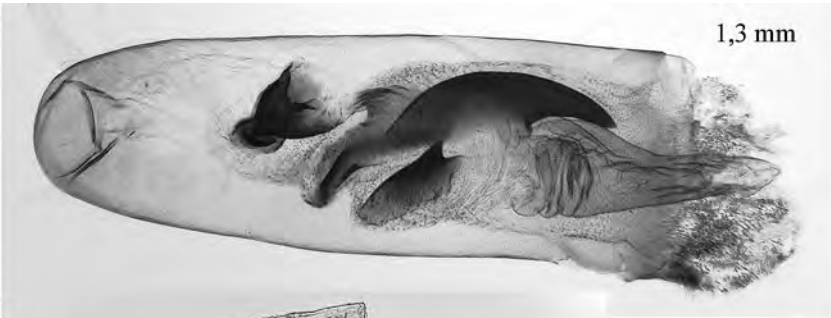


51

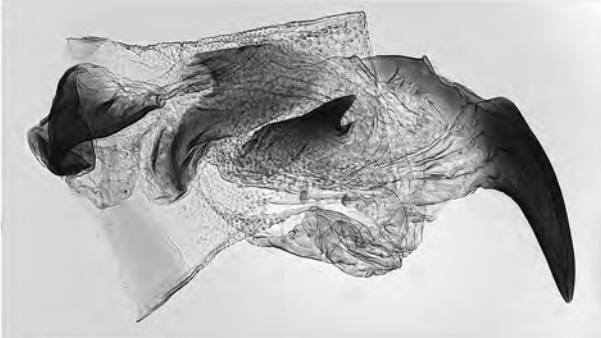


Figs. 48 - 51. Group 2. 48 - 49. *E. pauxillaria*. 50 - 51. *E. phoeniceata*.

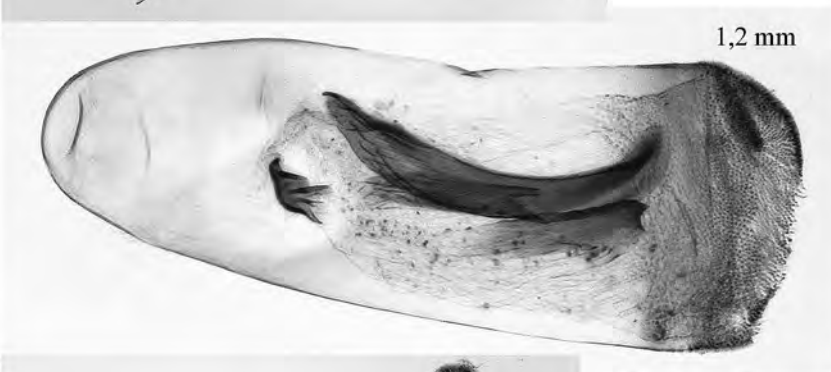
52



53



54

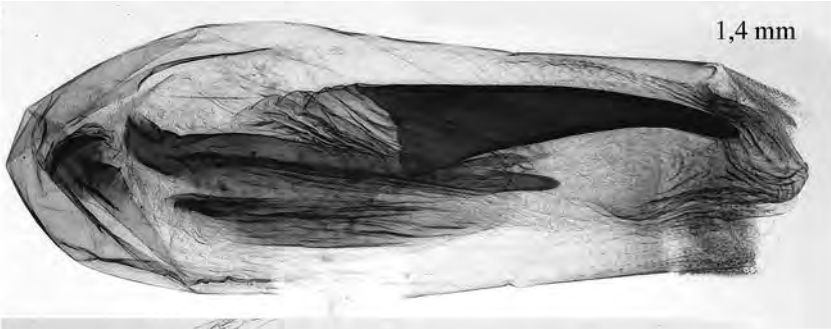


55



Figs. 52 - 55. **Group 2.** 52 - 53. *E. pimpinellata*. 54 - 55. *E. plumbeolata*.

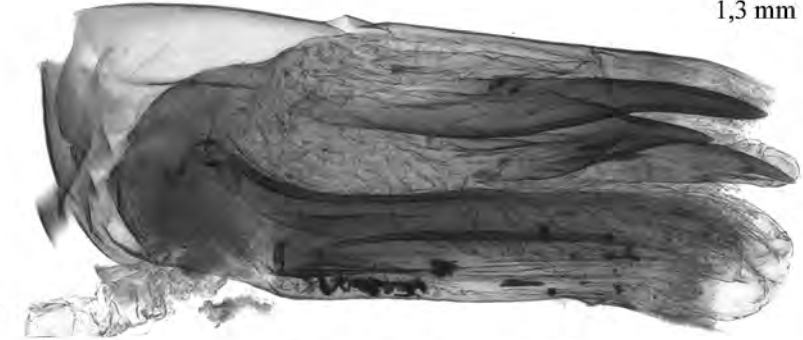
56



57



58



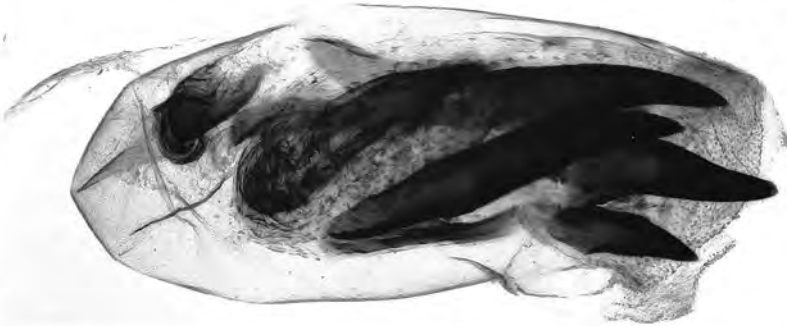
59



Figs. 56 - 59. Group 2. 56 - 57. *E. pusillata*. 58 - 59. *E. pygmaeata*.

60

1,2 mm



61

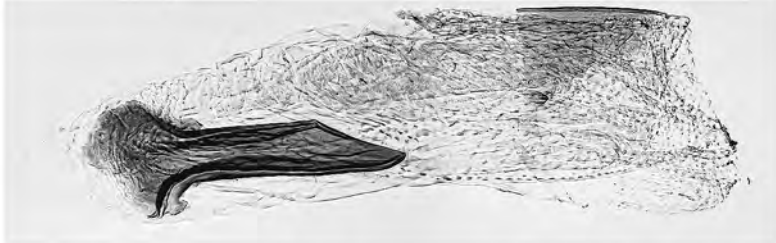


62

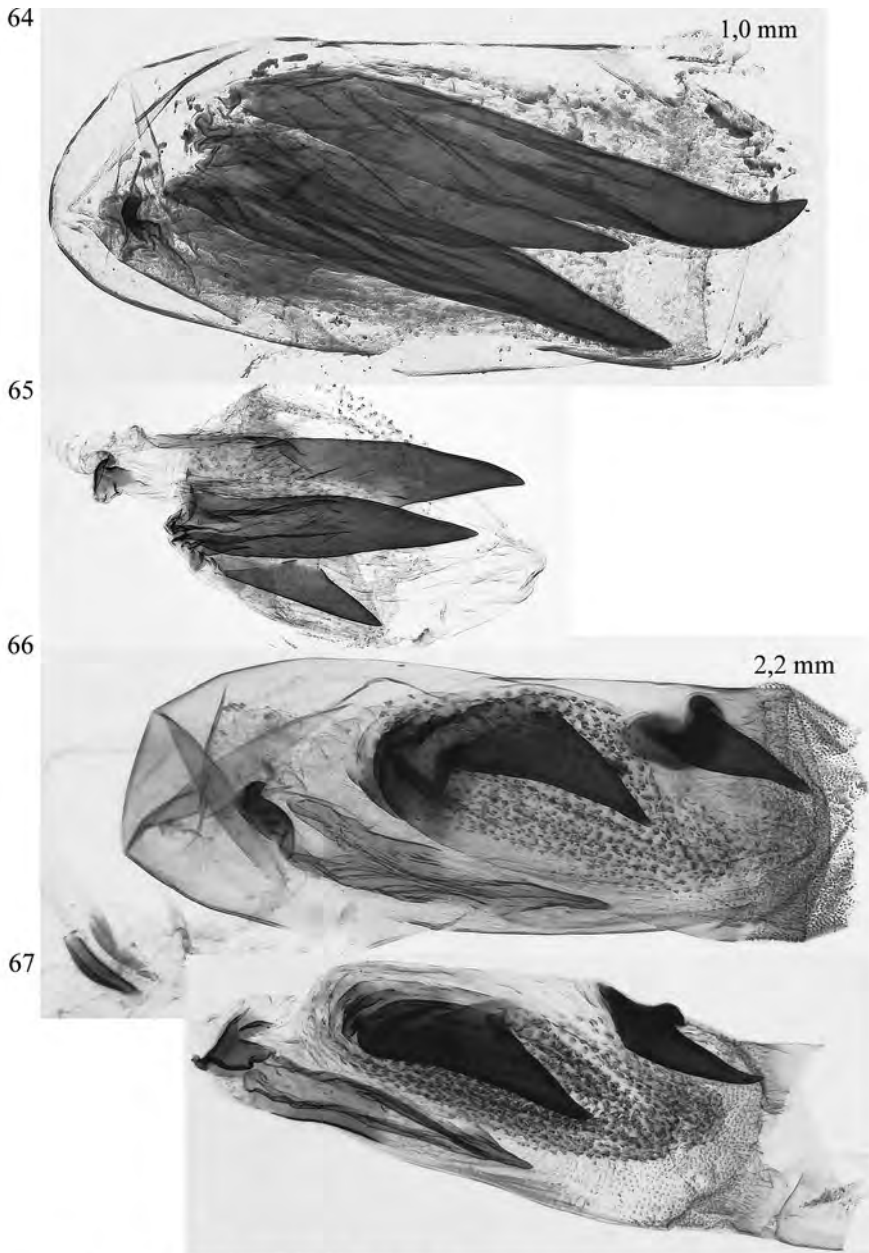


1,1 mm

63



Figs. 60 - 63. Group 2. 60 - 61. *E. quercetica*. 62 - 63. *E. schiefereri*.



Figs. 64 - 67. Group 2. 64 - 65. *E. scopariata*. 66 - 67. *E. selinata*.

68

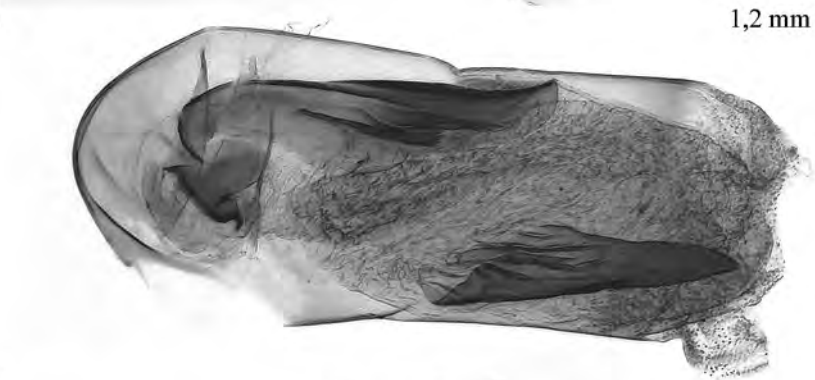


1,2 mm

69



70



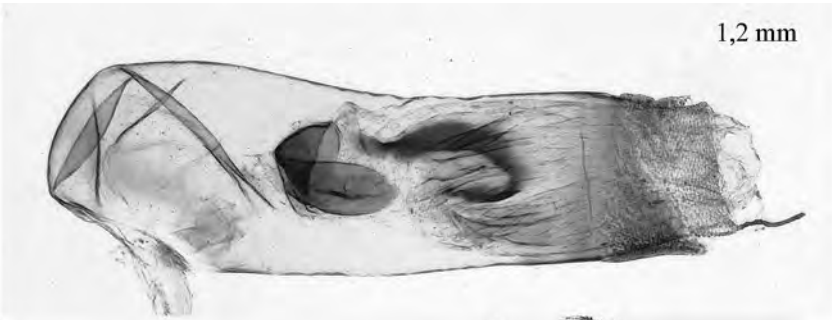
1,2 mm

71



Figs. 68 - 71. **Group 2.** 68 - 69. *E. silenicolata*. 70 - 71. *E. sinuosaria*.

