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Revision of the European species of *Euplectrus* Westwood (Hymenoptera, Eulophidae), with a key to European species of Euplectrini

Christer Hansson[1], Stefan Schmidt[2]

1 *Museum of Biology (Entomology), Lund University, Sölvegatan 37, SE-223 62 Lund, Sweden; Scientific Associate, Natural History Museum, Cromwell Road, London SW7 5BD, United Kingdom* **2** *SNSB – Zoologische Staatssammlung München, Munich, Germany*

Corresponding author: *Christer Hansson* (Christer.Hansson@biol.lu.se)

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Abstract

The European species of *Euplectrus* Westwood are comprehensively treated for the first time, using a combination of morphological and DNA data (CO1, the barcode). Ten species are included, seven already described: *E. bicolor* (Swederus), *E. flavipes* (Fonscolombe), *E. intactus* Walker, *E. liparidis* Ferrière, *E. maculiventris* Westwood, *E. nigriceps* Ferrière, *E. phthorimaeae* Ferrière, and three new species: *E. carinifer* **sp. n.**, *E. geometricida* **sp. n.**, *E. pallidigaster* **sp. n.** To stabilize the nomenclature a neotype is designated for *E. bicolor*. *Euplectrus intactus* is removed from synonymy under *E. bicolor* and *E nigriceps* from synonymy under *E. platyhypenae* Howard, and both are re-established as valid species. Several host records are given and presented in a table, and new geographical records are introduced for previously described species. All host records are from exposed Lepidoptera caterpillars and the dominant host groups are Geometridae and Noctuidae. A key including all European species of tribe Euplectrini is presented. Prior to this paper the identification of European *Euplectrus* species has been difficult and misidentifications have probably been common. Existing host and geographical records in the literature must therefore be treated with great care.

Keywords

Neotype designation, reevaluation of synonymized species, new species, new host records, new geographical records, gregarious ectoparasitoids, cocoon spinning, Geometridae, Noctuidae, *Platyplectrus*, *Metaplectrus*

Introduction

Species of the genus *Euplectrus* are found all over the world, with most species occurring in tropical parts (e.g. Hansson et al. 2015). This genus currently includes 199 species, but only five of them are recorded from Europe (Noyes 2018). Even though it is a very small genus in Europe the confusion resulting from misidentifications of specimens, and the unresolved taxonomy and nomenclature on species level, have resulted in many erroneous geographical and biological records in the literature. Most European records, geographical as well as biological, have been attributed to *E. bicolor* Swederus, this is in spite of the unclear identity of this species (very short and bland original description and type material missing – see below). The results presented in this paper necessitate a check, and probable re-evaluation of several records in the literature regarding European *Euplectrus*. Species of *Euplectrus* are parasitoids of Lepidoptera caterpillars, some of which cause damage to cultivated plants, and the accurate identification of the parasitoids on these pests is essential for successful biological control efforts.

The first more comprehensive study of *Euplectrus* in Europe was by Ferrière (1941) who included four species: *E. bicolor*, *E. nigriceps*, *E. cacoeciae*, *E. phthorimaeae*, the three latter were described in the paper. Graham (1963) made an effort to sort out the British fauna of *Euplectrus* but due to unresolved morphological variation he expressed uncertainty regarding the identity of some names. He included three species, *E. intactus* Walker, *E. maculiventris* Westwood, and *E. nigriceps* in a key, but due to total lack of information for the type material of *E. nigriceps* he had doubts about the geographical status of that species. In addition, he mentioned two species: *E. bicolor* with uncertain identity because of lack of type material, and *E. flavipes* (Fonscolombe) that obviously did not occur in Britain but was regarded as a distinct species by Graham. Bouček and Askew (1968) synonymized *E. maculiventris* and *E. intactus* with *E. bicolor.* Zhu and Huang (2002) re-evaluated the status of *E. maculiventris* and removed it from synonymy, and later (2003) included *E. bicolor*, *E. flavipes* and *E. maculiventris* in their study of *Euplectrus* from China, and added *E. liparidis* Ferrière to the list of European species, a species that previously was known only from North Africa.

Due to previous difficulties with the identification of the species and the somewhat unclear nomenclatural situation only distributional and biological information for specimens examined here will be included in this paper.

Methods

Imaging

The SEM micrographs are from uncoated specimens and were done with a Hitachi SU 3500, using a backscatter detector. The colour images were made using a Canon camera equipment including an EOS 70D body, MP E-65 macro lens, and macro twin lite MT-24 EX. The camera was attached to a Cognisys stackshot macrorail system. The picture stacking was done with Helicon Focus version 6 software.

DNA sequencing

For DNA extraction, whole specimens were sent to the Canadian Centre for DNA Barcoding (CCDB) in Guelph, Canada, for DNA extraction and barcode sequencing, and subsequent recovery of vouchers for preparation and morphological study. A complete list of voucher specimens included in the revision is given in Suppl. material S1. DNA extraction, PCR amplification, and sequencing were conducted at the Canadian Centre for DNA Barcoding (CCDB) using standardised high-throughput protocols (Ivanova et al. 2006, deWaard et al. 2008, http://www.ibolproject.org/resources.php). The 658 bp target region, starting from the 5' end of the mitochondrial cytochrome c oxidase I (COI) gene, includes the DNA barcode region of the animal kingdom (Hebert et al. 2003). The DNA extracts are stored at the CCDB. Specimens that were successfully sequenced are listed in Suppl. material S1. All specimen data are accessible in BOLD as a single citable dataset (dx.doi.org/10.5883/DS-EUPLEUR). The data include collecting locality, geographic coordinates, elevation, collector, one or more digital images, identifier, and voucher depository. Sequence data can be obtained through BOLD and include a detailed LIMS report, primer information, and access to trace files. The sequences are also available on GenBank (for accession numbers see Suppl. material S1).

Data analysis

Sequence divergence statistics were calculated using the Kimura two parameter model of sequence evolution (Kimura 1980). Barcode Index Numbers (BINs) were assigned by the BOLD system, representing globally unique identifiers for clusters of sequences that correspond closely to biological species (Ratnasingham and Hebert 2013). For BIN assignment, a minimum sequence length of 500 bp is required, and sequences between 300 and 500 bp can join an existing BIN but will not create or split BINs. In the present study, BINs were used to delineate Molecular Operational Taxonomic Units (MOTUs) prior to a detailed taxonomic study based on morphological characters. Sequences were aligned using the BOLD Aligner (amino acid-based hidden Markov models). The analyses are based on sequences with a minimum length of 500 bp and <1% ambiguous bases. Genetic distances and summary statistics were calculated using analytical tools in BOLD and are given as mean and maximum pairwise distances for intraspecific variation and as minimum pairwise distances for interspecific variations.

Abbreviations of morphological terms (Figs 3–6)

DO = largest diameter of one posterior ocellus; HE = height of eye in frontal view; HH = height of head; LC = length of scape; LP = length of petiole; LT = length of hind tarsus; LT1–4 = length of first–fourth tarsomere on hind leg; MS = malar space; OOL = the distance between eye and posterior ocellus; PM = length of postmarginal vein; POL = the distance between posterior ocelli; POO = the distance between posterior ocelli and oc-

cipital margin; ST = length of stigmal vein; TS1 = length of longest hind tibial spur; TS2 = length of shortest hind tibial spur; WE = width of eye; WF = width of frons, in frontal view the largest distance between eyes; WH = width of head, measured across the widest part; WM = width of mouth opening; WP = width of petiole, measured across widest part; WS = width of scape, measured across widest part. Lower face as defined by Gibson (1997), i.e. the part below an imaginary line from eye to eye touching ventral edge of toruli.

Museum acronyms

MZH	Finnish Museum of Natural History, Zoological Museum, Helsinki, Finland.
MZLU	Museum of Biology (Entomology), Lund University, Lund, Sweden.
NHM	the Natural History Museum, London, United Kingdom.
NHRS	the Natural History Museum, Stockholm, Sweden.
OUMNH	Oxford University Museum of Natural History, United Kingdom.
SMTP	Swedish Malaise Trap Project, Station Linné, Ölands Skogsby, Sweden.
VV	private collection of Veli Vikberg, Turenki, Finland.
ZSM	Zoologische Staatssammlung München, Germany.