72



73



74



75



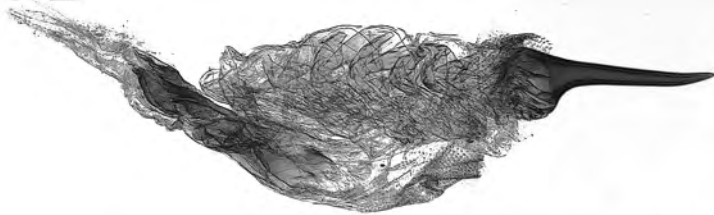
Figs. 72 - 75. Group 2. 72 - 73. *E. subfuscata*. 74 - 75. *E. tantillaria*.

76

1,3 mm

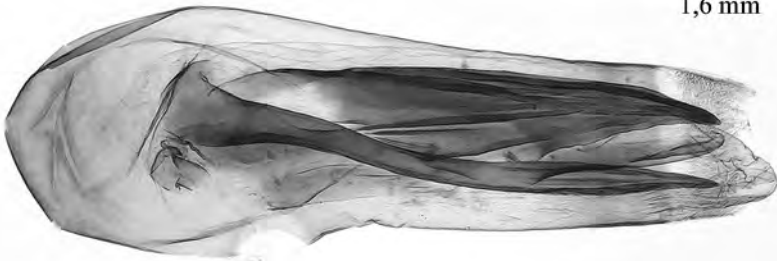


77



78

1,6 mm



79



Figs. 76 - 79. Group 2. 76 - 77. *E. tripunctaria*. 78 - 79. *E. undata*.

80



1,4 mm

81

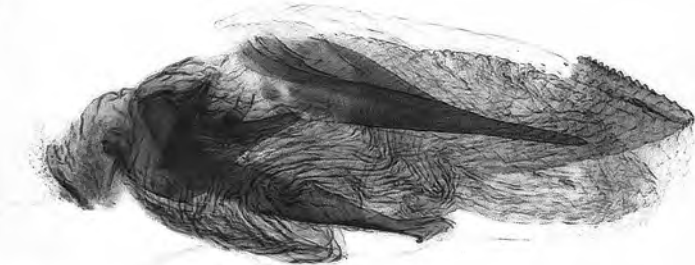


82



1,2 mm

83



Figs. 80 - 83. **Group 2.** 80 - 81. *E. venosata*. 82 - 83. *E. virgaureata*.

84

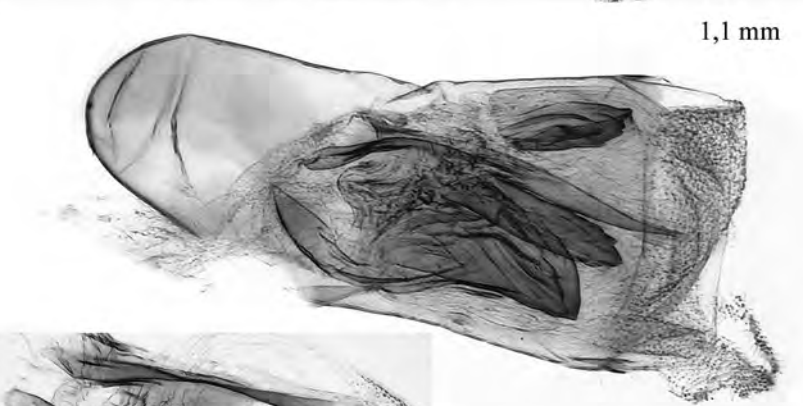


1,6 mm

85



86

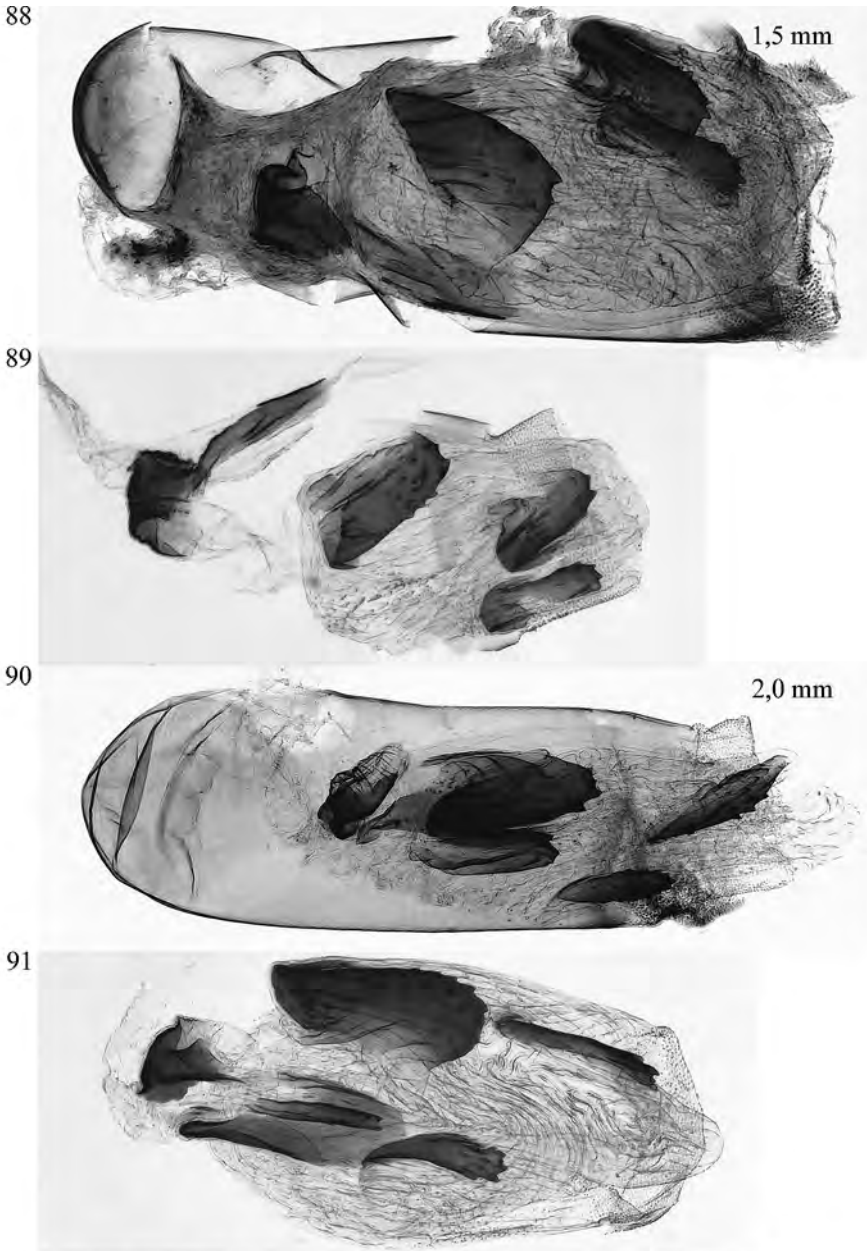


1,1 mm

87

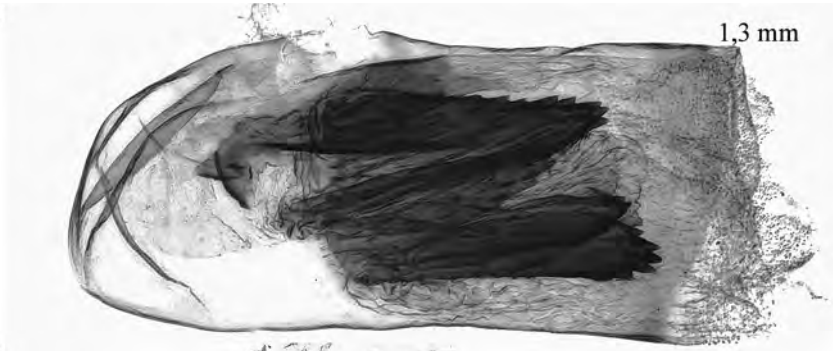


Figs. 84 - 87. **Group 3.** 84 - 85. *E. absinthiata*. 86 - 87. *E. assimilata*.



Figs. 88 - 91. **Group 3.** 88 - 89. *E. cauchiata*. 90 - 91. *E. expallidata*.