Results

Key to the European species of Euplectrini (i.e. Eulophinae species with 1–2 long spurs at apex of hind tibia)

1 Scutellum without lateral grooves (e.g. Fig. 48) (genus *Euplectrus*) **2**
– Scutellum with lateral grooves (Figs 57, 58) **13**
2 Head completely dark (Figs 44, 45) ..... ***Euplectrus nigriceps* Ferrière**
– Head with at least clypeal area pale (e.g. Figs 10, 27) **3**
3 Entire frons below level of toruli, including part below eye, white to yellowish-white, in males pale area reaches the eye and usually covers part of frons lateral to toruli (e.g. Figs 14, 31), in female pale area leaves at most a narrow dark stripe close to eyes (e.g. Fig. 30) **4**
– Frons below toruli with pale area smaller (e.g. Figs 9, 10), pale area never reaches eyes – in some males it almost reaches eyes but leaves a dark stripe close to eyes (Fig. 12) and never reaches up on surface lateral to toruli **7**
4 Female **5**
– Male **6**
5 Without groove between dorsellum and scutellum (Fig. 37); female gaster with pale area in anterior part as a round spot about as wide as ½ the width of gaster (Fig. 37) ..... ***Euplectrus liparidis* Ferrière (♂ unknown)**
– With a groove between dorsellum and scutellum (Fig. 52); pale area on female gaster with anterior ½ narrow, narrower than width of petiole, and with posterior

½ expanding and as wide as ½ the width of gaster (Fig. 19) ..... ***Euplectrus geometricida* sp. n.**

6 Scape 2.8–3.0× (mean = 2.86, n=10) as long as wide (Fig. 14) ..... ***Euplectrus maculiventris* Westwood**

– Scape 2.0–2.5× (mean = 2.24, n=10) as long as wide (Fig. 15) ..... ***Euplectrus geometricida* sp. n.**

7 Midlobe of mesoscutum with a distinct and complete median carina (Figs 51, 53), carina sometimes weak or missing close to posterior margin of pronotum and sometimes replaced by a groove close to scutellum; female gaster with apex pale (Figs 22, 35) **8**

– Median carina on midlobe of mesoscutum missing (e.g. Fig. 49) or incomplete (e.g. Fig. 48); female gaster with apex dark (Fig. 8) or pale (Figs 25, 26) **9**

8 Female with pale area in anterior ½ of first gastral tergite large and with narrow brown margins, margins about ½ as wide as width of petiole (Fig. 35); male gaster with pale area reaching margin in posterior part thus interrupting lateral brown margin (Fig. 13) ..... ***Euplectrus flavipes* (Fonscolombe) (♀, ♂)**

– Female with pale area in anterior ½ of first gastral tergite smaller and with wider brown margins, margins on average at least as wide as width of petiole (Fig. 22); male gaster with evenly wide brown uninterrupted margins in anterior ½ (Fig. 16) ..... ***Euplectrus carinifer* sp. n. (♀, ♂)**

9 Female gaster dark yellowish-brown with anterolateral corners dark brown (Fig. 25), in some specimens also with a dark brown round spot posteromedially (Fig. 26); male scutellum with weak and predominantly ±isodiametric meshes ..... ***Euplectrus pallidigaster* sp. n. (♀, ♂)**

– Female gaster predominantly dark brown (Figs 8, 29, 32); male scutellum with ± elongate meshes, thus appearing more striate than in alternate **10**

10 Posterior part of midlobe of mesoscutum wide (Figs 49, 56), ratio width base of midlobe (a)/width base of one sidelobe (b) = 0.80±0.048 (females), 0.80±0.054 (males); midlobe of mesoscutum without median line indicated (Figs 49, 56) ..... ***Euplectrus intactus* Walker (♀, ♂)**

– Posterior part of midlobe of mesoscutum narrow (e.g. Figs 48, 55), ratio width base of midlobe (a)/width base of one sidelobe (b) = 0.57±0.070 (females), 0.55±0.070 (males); median line on midlobe of mesoscutum usually indicated by a median groove or median carina in posterior ½ (Figs 48, 55), sometimes by a weak carina in anterior ½, in some specimens median line indicated just through a change in the reticulation **11**

11 Female with pale area on lower frons with upper-lateral part drawn out towards eye and almost reaches eye (Fig. 30); scutellum with isodiametric meshes (Fig. 50) (males key out under couplet 6) ..... ***Euplectrus maculiventris* Westwood**

– Female with pale area on lower frons not drawn out laterally (Fig. 10), scutellum with elongate or isodiametric meshes, or males **12**

12 Reticulation on posterior part of scutellum with elongate meshes, this part of scutellum thus appearing striate (Fig. 48) ..... ***Euplectrus bicolor* (Swederus) (♀, ♂)**

– Reticulation on posterior part of scutellum with ±isodiametric meshes (Fig. 40) ..... ***E. phthorimaeae* Ferrière (♀, ♂)**

13 Hind tibia with one spur at apex ..... ***Metaplectrus szepligetii* (Erdös) (♀, ♂)**

– Hind tibia with two spurs at apex (as in Fig. 36) (genus *Platyplectrus*) **14**

14 Scutellum smooth and shiny, without reticulation (Fig. 57) **15**

– Scutellum reticulate (Fig. 58) **16**

15 Petiole about twice as long as wide; flagellomeres long in both sexes, e.g. funicular 2&3 in female both 1.3× as long as wide (Fig. 62), in male 1.1 and 1.3× respectively ..... ***Platyplectrus laeviscuta* (Thomson) (♀, ♂)**

– Petiole transverse; flagellomeres short in both sexes, e.g. funicular 2&3 in female both 0.8× as long as wide (Fig. 61), in male 1.0× (Erdös 1966) ..... ***Platyplectrus bouceki* (Erdös) (♀, ♂)**

16 Occipital margin with a sharp carina (Fig. 59) ..... ***Platyplectrus pannonica* (Erdös) (♀, ♂)**

– Occipital margin rounded (Fig. 60) ..... ***Platyplectrus chlorocephala* (Nees) (♀, ♂)**

Genus *Euplectrus* Westwood

Euplectrus Westwood, 1832:128. Type species *E. maculiventris* Westwood, 1832:128, by monotypy.

Diplectron Dahlbom, 1857:292. Type species *Pteromalus bicolor* Swederus, 1795:204, designated by Gahan and Fagan 1923:46. Synonymized by Dalla Torre 1898:74.

Pachyscapha Howard, 1897:159. Type species *P. insularis* Howard, 1897:159, by monotypy. Synonymized by Ferrière 1941:38.

Rekabia Cameron, 1904:65. Type species *R. testaceipes* Cameron, 1904:66, by monotypy. Synonymized by Kerrich 1974:636.

Heteroscapus Brèthes, 1918:9. Type species *H. ronnai* Brèthes, 1918:10, by monotypy. Synonymized by De Santis 1980:153.

Heteroscapiscus Ghesquière, 1946:370. Replacement name for *Heteroscapus* Brèthes.

Biology

Species of *Euplectrus* are all parasitoids on Lepidoptera caterpillars that live exposed on their food plant and their life-history is very interesting, including some unique features (e.g. Hansson et al. 2015). Prior to egg-laying the female wasp injects a substance that prohibits further ecdysis by the host caterpillar – moulting would shed the parasitoid

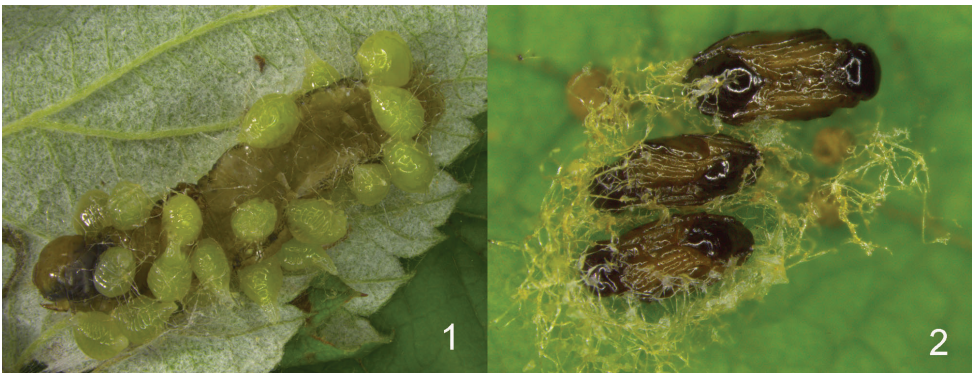
eggs/larvae that are attached to the cuticle. The female wasp then lays her eggs on the host, usually several per host and if the host is large several hundred eggs may be deposited, but occasionally if the host is small, only one egg per caterpillar is laid. The eggs are anchored in the cuticle of the caterpillar, usually on the dorsum. When the wasp larvae hatch they will remain attached to the same spot where the eggs were anchored (Fig. 1), using the egg shell as a pad to which they attach themselves to the host and they are difficult to scrape off. After completed development the wasp larvae pupate on, under or beside the (now) dead host, but before they pupate they spin a loose cocoon (Fig. 2), a feature that is unique within the entire Chalcidoidea. The spin is produced by modified Malpighian tubules and is secreted through the anal opening. The adult wasps emerge after a few days, the number of days depend on the ambient temperature and *Euplectrus* species.