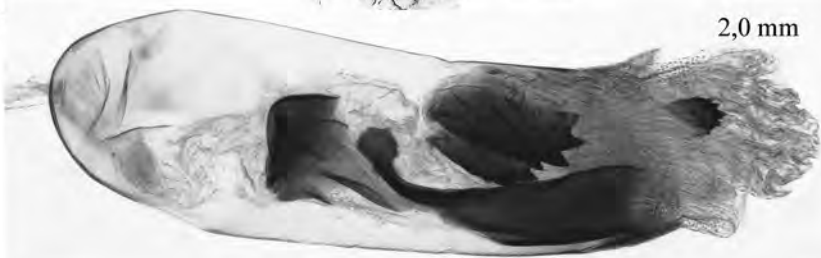
92



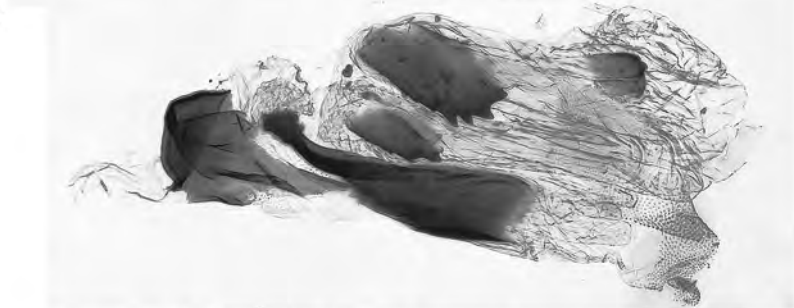
93



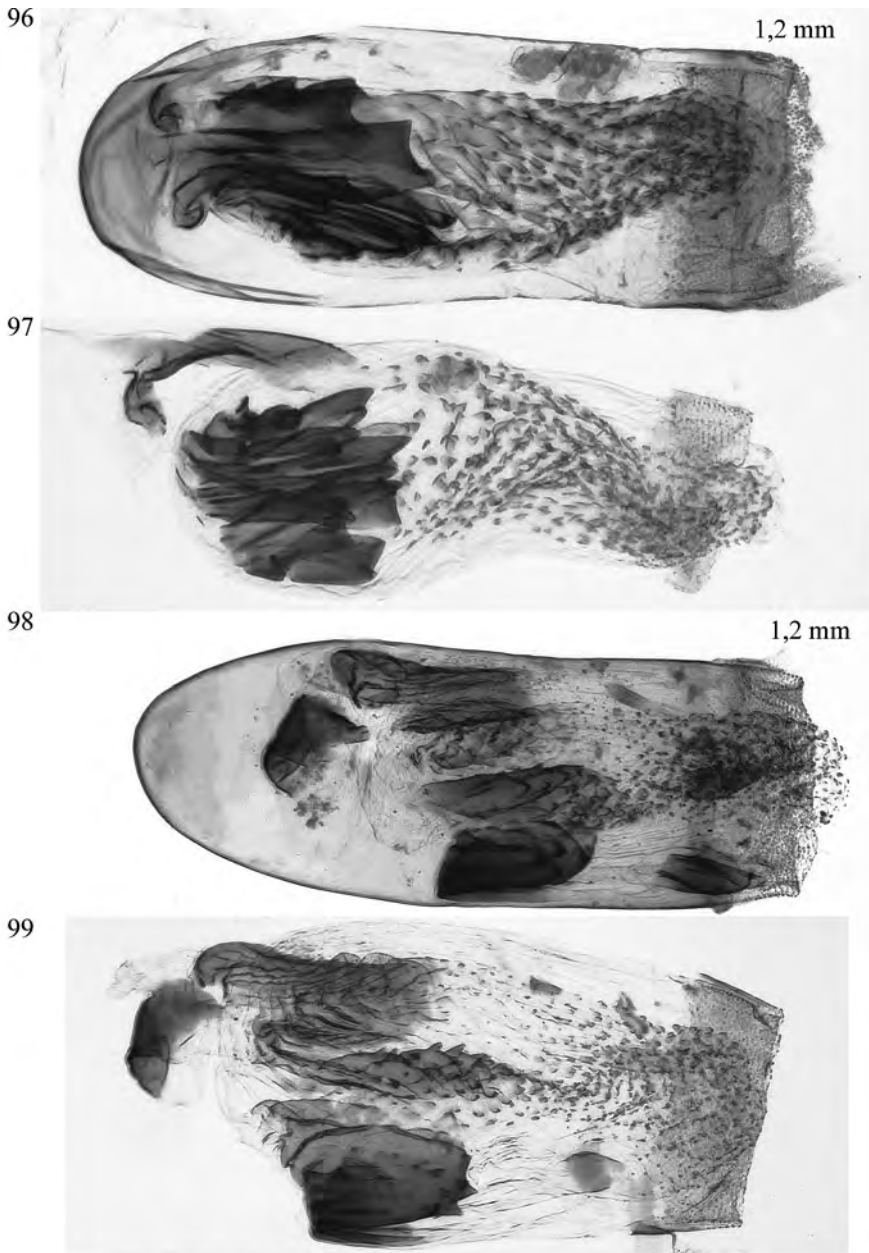
94



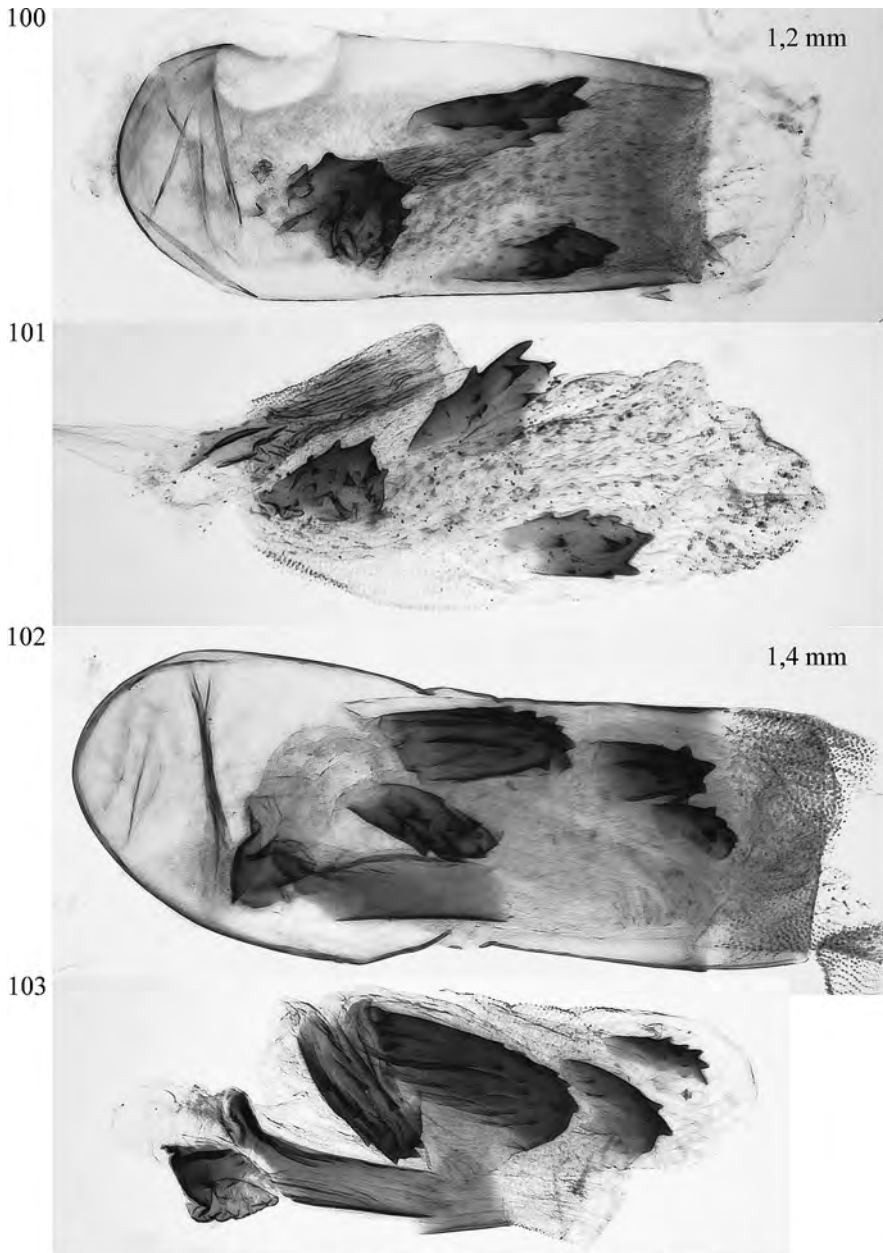
95



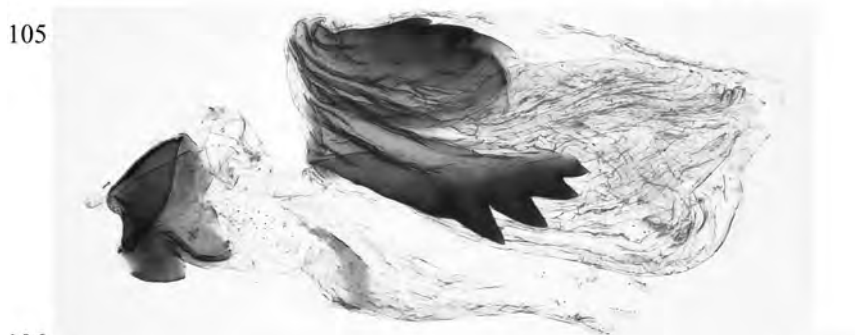
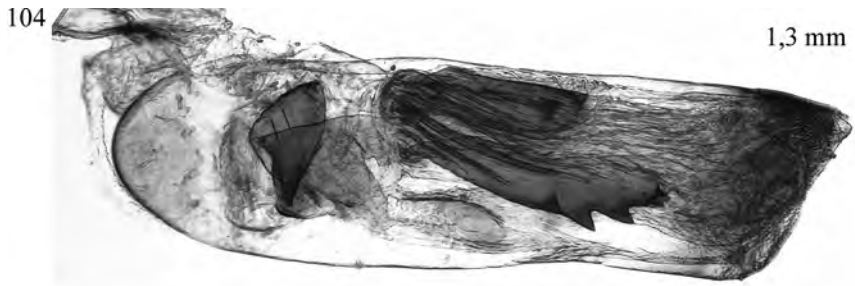
Figs. 92 - 95. Group 3. 92 - 93. *E. immundata*. 94 - 95. *E. impurata*.



Figs. 96 - 99. Group 3. 96 - 97, *E. indigata*. 98 - 99, *E. intricata*.



Figs. 100 - 103. **Group 3.** 100 - 101. *E. irriguata*. 102 - 103. *E. satyrata*.



Figs. 104 - 107. **Group 3.** 104 - 105. *E. subumbrata*. 106 - 107. *E. succenturiata*.