Species treatments

Euplectrus geometricida sp. n.

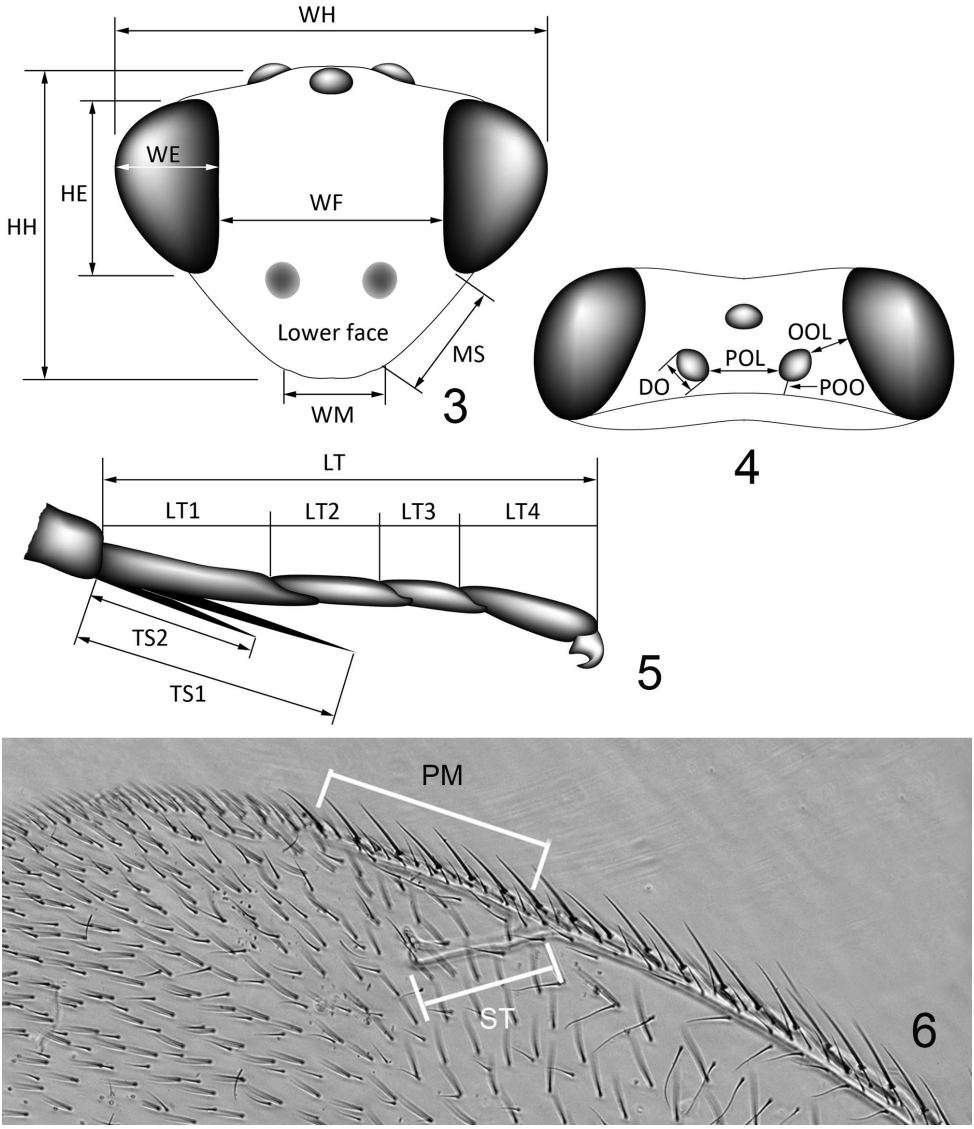
http://zoobank.org/FD397708-4CE5-470E-B979-FC5A90FAABBF
Figures 15, 17–19, 52

Material. Holotype female labeled "CZECH REPUBLIC: Mikulcice, 48,808N, 17,094E, 169m, 21-May-2013, M. Volf, Sample BC-ZSM-HYM-23872-E10, CO1-5p 652(0)bp BOLD: ACU3230", from *Colotois pennaria* on *Carpinus betulus*, in ZSM. Paratypes (133♀ 88♂): **CZECH REPUBLIC** (38♀ 54♂, in MZLU, NHM, ZSM): 1♀ 2♂ with same label data as holotype; following from same locality as holotype but collected 22-May-2013 from *Agriopis marginaria* on *C. betulus* (1♀), 23-May-2013 from *A. marginaria* on *C. betulus* (2♀ 1♂), 27-May-2013 from *Operophtera brumata* on *C. betulus* (2♂), 29-May-2013 from *Alsophila aescularia* on *C. betulus* (2♀), 31-May-2013 from *C. pennaria* on *C. betulus* (1♂), *A. aescularia* on *C. betulus* (1♂), 01-June-2013 from *A. aescularia* on *C. betulus* (1♀); "CZECH REPUBLIC: obora Soutok, Lanzhot, 48,69N, 16,945E, 165m, 08-May-2014, P. Drozd", from *A. marginaria* on *C. betulus* (13♀ 16♂), *A. aurantiaria* on *C. betulus* (7♀ 2♂), *A. aurantiaria* on *Tilia cordata* (1♀), *Epirrita dilutata* on *C. betulus* (3♀), *Phigalia pilosaria* on *C. betulus* (2♀ 2♂), unidentified Geometridae on *C. betulus* (2♀ 18♂); following from same locality as previous but collected 16-May-2013, from *Agriopis* sp. on *C. betulus* (1♂), 19-May-2013, from unidentified larva on *C. betulus* (2♂), *O. brumata* on *C. betulus* (2♂), 04-May-2014, from *Phigalia pilosaria* on *Acer campestre* (2♂), 05-May-2014, from *A. marginaria* on *C. betulus* (1♀), *O. brumata* on *Quercus cerris* (1♀ 2♂), 09-May-2014, from *A. aurantiaria* on *T. cordata* (1♀). **FINLAND** (44♀ 7♂, in MZH, MZLU): 1♀ "FINLAND, Ab: Lohjan kunta, 6693:334, 21.6.1991, M. Koponen leg."; 1♀ "FENNIA: EH, Hämeenlinna, 1978, P. Somerma leg."; 2♀ "SUOMI: EH, Janakkala, 6754:369, 19.8.1979, M. Koponen leg."; 1♂ "SUOMI: EH, Janakkala, 6760:369, 24.8.1980, M. Koponen leg."; 1♀ "SUOMI: EH, Lammi, 6773:394, 19.9.1982, M. Koponen leg."; 1♀ "SUOMI:



Figures 1–2. *Euplectrus bicolor* (Swederus): **1** larvae on caterpillar of *Orthosia* sp. (Lepidoptera: Noctuidae) **2** pupae with spin threads. Photo courtesy Špela Modic.

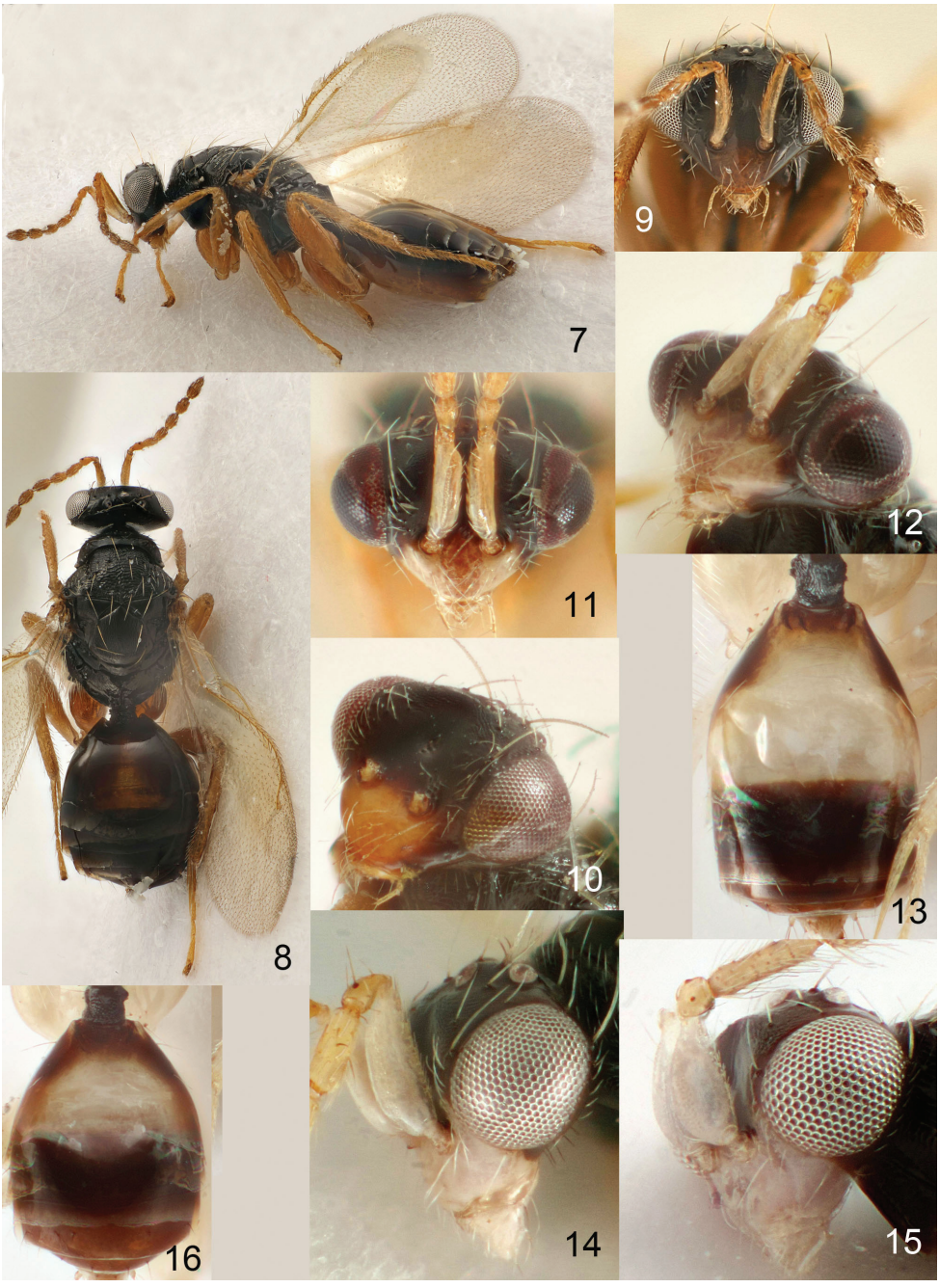
ES, Mikkelin mlk. 6830:501, 7.8.1989, M. Koponen leg."; 3♀ "SUOMI: ES, Ristiina, 6830:502, 5.8.1978, M. Koponen leg."; 1♂ "SUOMI: ES, Ristiina, 6826:502, 2.8.1981, M. Koponen leg."; 1♀ "SUOMI: KP, Vimpeli, 7015:346, 18.8.1982, M. Koponen leg."; 1♀ "SUOMI: PH, Rautalampi, 6961:484, 17.7.1983, M. Koponen leg."; 1♀ "SUOMI: PP, Pello, 7248:372, 5.7.1982, M. Koponen leg."; 1♀ "SUOMI: PP, Yli-Ii, 7248:444, 21.7.1980, M. Koponen leg."; 1♀ "SUOMI: PP, Ii, 7249:424, 11.8.1982, M. Koponen leg."; 1♀ "FINLAND, Sa, Ristiina, 6824:503, 10.7.1993, M. Koponen leg."; 1♀ "SUOMI: U. Helsinki, 6682:383, 6.9.1980, M. Koponen leg."; 1♀ "SUOMI: U. Hyvinkää, 6716.374, 2.6.1979, M. Koponen leg."; following from same locality as previous but collected 14.v.1983 (1♀), 19.vi.1983 (1♀), 31.vii.1984 (1♀); 1♀ "SUOMI: U. Nurmijärvi, 6718:381, 17.6.1979, M. Koponen leg."; 1♀ "SUOMI: U. Nurmijärvi, 6712:370, 11.6.1989, M. Koponen leg."; 1♀ "SUOMI: U. Nurmijärvi, 8713:386, 28.7.1989, M. Koponen leg."; 1♂ "SUOMI: U. Nurmijärvi, 6710:381, 1.9.1993, M. Koponen leg."; 1♂ "SUOMI: V, Vihti, 6717:366, 17.8.1975, M. Koponen leg."; 1♀ "Nystad, Hellén" "29.7.1923"; 1♀ "Nystad, Hellén" "26.8.1914"; 1♀ "Nystad, Hellén" "25.8.1923"; 1♀ "FENNIA, Hammarland, 3.8.1953, W. Hellén"; 1♀ "Sibbo, Norrkulla, 8-11.8.57, Hellén"; 1♀ "Suomi V Turku, 10.10.1949, E.K. Lahtiperä leg."; 1♀ "Kivinebb, K. Ehnberg"; 1♀ "Fennia, Bobäck, Hellén"; 1♀ "Fennia, Luumäki, Hellén"; 1♀ "Fennia, Oa, Maxmo, 4-14.6.46, Hellén"; 1♀ "Hauho, Hiiriniemi, 14.8.1935, Hellén"; 1♀ "Hauho, 1935, Hellén"; 1♀ "Keuru, 14.8.1928, Hellén"; 2♀ "Terijoki, 25.8.1927, Hellén"; 1♀ "Parikkala, Laurila, 15.7.1940, Hellén"; 1♀ "Parikkala, Hellén"; 1♀ "Vammeljoki, 4.8.1927, Hellén"; 1♀ "Fennia, Taipalsaari, Hellén"; 1♂ "P. Pirkkala, Grönblom, 11/7 1913"; 1♀ "Finland, AI, Lemland, Flaka, 1956, Vaselius"; 1♂ "Fennia, Lemland, 5.8.53, W. Hellén"; 1♂ "Fennia, Nurmes, 21.7.1939, A. Saarinen"; 1♀ "Tvärminne, Storå, Storkärret, medio 7.35, e.l. Agr. subr", from *Agrotis segetum*. **FRANCE** (20♀ 12♂, in NHM, leg. M.W.R. de V. Graham): 2♂ "FRANCE: Auvergne, nr. Les Essards (oakwood), 7.viii.1973"; 4♀ "FRANCE: Auvergne, S. bank of river Rhone, nr Essards, 7.viii.1973"; 1♀ "FRANCE: B. du Rhone, Fonscolombe (1),



Figures 3–6. *Euplectrus* terminology, schematic illustrations: **3** head in frontal view **4** vertex **5** apex of hind leg with tibial spurs and tarsus **6** part of left forewing. For explanation of abbreviations see text above "Abbreviations of morphological terms".

24.vii.1984"; following from same locality but collected 2.vii.1980 (1♂), 21.vi.1982 (1♂), 10.viii.1983 (1♂), 10.vii.1986 (2♀), 14.viii.1986 (1♂); 1♀ "FRANCE: B. du Rhone, Rognes, 13.vii.1978"; 1♀ "FRANCE: B. du Rhone, nr. Rognes, 24.vii.1974"; 3♀ 4♂ "FRANCE: Drôme, Le Poet-en-Percip (2), 21.viii.1990"; 1♀ "FRANCE: Drôme, Montagne de Bluye, 18.vii.1974"; 1♂ "FRANCE: Haute-Loire, nr. Lubilhac, 20.vii.1977"; 1♀ "FRANCE: Provence, Alpes de Haute, 2km N of Reillane, 21.vii.1978"; 1♀ "FRANCE: Provence, Alpes de Haute, nr. Reillane, 17.vii.1978";