108



1,3 mm

109



110

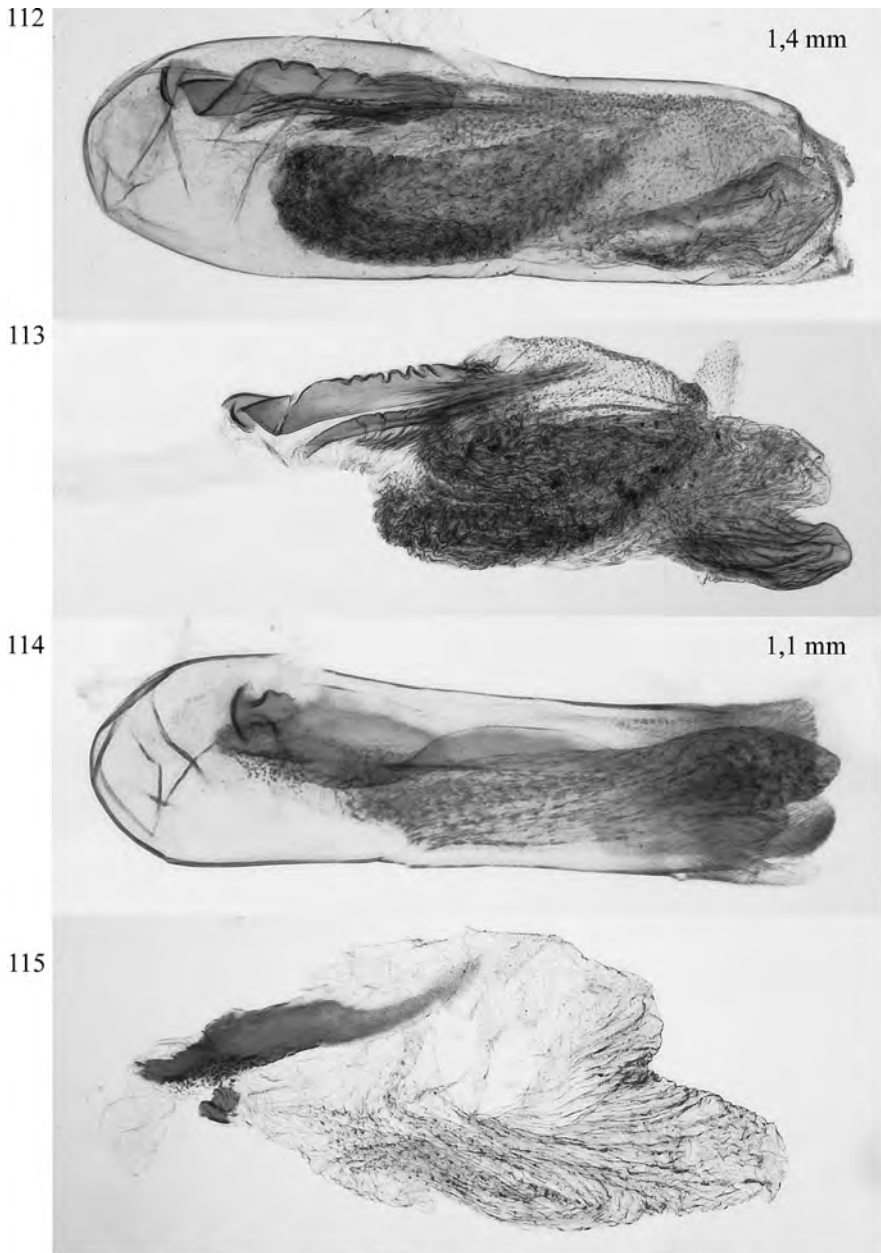


1,1 mm

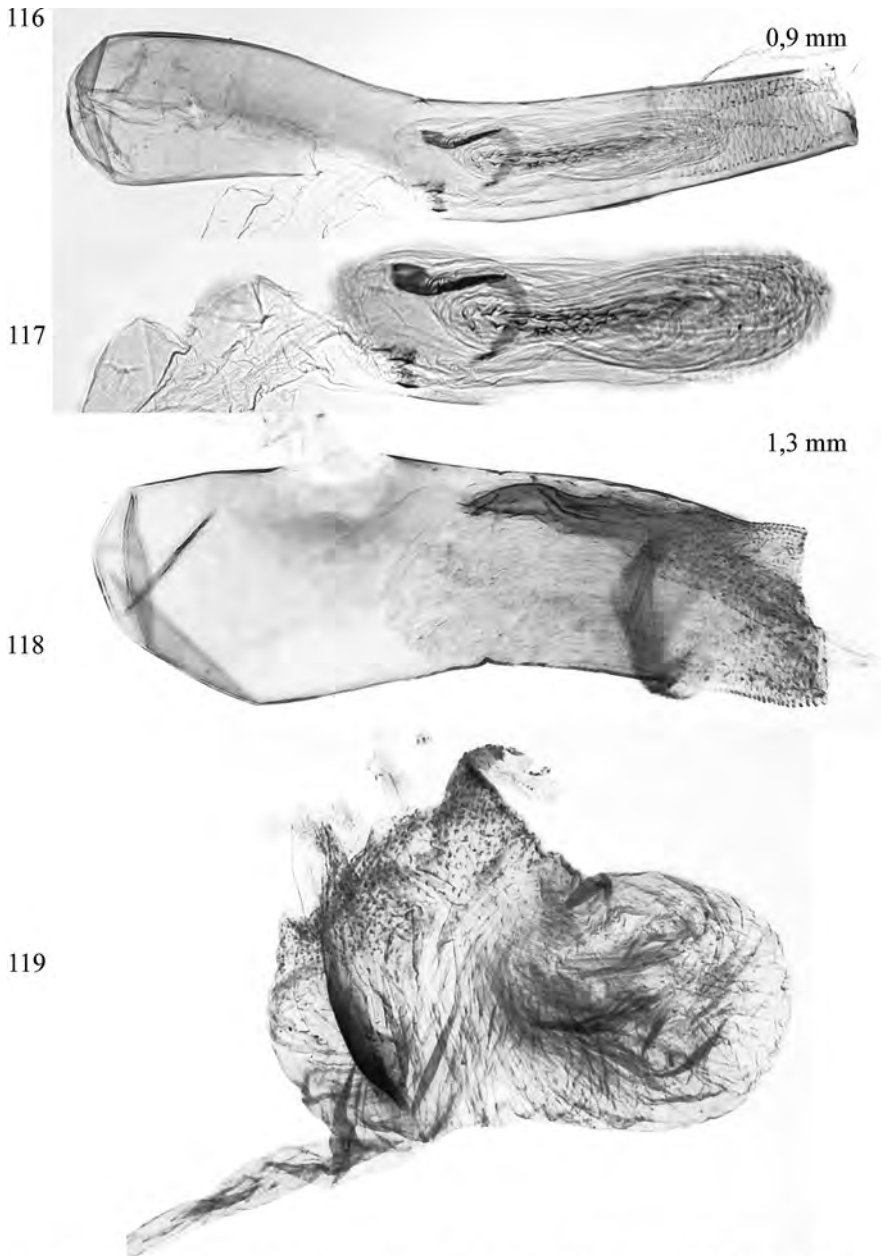
111



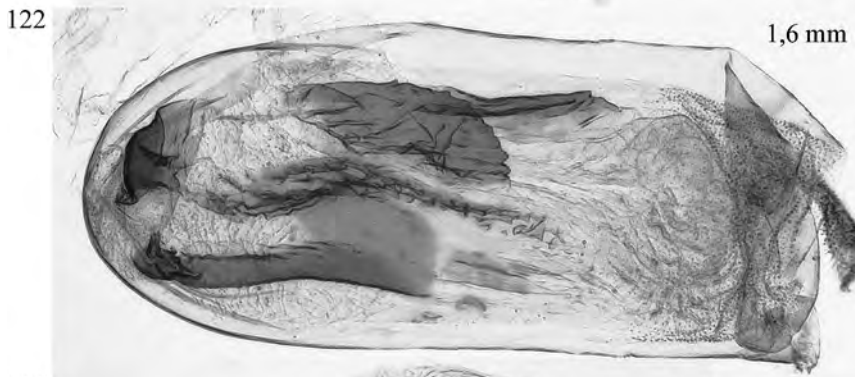
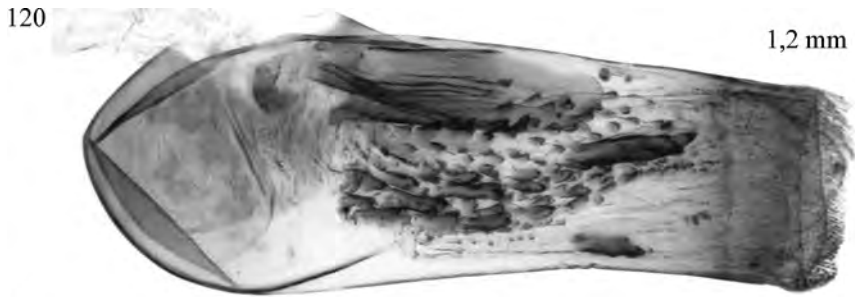
Figs. 108 - 111. **Group 3.** 108 - 109. *E. valerianata*. 110 - 111. *E. vulgata*.



Figs. 112 - 115. **Group 4.** 112 - 113. *E. distinctaria*. 114 - 115. *E. haworthiata*.

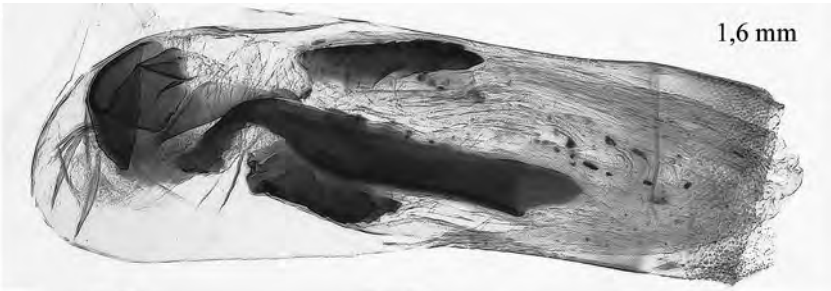


Figs. 116 - 119. **Group 4.** 116 - 117. *E. inturbata*. **Group 5.** 118 - 119. *E. alliaris*.



Figs. 120 - 123. **Group 5.** 120 - 121. *E. breviculata*. 122 - 123. *E. cretacea*.

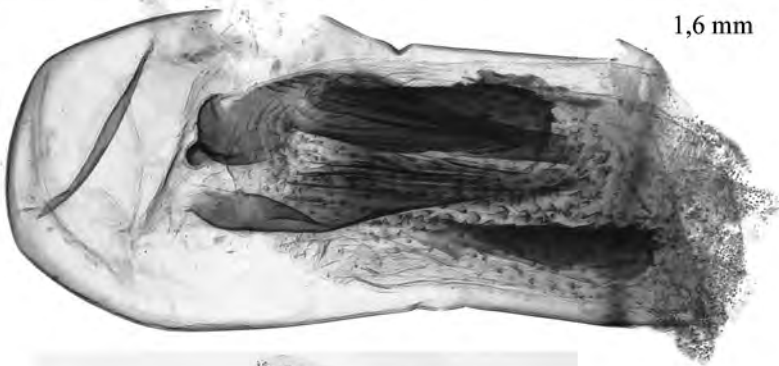
124



125



126

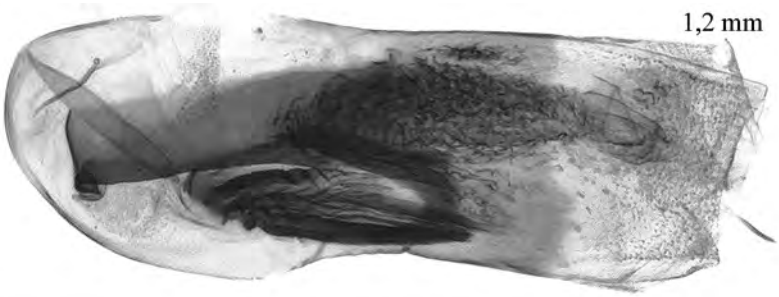


127



Figs. 124 - 127. **Group 5.** 124 - 125. *E. denticulata*. 126 - 127. *E. exiguata*.

128

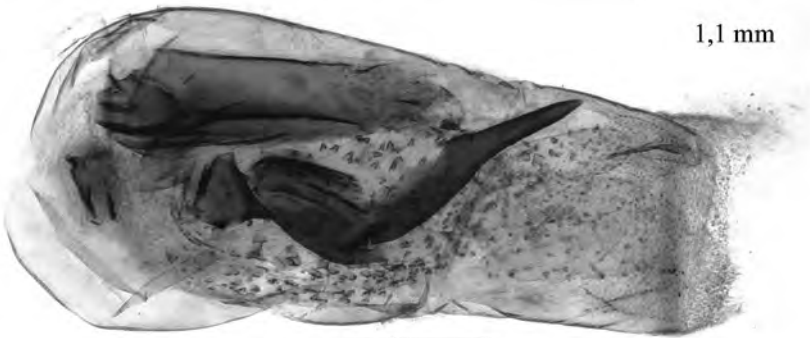


1,2 mm

129



130



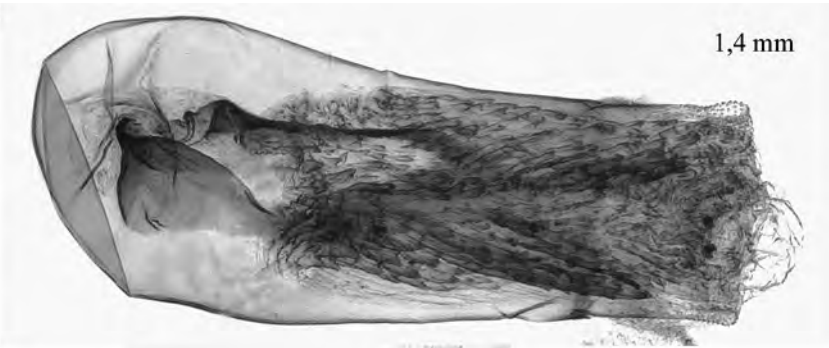
1,1 mm

131



Figs. 128 - 131. **Group 5.** 128 - 129. *E. extraversaria*. 130 - 131. *E. extremata*.

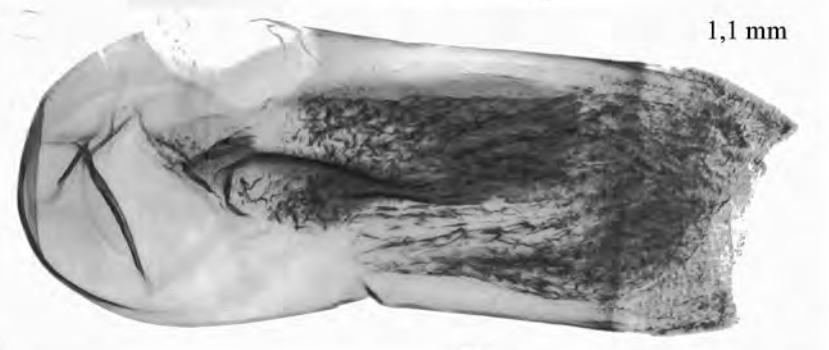
132



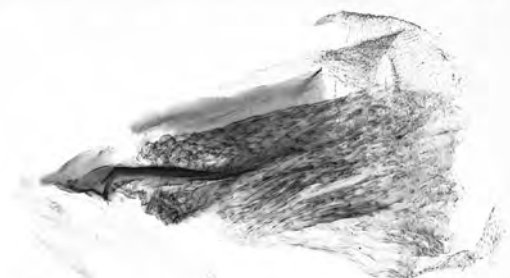
133



134



135

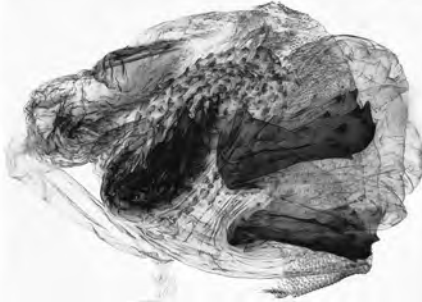


Figs. 132 - 135. **Group 5.** 132 - 133. *E. gemellata*. 134 - 135. *E. graphata*.

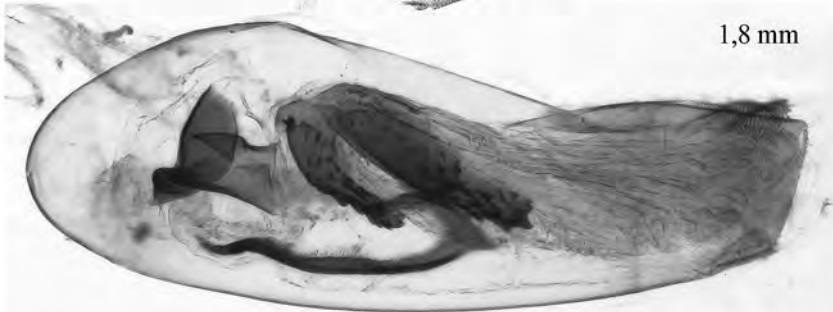
136



137



138

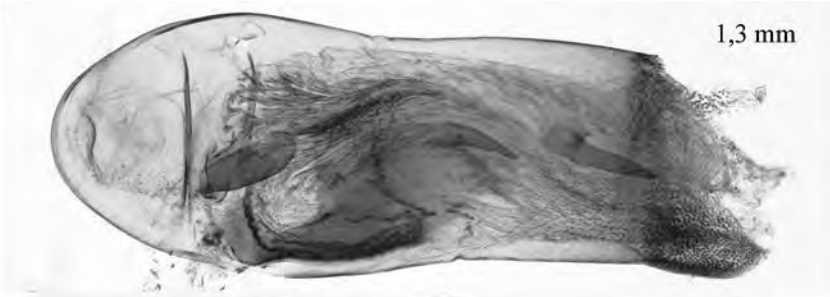


139



Figs. 136 - 139. **Group 5.** 136 - 137. *E. gueneata*. 138 - 139. *E. icterata*.

140



141



142

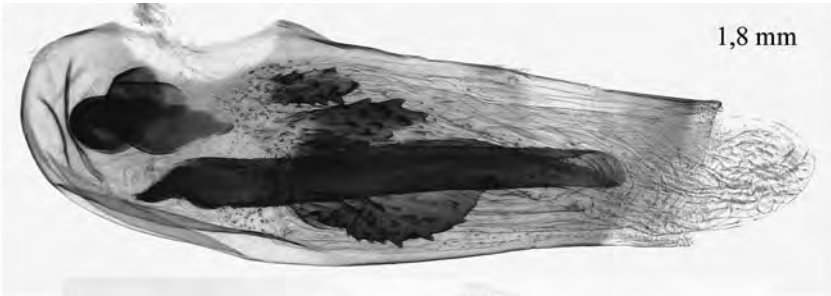


143

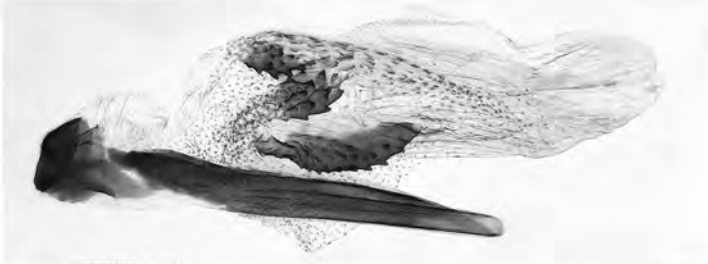


Figs. 140 - 143. Group 5. 140 - 141. *E. innotata*. 142 - 143. *E. insigniata*.

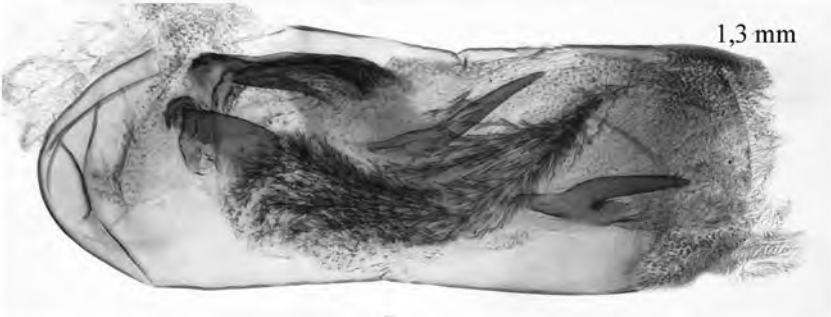
144



145



146



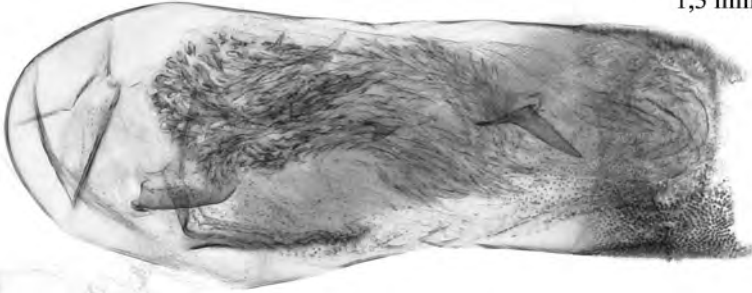
147



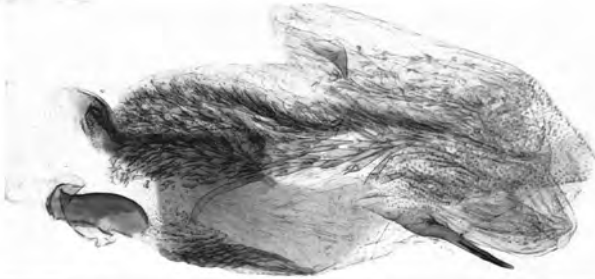
Figs. 144 - 147. **Group 5.** 144 - 145. *E. millefoliata*. 146 - 147. *E. nanata*.

148

1,3 mm

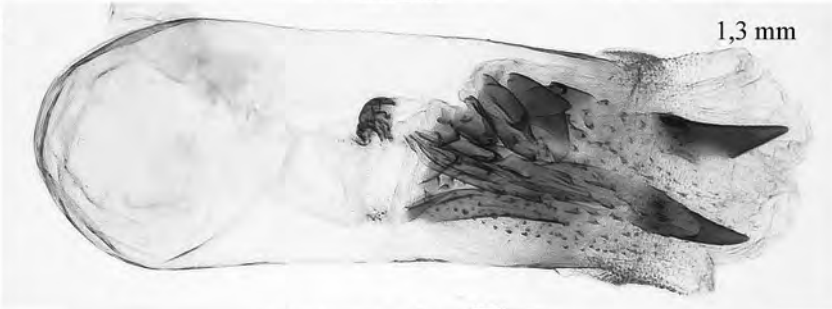


149



150

1,3 mm



151



Figs. 148 - 151. **Group 5.** 148 - 149. *E. ochridata*. 150 - 151. *E. reisserata*.

152



2,1 mm

153

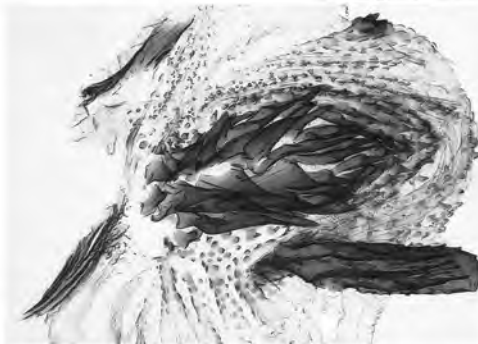


154

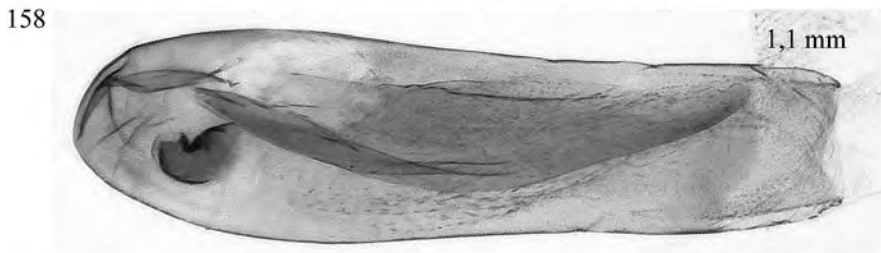
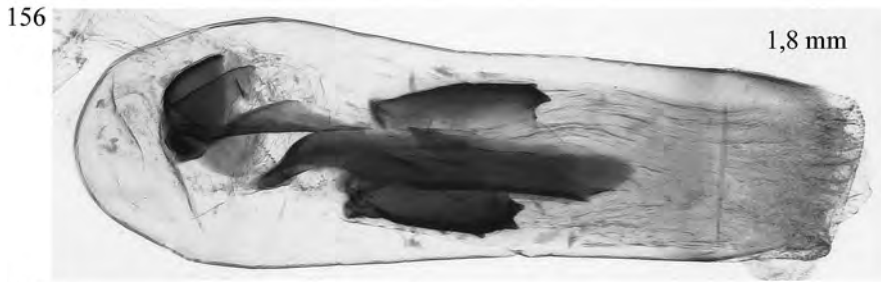


1,3 mm

155

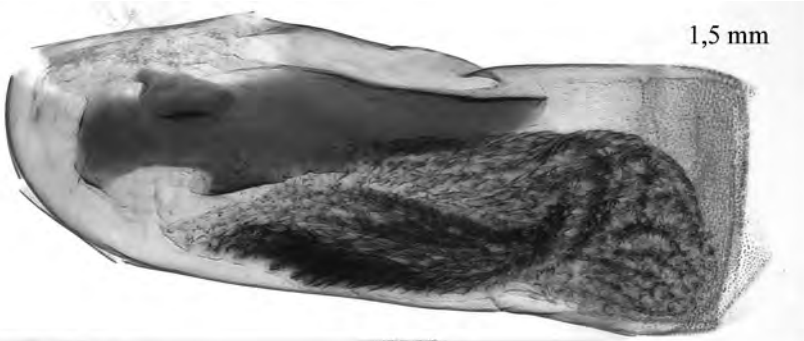


Figs. 152 - 155. **Group 5.** 152 - 153. *E. santolinata*. 154 - 155. *E. scalptata*.