1♂ "FRANCE: Var: St. Tropez, 6.vi.1980, Bouček"; 1♀ "FRANCE: Vaucluse, nr Bèdoin (2), 13.vii.1980", 1♀ from same locality but collected 19.vii.1983; 1♀ "FRANCE: Vaucluse, nr Col de Murs, 27.vii.1975"; 1♀ "FRANCE: Vaucluse, Mt. Ventoux, Massif des Cèdres, 25.viii.1975"; 1♀ "FRANCE: Vaucluse, Sérignan, 29.6.1977". **ITALY** (1♂): "PIEMONTE, Castel, D.Bosca, 12.viii1954, A. Goidanich leg" (NHM). **THE NETHERLANDS** (1♀): "NETHERLANDS, Gelderland, Ede, Edense Heide, 52.056N, 5.7E, 30m, 09-Aug-2005", from *Anarta myrtilli* (ZSM). **POLAND** (3♂): "POLAND, Dybki, Mazovia, 52.7333N. 21.7166E, 108m, 19-May-2016, M. Shaw" (ZSM). **ROMANIA** (1♀): "Romania: Iaşi, Bârnova Forest, nr Slobozia, 47°00'41"N, 27°36'11"E, 290m, 4.vii.2011, J.S.Noyes" (NHM). **SWEDEN** (20♀ 10♂): 1♀ "Bohuslän, Ljung, Lyckorna, Bo Tjeder, 25/6 -46" (MZLU); 1♀ "Lycksele Lappmark, Vilan, 20.7.1981, K.-J. Hedqvist" (NHM); 2♀ "Lycksele Lappmark, Tärna, 3.8.1956, K.-J. Hedqvist" (NHM); 1♂ "Norrbotten, Haparanda, 23.7.66, A. Sundholm" (MZLU); 1♂ "Skåne, Åhus, 14.7.1957, leg. K.-J. Hedqvist" (NHM); 1♀ 5♂ (one male without head) on same pin "Skåne, Vånga, utkl. 1/7 06" (MZLU); 1♀ "S: Småland, Växjö, Åryd, 3.VII.1989, leg. R. Danielsson (DAYS)" (MZLU); 1♀ "Södermanland, Röm., 1937, A.J." (MZLU); 1♀ "SWEDEN: Södermanland, Haninge kn, Tyresta, 59.107N, 18.138E, 18.vi.2004, SMTP" (SMTP); 1♀ "SWEDEN: Södermanland, Haninge kn, Tyresta, Urskogsslingan, 59.10N, 18.14E, 28.1–28.iv.2004, SMTP" (SMTP); 1♀ "Södermanland, Tungelsta, 13.6.1957, B. Hansson", from *Angerona prunaria* (NHM); 1♂ "Runmarö, Geometrid, 8.1916" "F.N.m" [=Frithiof Nordström] (MZLU); 1♀ "SWEDEN: Uppland, Älvkarleby kn, Båtfors, 60°27'38.3"N, 17°19'4.1'E, 26.viii-9.ix.2003, SMTP" (SMTP); 1♀ "Uppland, Frösunda, 21.x.1977, leg. K.-J. Hedqvist" (NHM), following from same locality but collected 24.8.1973 (1♂), 29.7.1977 (1♂) (NHM); 1♀ 1♂ "Uppland, Älvkarleby, Komossen, Kl. 15.6.1981, Nils Ryrholm" "Ur larv av Cleora repandata", from *Alcis repandata* (NHM); 1♀ "SWEDEN: Värmland, Ransäter, Rudstorp, 59.46N, 13.28E, 7–15.vii.2005, SMTP" (SMTP); 1♀ "SWEDEN: Värmland, Munkfors kn, Ransäter, Ransberg herrgård, 59.47N, 13.25E, 12.ix.2005–19.ii.2006, SMTP" (SMTP); 1♀ "SWEDEN: Västerbotten, Vindelns kn, Svartbergets försökspark, 64.138N, 19.471E, 22.ix.2003, SMTP" (SMTP); 1♀ "SWEDEN: Västerbotten, Vindelns kn, Kulbäckslidens trail park, 64°09'16.2"N, 19°35'35.5"E, 1–22.ix.2003, SMTP" (SMTP); 1♀ "Västerbotten., Hällnäs, 20.9.1956, K.-J. Hedqvist" (NHM); 1♀ "Ångermanland, Mjällom, 28.7.1989, K.-J. Hedqvist" (NHM); 1♀ "Sweden: Öland, Jordtorpsåsen, Kvarnbackarna, 56°40'44.3"N, 13°34'51.0"E, 27.vii.2015, C. Hansson" (MZLU); 1♀ "Östergötland., Ändebol, 1–4.9.1955, K.-J. Hedqvist" (NHM). **SWITZERLAND** (1♀): "Helvetia, umgb Aarau, 25.v.1926" (NHM). **UNITED KINGDOM** (9♀ 1♂, in NHM, leg. M.W.R. de V. Graham): 2♀ "ENGLAND: Berks., Wytham Wood (2), 1.ix.1959", following from same locality but collected 18.vii.1958 (2♀), 25.vii.1958 (3♀); 1♀ "ENGLAND: Bucks., Hell Coppice (5), nr Oakley, 24.vi.1958"; 1♂ "ENGLAND: Cambs., Peterborough, Castor Hanglands, NNR"; 1♀ "ENGLAND: Oxon, Otmoor (3), 12.viii.1955".



Figures 7–16. *Euplectrus* spp.: **7–12** *E. bicolor* (Swederus) **7–9** neotype, female **7** habitus lateral **8** habitus dorsal **9** head frontal **10** non-type female, head front-lateral **11** head frontal, male **12** head front-lateral, male **13** *E. flavipes* (Fonscolombe), gaster dorsal, male **14–15** head including scape lateral, male **14** *E. maculiventris* Westwood **15** *E. geometricida* sp. n. **16** *E. carinifer* sp. n., gaster dorsal, male.

Diagnosis. Entire frons below level of toruli white to yellowish white, including part below eye (Figs 17, 18), some specimens with a very narrow dark stripe close to eyes; male scape 2.0–2.3× as long as wide; reticulation on median part of scutellum with elongate meshes (Fig. 52); with a groove between scutellum and dorsellum (Fig. 52).

Description (holotype female). Length of body 2.4 mm, female paratypes 1.9–2.4 mm. Antenna with scape yellowish-white with apical ⅓ yellowish-brown, pedicel and flagellum yellowish-brown. Mandibles and palpi yellowish-white. Head black, lower face yellowish-white, reaching to eyes and also below eyes (Fig. 17). Frons smooth, medially with a reticulate band reaching from eye to eye; close to eyes with scattered setae in lower ½ (Fig. 17). Vertex smooth and shiny. Occipital margin with a carina behind ocellar triangle.

Mesosoma black and shiny; midlobe with raised and strong reticulation, meshes isodiametric, midline on midlobe of mesoscutum indicated by a carina (Fig. 52), carina sometimes replaced by a change in the reticulation in posterior ⅓. Scutellum 1.0× as long as wide; with strong reticulation, meshes elongate (Fig. 52). Dorsellum with a deep groove along anterior margin (Fig. 52), groove medially 0.2× as long as length of dorsellum. Propodeum smooth and shiny (Fig. 52); anteromedially with a semicircular cup that is strongly raised in posterior part; propodeal callus with 19 setae. Legs yellowish-white, except yellowish-brown hind coxa and hind femur. Forewing: costal cell with two rows of setae on ventral surface, and margin with six setae close to marginal vein; with 15 admarginal setae.

Gaster dark brown with an inverted T-shaped white area in anterior ½ (Fig. 19).

Ratios. HE/MS/WM = 1.8/1.0/1.1; POL/OOL/POO = 9.7/4.3/1.0; OOL/DO = 1.4; WE/WF/WH/HH = 1.0/2.1/3.9/2.8; WH/WT = 1.0; PM/ST = 1.8; TS1/TS2/LT/LT1/LT2/LT3/LT4 = 4.6/3.1/7.4/2.4/1.4/1.0/1.9; LP/WP = 0.9; MM/LG = 1.3.

Male. Length of body 1.7–2.4 mm. Scape white, 2.0–2.3× as long as wide, widest medially, with sensory pores along entire ventral margin, sensory area white. Gaster with anterior ½–⅔ white with narrow dark brown margins, posterior part dark brown. Otherwise similar to female.

Ratios. LC/WS = 2.0–2.3, LP/WP = 1.0.

Hosts. Geometridae: *Agriopis aurantiaria* (Hübner) on *Carpinus betulus* and *Tilia cordata*, *Agriopis marginaria* (Fabricius) on *C. betulus*, *Alcis repandata* (L.), *Alsophila aescularia* (Denis & Schiffermüller) on *C. betulus*, *Angerona prunaria* (L.), *Colotois pennaria* (L.) on *C. betulus*, *Epirrita dilutata* (Denis & Schiffermüller) on *C. betulus*, *Macaria brunneata* (Thunberg) on *Vaccinium myrtillus*, *Operophtera brumata* (L.) on *C. betulus* and *Quercus cerris*, *Phigalia pilosaria* (Denis & Schiffermüller) on *Acer campestre* and *C. betulus*. **Noctuidae**: *Agrotis segetum* (Denis & Schiffermüller), *Anarta myrtilli* (L.), *Orthosia opima* (Hübner) on *Vaccinium* sp.

Distribution. Czech Republic, Finland, France, Italy, the Netherlands, Poland, Romania, Sweden, Switzerland, United Kingdom.

Etymology. Named after preferred target group, geometrid caterpillars. From the Latin suffix *–cida*, which means “killer”.

Genetic data. The species exhibits high levels of intraspecific variation, with a maximum of 11.6%, but a clear separation from the next neighbour, with a distance of 10.8% to the next neighbour species, *E. carinifer* (Fig. 63). The populations of the species segregate into several subclusters, each with its own Barcode Index Number. Four of the six subclusters were recorded from one country (Czech Republic) whereas two were recorded in two or more countries (Suppl. material S1). The presence of several distinct subclusters within the species indicates the presence of more than one species, but morphological analysis did not reveal any reliable characters for separating the species.