Figs. 156 - 159. **Group 5.** 156 - 157. *E. semigraphata*. 158 - 159. *E. silenata*.

160

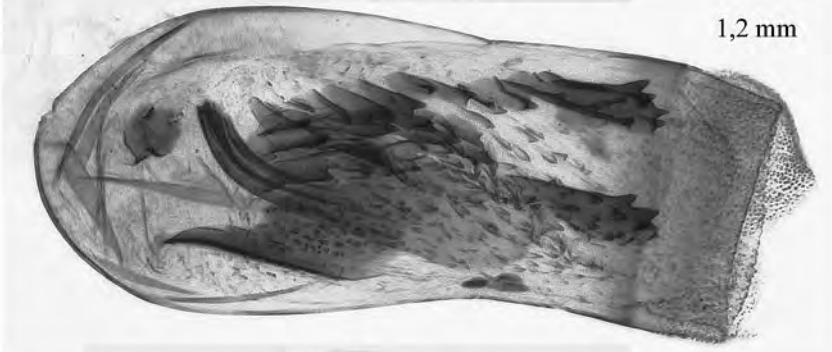


1,5 mm

161



162

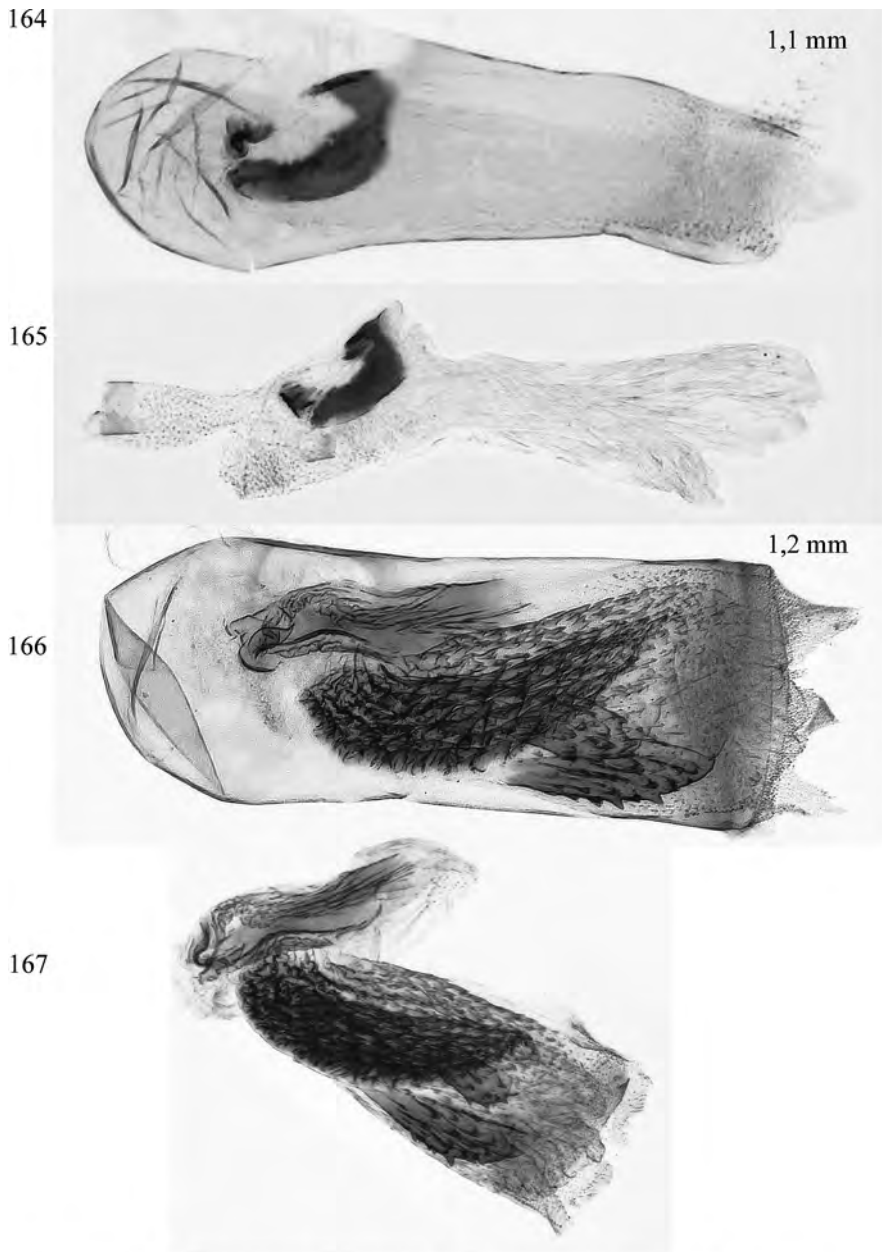


1,2 mm

163

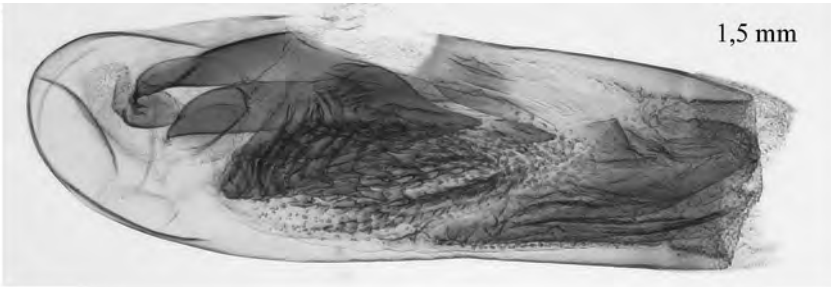


Figs. 160 - 163. **Group 5.** 160 - 161. *E. simplicciata*. 162 - 163. *E. spissilineata*.



Figs. 164 - 167. Group 5. 164 - 165. *E. tenuiata*. 166 - 167. *E. trisignaria*.

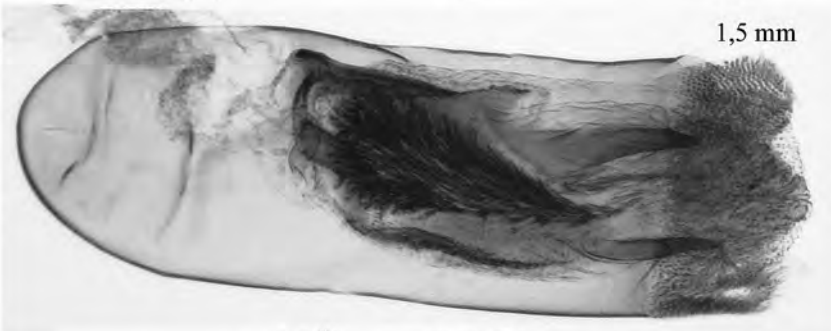
168



169



170

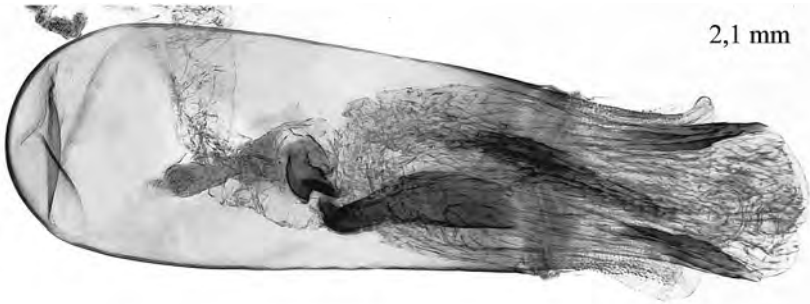


171

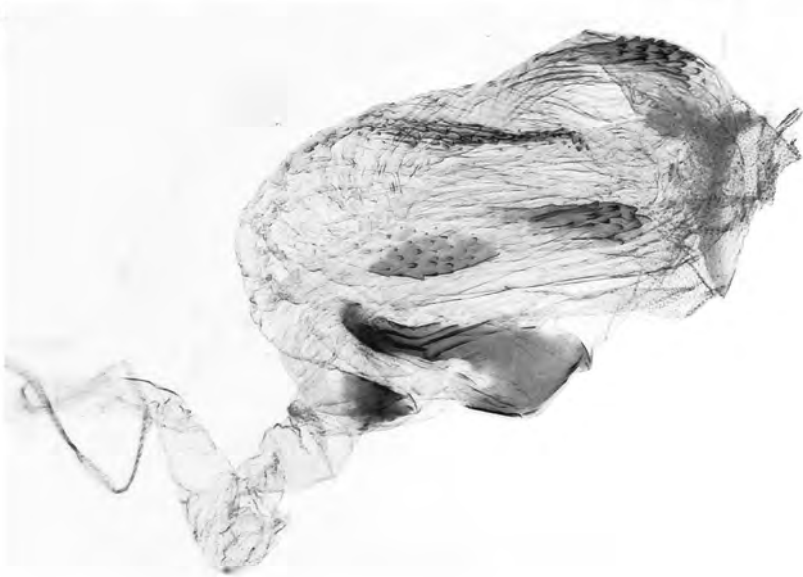


Figs. 168 - 171. **Group 5.** 168 - 169. *E. ultimaria*. 170 - 171. *E. unedonata*.

172

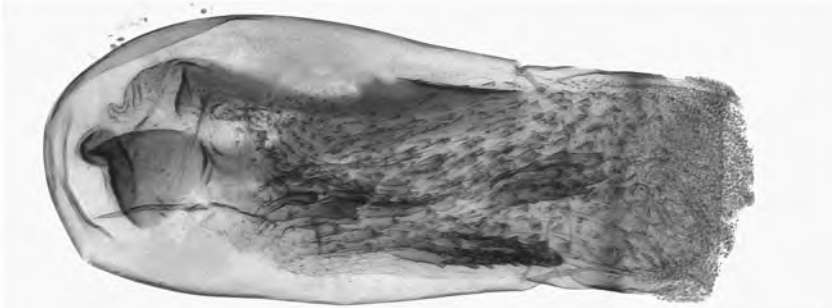


173

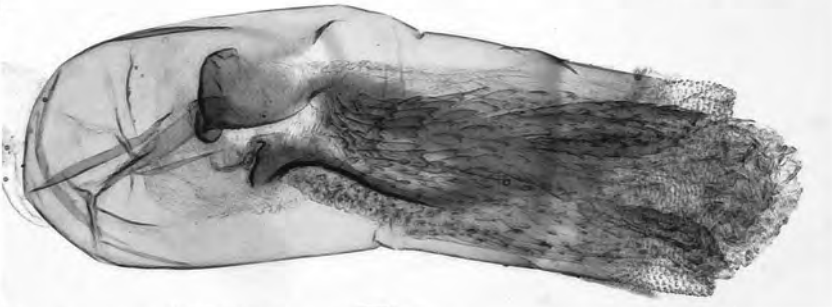


Figs. 172 - 173. **Group 5.** *E. veratraria*.