***Euplectrus carinifer* sp. n.**
http://zoobank.org/4D4F531F-2F74-4D5C-9FD8-F8A466716695
Figures 16, 20–22, 53

Material. Holotype female labelled " CZECH REPUBLIC: Mikulcice, 48.808N, 17.094E, 169m, 21-May-2013, M. Volf, Sample BC-ZSM-HYM-27734-H05, CO1-5p 591 (0)bp BOLD: ACU2970", from *Amphipyra pyramidea* on *Carpinus betulus*, in ZSM. Paratypes (2♀ 6♂): 1♂ with same label data as holotype (ZSM); following from same locality as holotype but collected 22-May-2013, from *Orthosia cruda* on *C. betulus* (2♂, MZLU, NHM), *Perigrapha munda* on *C. betulus* (2♀, MZLU, NHM), 24-May-2013 from *P. munda* on *C. betulus* (2♂, ZSM); 1♂ "CZECH REPUBLIC: obora Soutok, Lanzhot, 48,69N, 16,945E, 165m, 16-May-2013, P. Drozd", from *Carcina quercana* on *Acer campestre* (ZSM); 3♀ "NETHERLANDS ZH Delft 30-VIII-2009 e.l., leg S. Wegh, ex *Autographa gamma*" (ZSM).

Diagnosis. Frons below level of toruli with pale area not extending laterally to the eye but with a wide dark stripe between pale area and eye, in both sexes (Figs 20, 21); midlobe of mesoscutum with a complete median carina (Fig. 53); with a narrow groove between scutellum and dorsellum (Fig. 53); female gaster with wide brown margins (Fig. 22).

Description (holotype female). Length of body 2.0 mm, female paratypes 2.1–2.2 mm. Antennal scape yellowish-white with apical ½ yellowish-brown, pedicel and flagellomeres yellowish-brown. Mandibles and palpi yellowish-white. Head black with yellowish-brown clypeal area, pale area does not extend to eyes (Fig. 20). Frons smooth except a reticulate band closer to anterior ocellus than to toruli reaching from eye to eye, close to eyes with two rows of setae (Fig. 20). Vertex smooth and shiny. Occipital margin with a carina behind ocellar triangle.

Mesosoma black and shiny; midlobe with raised and strong reticulation, meshes ±isodiametric, midlobe of mesoscutum with a complete median carina (Fig. 53). Scutellum 1.0× as long as wide; with engraved reticulation, meshes small and isodiametric in median part and larger and elongate in lateral part, except smooth and shiny posterior margin (Fig. 53). Dorsellum with a narrow groove along anterior margin (Fig. 53), groove medially 0.3× as long as length of dorsellum. Propodeum smooth and shiny (Fig. 53); anteromedially with a triangular cup that is strongly raised in posterior part; propodeal callus with

12 setae. Legs pale yellowish-brown. Forewing: costal cell with two rows of setae on ventral surface, and margin with four setae close to marginal vein; with 14 admarginal setae.

Gaster dark brown, anterior ½ with a wide white stripe medially, stripe 2× as wide as width of petiole and expanding in posterior part, and with apex pale (Fig. 22).

Ratios. HE/MS/WM = 2.1/1.0/1.0; POL/OOL/POO = 6.3/2.9/1.0; OOL/DO = 1.4; WE/WF/WH/HH = 1.0/2.4/4.2/3.2; WH/WT = 1.0; PM/ST = 1.3; TS1/TS2/LT/LT1/LT2/LT3/LT4 = 3.5/2.2/7.2/2.0/1.6/1.0/2.0; LP/WP = 1.0; MM/LG = 1.2.

Male. Length of body 1.8–2.0 mm. Scape slightly enlarged, widest medially, with sensory pores along entire ventral margin. Similar to female except gaster with anterior ½ white with dark brown lateral margins, posterior ½ dark brown (Fig. 16).

Ratios. LC/WS = 2.8–3.0, LP/WP = 1.0.

Hosts. Noctuidae: *Amphipyra pyramidea* (L.) on *Carpinus betulus*, *Autographa gamma* (L.), *Orthosia cruda* (Denis & Schiffermüller) on *C. betulus*, *Perigrapha munda* (Denis & Schiffermüller) on *C. betulus*. **Depressariidae**: *Carcina quercana* (Fabricius) on *Acer campestre*.

Distribution. Czech Republic, the Netherlands.

Etymology. Named after complete median carina on midlobe of mesoscutum. From the Latin *carina* (=keel) and the suffix *–fer* (=carry).

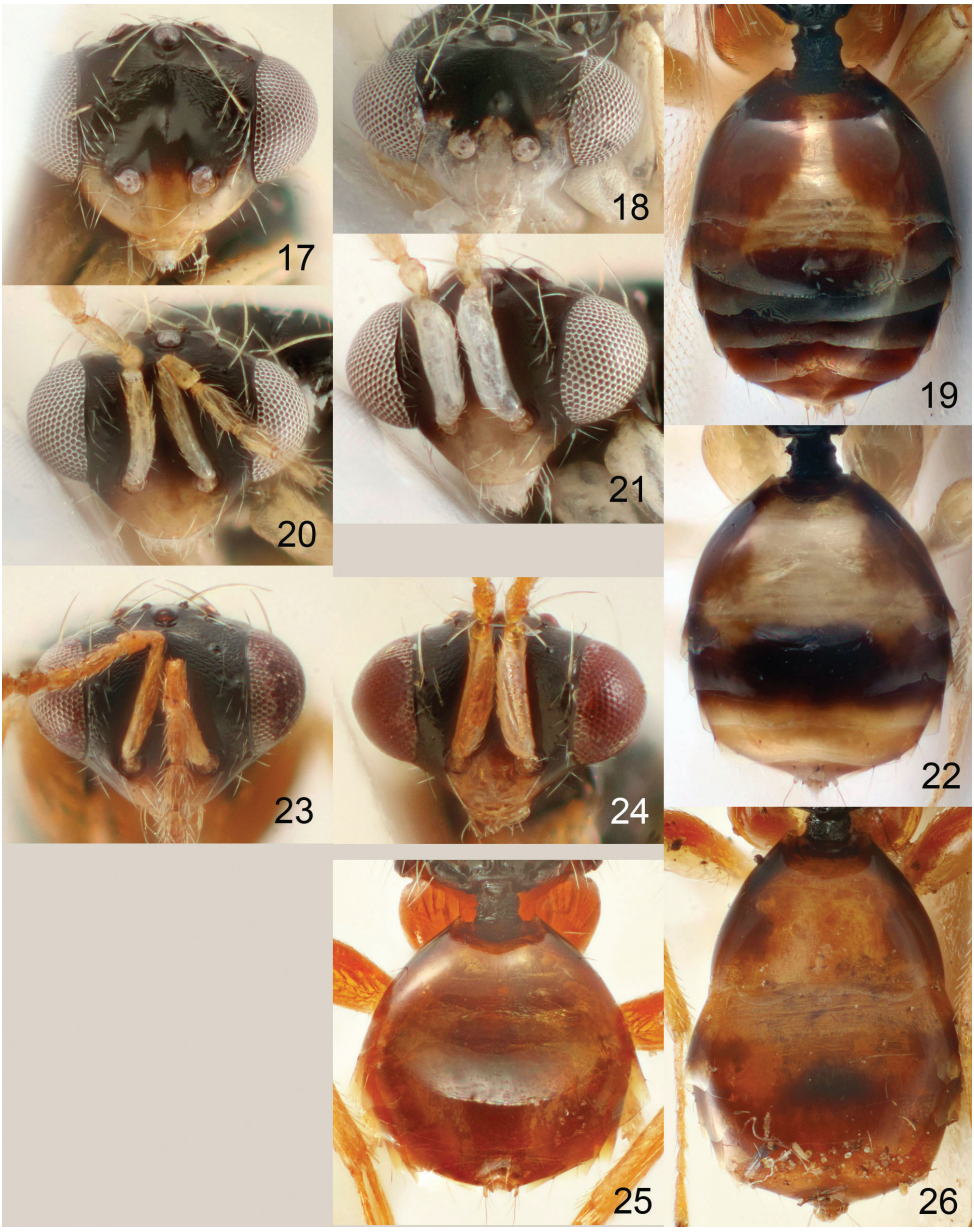
Genetic data. The species consists of several subclusters, each assigned a different BIN by the BOLD system (Fig. 63) and a maximum intraspecific variation of 8.7%. Three of the subclusters occur in the Czech Republic, whereas the fourth was recorded from the Netherlands (Suppl. material S1). The high levels of intraspecific variation suggest the presence of more than one species, but in absence of reliable morphological characters for separating the MOTUs the populations are treated as a single species until more material from other regions and additional genetic data will allow a more thorough examination of the species status of each of the populations.

Euplectrus pallidigaster sp. n.

http://zoobank.org/B368575A-16F2-4C75-ADFB-25C61DD122B9

Figures 23–26, 54

Material. Holotype female labelled ”FRANCE: B du Rhone [possibly meaning “Bouches-du-Rhone], Fonscolombe, 20.vii.1979”, in NHM. Paratypes (20♀ 8♂): **FRANCE** (17♀ 8♂, in NHM, MZLU, leg. M.W.R. de V. Graham): following from same locality as holotype but collected 13.vii.1984 (1♀), 1.viii.1984 (1♀), 24.vi.1986 (1♀), 1.vii.1986 (1♀), 10.vii.1986 (1♀), 17.vii.1986 (1♀); 4♀ “FRANCE: Drome, Le Poet-en-Percip, (2), 3.viii.1990”, 1♂ from same locality but collected 21.viii.1990; 1♀ 2♂ “FRANCE: Gard, Causse de Blandas, (2), 8.viii.1984”; 1♀ ”FRANCE: Gard, Estezargues, nr. Remoulins, on elm leaf, 23.vi.1977”; 1♂ “FRANCE: Vaucluse, Beauregard, nr Gigondas, 19.ix.1989”; 1♀ “FRANCE: Vaucluse, nr Bèdoin, (1), 20.vii.1981”, following from same locality but collected 11.vii.1980 (1♀), 15.vii.1981 (2♂), 22.vii.1981 (1♀), 28.vii.1981 (1♂); 2♀ “FRANCE: Vaucluse, Mt Ventoux, Col de Perrache, (2), 6.viii.1979”; 1♂ “FRANCE: Vaucluse, Mt Ventoux, about Rte. de Per-



Figures 17–26. *Euplectrus* spp.: **17–19** *E. geometricida* sp. n., paratypes **17** head frontal, female **18** head frontal, male **19** gaster dorsal, female **20–22** *E. carinifer* sp. n., paratypes **20** head frontal, female **21** head frontal, male **22** gaster dorsal, female **23–26** *E. pallidigaster* sp. n., paratypes **23** head frontal, female **24** head frontal, male **25** gaster dorsal, female **26** gaster dorsal, female.

rache, (3), 11.viii.1976". **ITALY** (2♀): 1♀ "ITALY, Malcesine, 200–300m, 23.4.1977, leg. V. Vikberg" (MZH); 1♀ "ITALIA: Varazze, nr Genova, 4.IX.71, Bouček" (NHM). **SPAIN** (1♀): "SPAIN: Barcelona, Calella d. Costa, VI.1971, Bouček" (NHM).

Diagnosis. Frons with clypeal area yellowish-brown (Figs 23, 24); scutellum with engraved reticulation, meshes ±isodiametric (Fig. 54); without a groove between scutellum and dorsellum (Fig. 54); female gaster dark yellowish-brown with anterolateral corners dark (Fig. 25), in some specimens also with a round black spot in medioposterior part (Fig. 26).

Description (holotype female). Length of body 1.9 mm, female paratypes 1.6–2.6 mm. Antenna yellowish-brown, flagellomeres 4–6 slightly darker than scape and pedicel. Mandibles and palpi yellowish-white. Head black and shiny, with clypeal area yellowish-brown (Fig. 23). Face and median part of frons smooth, remaining part of frons with weak reticulation, close to eyes with two rows of setae (Fig. 23). Vertex smooth and shiny. Occipital margin with a carina behind ocellar triangle.

Mesosoma black and shiny; midlobe with raised and strong reticulation, meshes slightly transverse, midlobe of mesoscutum with a weak median groove in posterior ⅓ (Fig. 54). Scutellum 1.0× as long as wide; with engraved reticulation, meshes slightly elongate, except smooth and shiny posterior margin (Fig. 54). Without groove between scutellum and dorsellum (Fig. 54). Propodeum smooth and shiny medially, with weak reticulation laterally (Fig. 54); anteromedially with a semicircular cup that is raised in posterior part; propodeal callus with 10 setae. Legs yellowish-brown. Forewing: costal cell with two irregular rows of setae on ventral surface, and margin with five setae close to marginal vein; with 13 admarginal setae.

Gaster circular, dark yellowish-brown with anterolateral corners dark brown (Fig. 25).

Ratios. HE/MS/WM = 2.1/1.2/1.0; POL/OOL/POO = 8.0/4.3/1.0; OOL/DO = 1.6; WE/WF/WH/HH = 1.0/2.4/4.2/3.1; WH/WT = 1.0; PM/ST = 1.7; TS1/TS2/LT/LT1/LT2/LT3/LT4 = 4.1/2.9/6.9/2.3/1.4/1.0/1.3; LP/WP = 0.8; MM/LG = 1.3.

Variation. Several female paratypes have a dark round spot posteromedially on gaster (Fig. 26).

Male. Length of body 1.7–2.5 mm. Scape slightly enlarged, widest medially, with sensory pores along entire ventral margin. Similar to female except scutellum with ±isodiametric meshes, and gaster with posterior ½ dark brown.

Ratios. LC/WS = 2.7–2.9, LP/WP = 1.0–1.1.

Hosts. Unknown.

Distribution. France, Italy, Spain.

Etymology. From the Latin *pallidus*, meaning pale, referring to the predominantly pale gaster in female.

Genetic data. No specimens of the species were available for genetic analysis.

Euplectrus bicolor (Swederus)

Figures 1–2, 7–12, 48, 55

Pteromalus bicolor Swederus, 1795:204. Neotype female, **designated here**, in MZLU. Combined to *Eulophus* by Walker (1839:173), and to *Euplectrus* by Haliday (1844:297).

Elachertus albiventris Spinola, 1811:151. Combined to *Eulophus* by Haliday (1842:plate J) and to *Euplectrus* by Walker (1872b:112); synonymized with *E. bicolor* by Bouček and Askew (1968:15).

Material. Type material: Neotype female labelled "Sweden: Skåne, Kranke, Ekskogen, 55°41'10.3N, 13°27'40.2E, 5.vii.2015, C. Hansson", "BC-ZSM-HYM-25460-C11" in MZLU. Additional material (440♀ 306♂): Finland: 13♀ 8♂ (VV), 163♀ 125♂ (MZH, MZLU), this material includes 1♀ 1♂ from *Eugraphe subrosea*, 1♀ 4♂ from *Agrotis* sp., 4♀ 14♂ from *Orthosia opima*, 1♀ from *Xylina* sp., 4♀ 2♂ from a "polyphagous noctuid"; France: 18♀ 4♂ (NHM); Greece: 1♀ (MZLU); Hungary: 1♂ (MZLU); Norway: 1♀ 1♂ (VV); Slovenia 6♂ (MZLU), this material includes 6♂ from *Orthosia* sp. on raspberries (*Rubus idaeus*); Sweden: 179♀ 211♂ (MZLU, NHM, ZSM); United Kingdom: 65♀ 54♂ (NHM), this material includes 6♀ from *Diarsia mendica*, 7♀ 14♂ from *Mamestra brassicae*, 9♀ 26♂ from *Polia hepatica*, 14♀ 8♂ from *Polia nebulosa*. Detailed geographic information of all barcoded specimens is listed in Suppl. material S1.

Diagnosis. Frons below level of toruli with pale area not extending laterally to the eye but with a dark stripe between pale area and eye, in the female dark area is wider (Figs 9, 10) than in the male (Figs 11, 12); midline on midlobe of mesoscutum usually indicated by either a median carina (Fig. 48) or a median groove in posterior ½, in some specimens midline indicated just through a change in the reticulation; posterior part of midlobe mesoscutum narrow (Figs 48, 55), ratio width base of midlobe (a)/width base of one sidelobe (b) = 0.57±0.070 (female), 0.55±0.070 (male), width base of midlobe/width base of entire mesoscutum = 0.22±0.019 (female), 0.21±0.019 (male), n= 10 for female and male respectively.

Description (neotype). Length of body 2.8 mm (2.0–3.1 mm in additional material). Antenna with scape yellowish-brown with dorsal edge pale brown, pedicel and flagellomeres 1+2 yellowish-brown, flagellomeres 3–6 pale brown. Mandibles and palpi yellowish-brown. Head black and shiny, lower face with median part yellowish-brown reaching laterally to level of outer edge of toruli (Figs 9, 10). Frons smooth except a reticulate band closer to anterior ocellus than to toruli, reaching from eye to eye, close to eyes with two rows of setae (Fig. 9). Vertex smooth and shiny. Occipital margin with a carina behind ocellar triangle.

Mesosoma black and shiny; midlobe with raised and strong reticulation, meshes isodiametric, midline on midlobe of mesoscutum usually indicated by either a median carina (Fig. 48) or a median groove in posterior ½, in some specimens midline indicated just through a change in the reticulation. Scutellum 0.9× as long as wide; with engraved reticulation, meshes elongate, except smooth and shiny posterior margin (Fig. 48). Dorsellum with a very narrow groove along anterior margin (Fig. 48), groove medially 0.1× as long as length of dorsellum. Propodeum smooth and shiny medially, with very weak reticulation laterally (Fig. 48); anteromedially with strongly raised triangular cup in posterior part; propodeal callus with 17 setae. Legs yellowish-brown. Forewing: costal cell with two rows of setae on ventral surface, and margin with four setae close to marginal vein; with 17 admarginal setae.