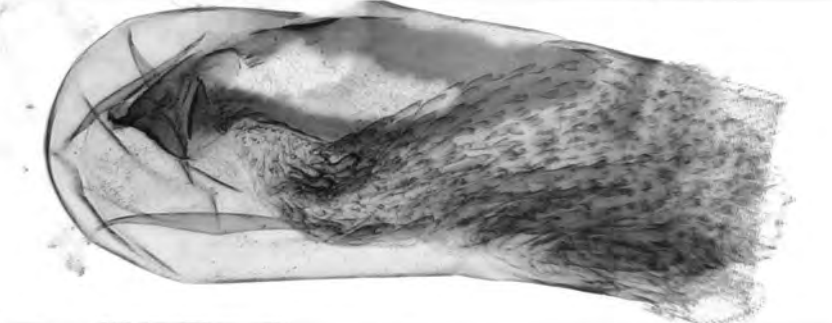
174



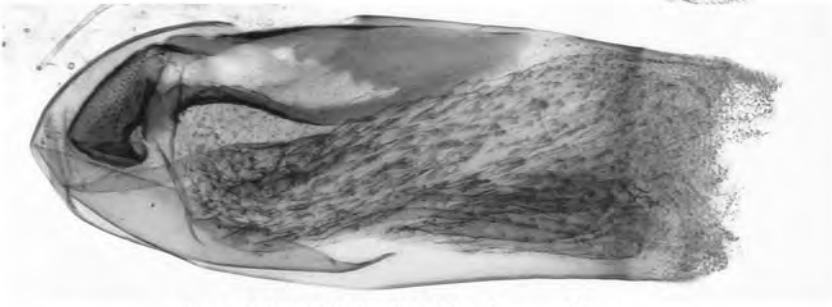
175



176

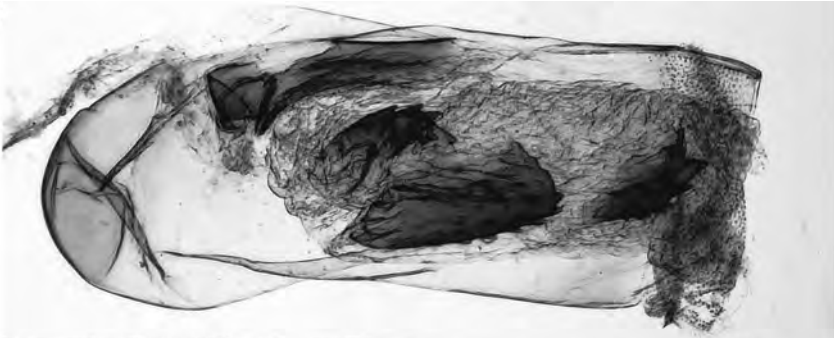


177

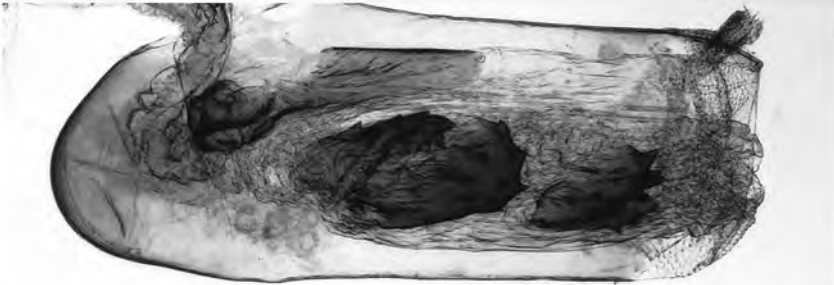


Figs. 174 - 177. Variability *E. gemellata*.

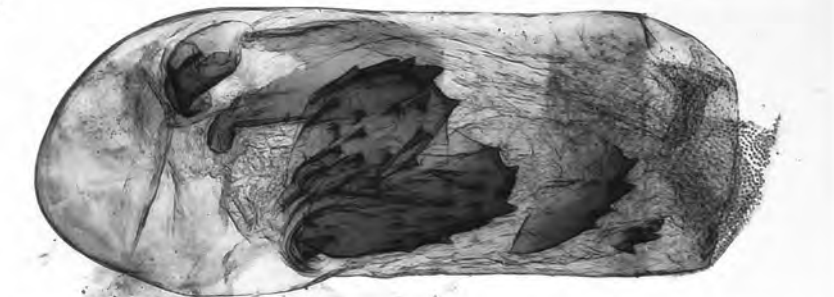
178



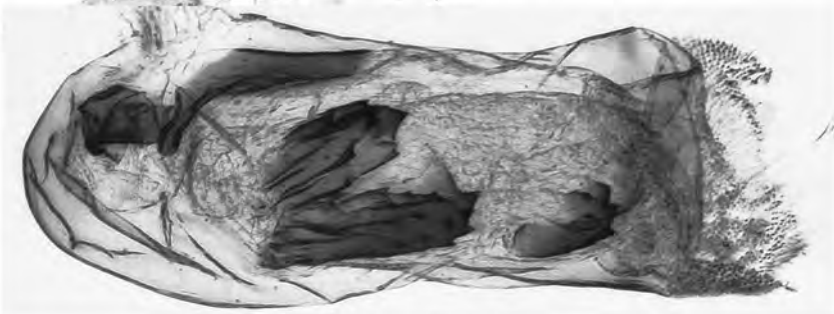
179



180

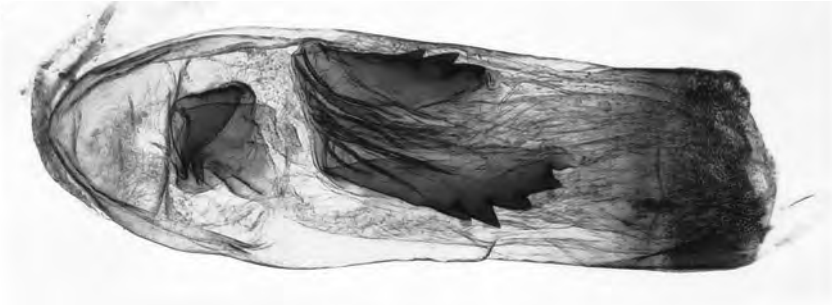


181

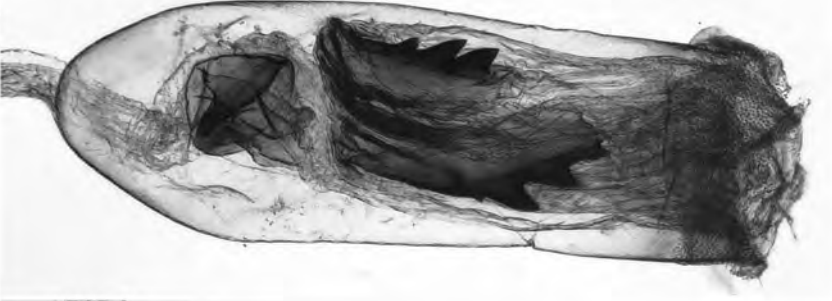


Figs. 178 - 181. **Variability** *E. satyrata*.

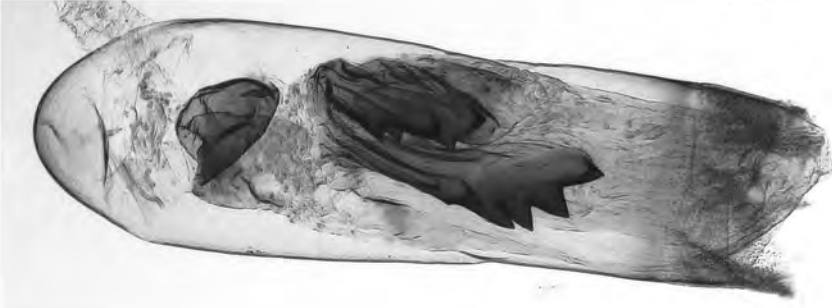
182



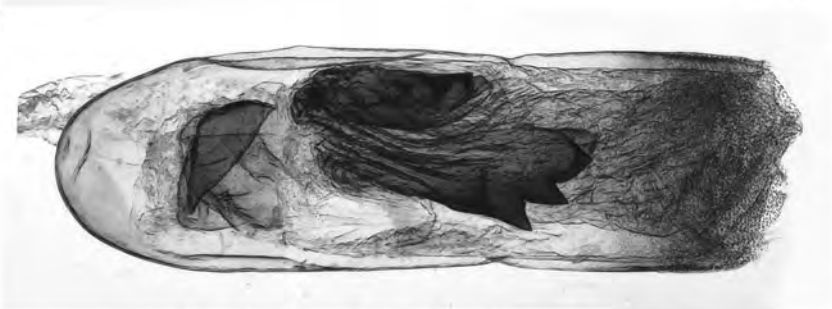
183



184



185



Figs. 182 - 185. **Variability** *E. subumbrata*.

Discussion

The morphological consideration of the aedeagus remains the basic criterion in the determination of the males of the genus *Eupithecia*. In combination with considering the shape of abdominal segment A8 (KUBÍN & PROCHÁZKA, 2012-b) and the form of the uncus (KUBÍN & PROCHÁZKA, 2012-a) it guarantees a relatively quick and – above all – reliable determination of species. However, it is necessary to take into account that – opposed to abdominal segments (which are two-dimensional) – the aedeagus is a three-dimensional structure, therefore, when examining it microscopically, it needs to be observed from several angles. This may influence the image of cornuti, which, in some positions, may overlap. This circumstance must be considered when arranging permanent preparations – all significant marks should be unambiguously visible. In some cases (e.g. in *E. ochridata*, *E. innotata* or *E. scopariata*), cornuti may be relatively less sclerotized and, consequently, badly discernable. They may be seen only after clearing and using a larger magnification with a high-quality lens. The same is true in species lacking significantly sclerotized cornuti whose vesicae are equipped only with variously arranged clusters of spines (Group 4). In the *Graphata*-group (MIRONOV, 2003), some species are totally indistinguishable in the morphology of the aedeagus. It was impossible to come to a conclusive result in the description of the aedeagus of *E. riparia* due to the unsatisfactory number of specimens of this species available for study. In most species, a potential variability does not influence decisively a correct determination. It is important to distinguish between different aspects caused only by variable positions in the preparations of the aedeagus from real morphological differences.

In most cases, the cornuti are substantially sclerotized. That is why any staining of them is not necessary – opposed to the abdominal segments A8 where, rather frequently, staining is necessary for their visualization. Both vesicae and cornuti preserved their effective significance even after being sealed in permanent preparations.

The extractions of vesicae from the aedeagi are often quite demanding manipulations and ask for a considerable dose of patience. In most cases, after performing the operation, the position of cornuti is shifted, but, on the other hand, it enables a more precise determination of their shape and number.

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Corrections

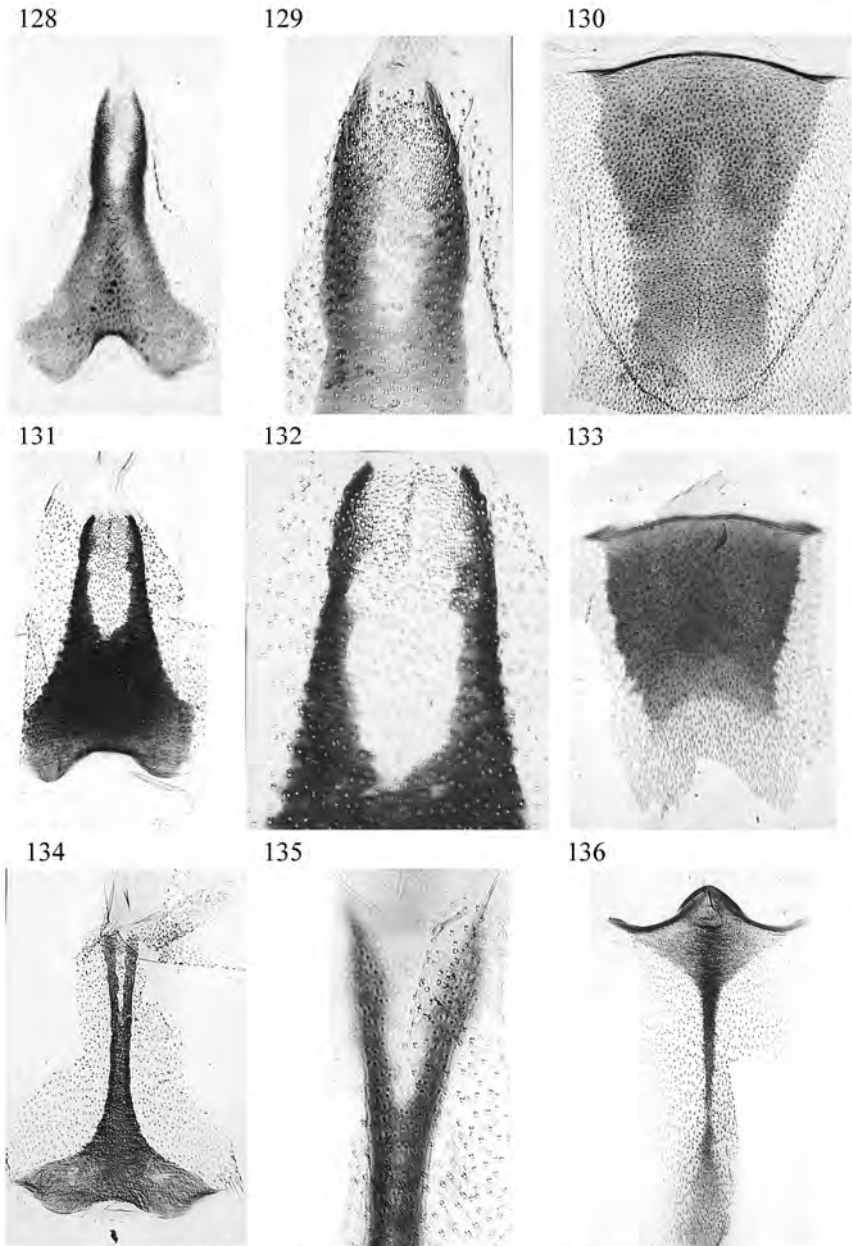
to the paper: KUBÍN, V. & PROCHÁZKA, J. (2012 – b): The importance of morphology of abdominal segment A8 for the determination of the males of the genus *Eupithecia* CURTIS 1825 (Lepidoptera, Geometridae). – Entomofauna, Zeitschrift für Entomologie **33**: 213 – 272.

p. 215-218. The following 6 species have been omitted from tab. 1:

Species / Groups	Tergum		Sternum	Figs.
	Tab. 2 margo cranialis	Tab. 3 caudal margin	Tab. 4 apex caudalis	
<i>E. analoga</i> DJAKONOV, 1926	2	1	5	188 - 190
<i>E. assimilata</i> DOUBLEDAY, 1856	2	3	2	64 - 66
<i>E. inturbata</i> (HÜBNER, 1817)	1	2	6	221 - 223
<i>E. irriguata</i> (HÜBNER, 1813)	2	2	3	122 - 124
<i>E. silenata</i> ASSMANN, 1848	1	3	3	134 - 136
<i>E. silenicolata</i> MABILLE, 1867	1	3	7	260 - 262

p. 219 (figure 2): Instead of "trebeculum" please read **trabeculum**.

p. 244. Please replace the figures erroneously duplicated from page 243 by the following figures:



Figs. 128-136. **Group 3.** 128-130. *E. pauxillaria*. 131-133. *E. scalptata*.
134-136. *E. silenata*.

p. 251: Instead of *E. dessertata* (No. 194-196) please read *E. dissertata*.

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Literaturbesprechung

BLÖSCH, M.: Grabwespen. Illustrierter Katalog der einheimischen Arten. - NBB Scout, Band 2, Westarp Wissenschaften, Hohenwarsleben, 2012. 219 S.

Grabwespen zeigen ein faszinierendes, hochkomplexes Verhaltenssystem, welches sich in einem komplizierten Fortpflanzungsverhalten, verschiedenen Grabtechniken beim Nestbau, unterschiedlichen Jagdmethoden und diversen Formen des Beutetransportes, des Nestverschließens, der Abwehr von Parasitoiden sowie der Orientierung äußert.

In diesem kompakten Taschenbuch (in der Tat im Taschenformat von 15x11cm) werden alle 246 derzeit aus Deutschland bekannten Arten aufgelistet und mit Farbfotos anhand von 137 ausgewählten Arten (viele davon in beiderlei Geschlecht) dargestellt. Z. T. sind auch Vertreter der weiteren 63 aus Österreich und der Schweiz bekannten Arten berücksichtigt. Da das Hauptverbreitungsgebiet in den wärmeren Zonen nördlich der Alpen liegt, erreichen viele Arten bei uns die nördliche Grenze ihrer Verbreitung. Systematisch werden die Grabwespen (Spheciformes) heute in die drei Familien Ampulicidae, Sphecidae und Crabronidae eingeteilt. Auf eine kurze Einleitung folgt der illustrierte Artenkatalog, dessen Kurzbeschreibungen Kennzeichen, Größe, Flugzeit, Verbreitung, Lebensraum und Lebensweise beinhaltet. Gegebenfalls werden bei bestimmten Gattungen weitere Arten kurz erwähnt.

Als Biologe hätte man sich vielleicht einen Bestimmungsschlüssel zu den Gattungen gewünscht, ansonsten gibt es an diesem fantastischen Büchlein nichts auszusetzen. Eine sehr schöne, kompakte Darstellung dieser auffälligen, aber oft zu wenig berücksichtigten Insektengruppe.

R. GERSTMEIER

NIETHAMMER, J., KRAPP, F.: Handbuch der Säugetiere Europas auf DVD. - Aula-Verlag, Wiebelsheim, 1978-2005.

Die 14 Bände des "Handbuch der Säugetiere Europas" entstand zwischen 1978 und 2005, herausgegeben von der Akademischen Verlagsgesellschaft Wiesbaden. Es behandelt alle in Europa vorkommenden Säugetierarten, inklusive der Meeressäuger. Die DVD bietet dieses Werk in digitalisierter Form an und setzt den Adobe (Acrobat) Reader ab Version 7.0 sowie die Betriebssysteme Windows XP, Vista, 7 oder Mac OS X 10.1 (bzw. höher) voraus. D.h., die einzelnen Bände liegen als PDF vor und können bequem über die Volltextsuche oder eine spezielle Stichwortsuche erschlossen werden.

Inhaltlich handelt es sich um die Bände Nagetiere 1+2, Paarhufer, Insektenfresser und Herrentiere, Hasentiere, Fledertiere 1+2, Raubsäuger 1+2, Meeressäuger (Wale 1+2), Meeressäuger (Robben), Registerband und Bonusband (Threatened Mammals of Europe; i.w. Datenblätter zu den bedrohten Arten). Der systematische Aufbau beginnt mit einer jeweiligen Familiendiagnose, Beschreibung, Verbreitung, Gliederung (Gattungen und Arten innerhalb der Familien), Paläontologie und Schlüssel zu den Gattungen. Bezüglich der Gattungen und Arten wird ebenfalls nach Diagnose, Verbreitung, Untergattungen und Arten, Paläontologie, Ökologie (inkl. Verhalten) sowie Schlüssel zu den Arten (nach Schädel- und Zahnmerkmalen) und der entsprechenden Literatur aufgeschlüsselt.

Eine praktische und preiswerte digitalisierte Version dieses Standardwerkes der europäischen Mammologie.

R. GERSTMEIER

BENDIX, J. et al. (eds.): Ecosystem Services, Biodiversity and Environmental Change in a Tropical Mountain Ecosystem of South Ecuador. - Springer-Verlag, Berlin-Heidelberg 2013. 438 S.

Der Einfluss des Klimawandels bezüglich einer Bedrohung der Biodiversität und von Ökosystem-Dienstleistungen ist heute unbestritten. Neben Klimawandel spielen eine Ausdehnung der Landnutzung, atmosphärische Düngung und das Eindringen invasiver Arten die entscheidende gegenwärtige und zukünftige Rolle für eine Ökosystem-Verschlechterung. Allerdings gibt es weltweit nur wenige Untersuchungen, die eine globale Dimension hinsichtlich Ökosystem-Dienstleistungen analysieren; gerade für hotspots der Biodiversität wären solche Forschungsprojekte äußerst wünschenswert. Eine kleine Lücke kann nun mit dem Inhalt dieses Buches gefüllt werden, basierend auf 15-jähriger, interdisziplinärer Feldforschung in den südöstlichen Anden Ecuadors. Als großer Vorteil des Untersuchungsgebietes erwies sich die direkte räumliche Nähe einer geschützten Bergregenwaldregion auf der einen Seite eines Tales zur gegenüberliegenden Seite mit landwirtschaftlicher Nutzung.

In Teil 1 (Einführung) wird das Untersuchungsgebiet detailliert dargestellt. Der 2. Teil beschreibt die gegenwärtige Situation von Biodiversität und Ökosystem-Dienstleistungen anhand ausgewählter Beispiele. Mit 13 Kapitel (u.a. Landscape history, Past dynamics of speciation, Diversity in soil fungi, protists and microarthropods, Plant diversity, Carbon balance, Nutrient cycles, Mycorrhiza networks, Landscape transformation, Land use and Plant use. Teil 3 analysiert die zukünftigen Änderungen der Umwelt und ihren Einfluss auf Biodiversität und Ökosystem-Dienstleistungen. Diverse Analysen und Modellierungsverfahren versuchen den Einfluss von Klimawandel, Landnutzung und Nährstoffanreicherung auf Biodiversität, Produktivität und landwirtschaftliche Managementstrategien zu zeigen. Der 4. Teil (Synopsis) gibt eine Zusammenfassung und versucht Empfehlungen für ein nachhaltiges Landnutzungssystem in einem hotspot-Gebiet zu geben.

Ein hochkarätiger und empfehlenswerter Band der Reihe "Ecological Studies".

R. GERSTMEIER

SCHWOERBEL, J., BRENDENBERGER, H.: Einführung in die Limnologie. - Springer-Verlag, Berlin-Heidelberg 2013. 10. Aufl., 386 S.

Die Einführung in die Limnologie ist ein Klassiker, von Lehrenden wie Studierenden gleichermaßen hoch geschätzt. Beschrieben werden die Systemeigenschaften der Gewässer, die Zusammenhänge zwischen den klimatischen, geologischen und physikalisch-chemischen Faktoren sowie dem Stoffhaushalt und den aquatischen Tier- und Pflanzengemeinschaften. Heinz Brendelberger gibt aktuellen Schwerpunkten gebührenden Raum, wie z.B. longitudinale, laterale und vertikale Konnektivität der Fließgewässer, die vermehrte Erfassung von Gewässer-Umland-Beziehungen, die

Koppelung verschiedener Habitats oder auch die Bedeutung von Wellenbewegungen in Seen. Neu hinzugekommen sind Abschnitte über die Rolle des Totholzes in Fließgewässern, die EG-Wasserrahmenrichtlinie und die Horizontalwanderung des Zooplanktons. Das Ökotoxikologie-Kapitel wurde vollständig neu bearbeitet, alle anderen Kapitel liegen in aktualisierter Fassung vor. Aktualisiert wurden u.a. die Themen Schilfsterben, allelopathische Interaktionen, tagesperiodische Wanderungen, kryptische Arten, Mikrobiologie, molekularbiologische Beiträge und Eutrophierung.

Vergleicht man dieses Buch mit amerikanischen Lehrbüchern, könnte man sich allerdings die Frage stellen, ob etwas "mehr Farbe" ein moderneres Gesicht geben würde.

R. GERSTMEIER

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