Gaster dark brown with a yellowish-brown spot in anteromedian part (Fig. 8).

Ratios. HE/MS/WM = 1.8/1.0/1.1; POL/OOL/POO = 9.7/5.3/1.0; OOL/DO = 1.5; WE/WF/WH/HH = 1.0/3.0/5.3/3.6; WH/WT = 1.0; PM/ST = 1.6; TS1/TS2/LT/LT1/LT2/LT3/LT4 = 3.6/2.3/2.3/1.3/1.0/1.8; LP/WP = 0.8; MM/LG = 0.9.

Male. Length of body 1.7–2.4 mm. Scape slightly enlarged, widest medially, with sensory pores along entire ventral margin. Similar to female except wider pale clypeal area (Figs 11, 12), wider scape, longer petiole.

Ratios. LC/WS = 3.1–3.4, LP/WP = 1.0–1.2.

Hosts. *Agrotis* sp., *Diarsia mendica* (Fabricius), *Eugraphe subrosea* (Stephens), *Mamestra brassicae* (L.), *Orthosia opima* (Hübner), *Orthosia* sp. on raspberries (*Rubus idaeus*), *Polia hepatica* (Clerck), *Polia nebulosa* (Hufnagel), *Xylina* sp., a "polyphagous noctuid". All records are from caterpillars of the Noctuidae.

Distribution. Sweden (Swederus 1795), Finland, France, Greece, Hungary, Norway, Slovenia, United Kingdom (new/confirmed records).

Remarks. Neotype designation: the original type material for *E. bicolor* is lost (Graham 1963). Presumably it was originally in the Natural History Museum in Stockholm (Sweden), but cannot be found there. When Swederus described *E. bicolor* he was very parsimonious with information, which was as usual at that time. The description is very short and fits any European species of *Euplectrus*. Biological and geographical information were not included. Swederus was working in Sweden but made scientific trips to several European countries (Waldeck 2018) and it is difficult to be sure from where he had the material forming the base for the description. However, since Swederus was Swedish it is probable that he had access to Swedish material. Therefore, the neotype is selected from Swedish material, and it is selected from material belonging to the species that appears to be the most common in this country. The neotype has a DNA barcode of 621 bp and belongs to one of the two haplotypes that were found within the species (Fig. 63).

Genetic data. Genetically analysed specimens of *E. bicolor* exhibited comparatively high levels of intraspecific variation (maximum 6.5%) but with a distinct gap to the nearest neighbours (*E. intactus*, 10.9% and *E. carinifer*, 10.2%) (Fig. 63). The analysed specimens, all from Sweden, fall into two genetic clusters that occur sympatrically (Suppl. material S2). The absence of morphological characters to separate the two haplotypes does not preclude the possibility that *E. bicolor* consists of two or more species, but analysis of material of other populations and ideally additional (nuclear) gene regions will be required to clarify the status of each population.

Euplectrus flavipes (Fonscolombe)

Figures 13, 33–35, 51

Spalangia flavipes Fonscolombe, 1832:299. Lectotype female, designated by Bouček (1970:88) in OUMNH, examined. Combined to *Euplectrus* by Fonscolombe (1840:192).

Euplectrus cacoeciae Ferrière, 1941:42. Holotype female in NHM, examined. Synonymized with *E. flavipes* by Bouček (1970:88).

Material (74♀ 39♂). Bosnia/Hercegovina: 1♀ (NHM); Cyprus: 19♀ 11♂ (NHM), this material includes 1♀ from *Spodoptera litura*, 6♀ 4♂ from *Spodoptera exigua*, 6♀ ♂ from *Heliothis* sp. on alfalfa (*Medicago sativa*), 22♀ ♂ from *Plusia* sp. on alfalfa; Czech Republic: 20♀ 14♂ (MZLU, ZSM), this material includes 13♀ 8♂ from *Alsophila aescularia* on *Carpinus betulus* and 2♀ and *Populus alba,* 1♂ from *Carcina quercana* on *C. betulus,* 1♂ from *Cosmia trapezina* on *C. betulus,* 3♀ from *Cyclophora annularia* on *Acer campestr*e; France: 15♀ 9♂ (NHM, ZSM), this material includes 1♀ 2♂ from *Alsophila aescularia,* 1♀ from *Colobochyla salicalis*, 1♀ 1♂ from unknown caterpillar on *Sonchus* sp; Greece: 1♀ (MZLU); Hungary: 1♀ (MZLU); Italy:1♀ (NHM); Macedonia: 1♀ (NHM); Romania: 6♀ (MZLU; NHM); Serbia: 3♀ (NHM); Slovenia: 2♀ 1♂ (MZLU, NHM), this material includes 1♀ from unidentified noctuid caterpillar on tomato; Spain: 1♀ 2♂ (NHM); Switzerland: 1♀ 1♂ (MZLU), this material includes 1♀ 1♂ from *Mamestra brassicae*; Turkey: 2♀ 1♂ (NHM), this material includes 2♀ 1♂ from *Plusia* sp. Detailed geographic information of all barcoded specimens is listed in Suppl. material S1.

Diagnosis. Frons below level of toruli with pale area not extending laterally to the eye but with a wide dark stripe between pale area and eye in both sexes (Figs 33, 34); midlobe of mesoscutum with a complete median carina (Fig. 51); female with pale area in anterior ½ of first gastral tergite large and with narrow brown margins, margins about ½ as wide as width of petiole (Fig. 35); male gaster with pale part in anterior ½ reaching margin in posterior part, thus interrupting the dark lateral margins of the gaster (Fig. 13); female gaster with apex pale (Fig. 35).

Hosts. Tortricidae: *Archips rosana* (L.) (Ferrière 1941). **New/confirmed records**: **Depressariidae**: *Carcina quercana* (Fabricius) on *Carpinus betulus.* **Erebidae**: *Colobochyla salicalis* (Denis & Schiffermüller); **Geometridae**: *Alsophila aescularia* (Denis & Schiffermüller) on *C. betulus* and *Populus alba; Cyclophora annularia* (Fabricius) on *Acer campestre;* **Noctuidae**: *Cosmia trapezina* (L.) on *C. betulus*; *Heliothis* sp.; *Mamestra brassicae* (L.); *Plusia* sp.; *Spodoptera exigua* Hübner; *Spodoptera litura* Fabricius, unidentified noctuid caterpillar on tomato (*Solanum lycopersicum*).

Distribution. Bulgaria (Ferrière 1941), France (Fonscolombe 1832), Bosnia/Hercegovina, Cyprus, Czech Republic, Greece, Hungary, Italy, Macedonia, Romania, Serbia, Slovenia, Spain, Switzerland, Turkey (new/confirmed records). This species seems to occur only in Central and South Europe, but not in northern Europe. Hedqvist (2003) listed *E. flavipes* from Sweden, from the province of Södermanland. One of us (CH) has seen this material in coll. Hedqvist (now in NHM), a reared series consisting of 15 females and four males and they are misidentified. Instead these specimens belong to *E. bicolor*.

Genetic data. *Euplectrus flavipes* consists of eight subclusters, each of which was assigned a different BIN by the BOLD system (Fig. 63). The subclustering coincides with a higher than usual intraspecific variation of 5.3%. Geographic subclustering in this species is prominent and four of the haplotypes have been recorded from a single country only, whereas the other haplotypes occurred in two or more countries. In

Romania, three haplotypes, each with a different BIN, represented by four specimens, were recorded (Suppl. materials S1, S2). The analysed specimens do not represent the full distributional range of the species, and it is therefore to be expected that more haplotypes are present in the species. A more comprehensive sampling regime and analysis of more material and additional gene regions is required to assess the status the genetically different populations of *E. flavipes*.

Euplectrus intactus Walker, revised status

Figures 27–29, 49, 56

Euplectrus intactus Walker, 1872a:102. Lectotype female in NHM, examined. Synonymized with *E. bicolor* by Bouček & Askew, (1968: 15).

Material (26♀ 18♂). Belgium: 3♀ 3♂ (ZSM), this material includes 3♀ 3♂ from *Pieris rapae*; France: 1♀ 2♂ (NHM), this material includes 2♂ from a caterpillar on *Artemisia vulgaris*; Hungary: 2♀ 9♂ (MZLU, NHM); Romania: 1♀ (NHM); Sweden: 7♀ 1♂ (MZLU, NHM); United Kingdom: 12♀ 5♂ (NHM), this material includes 1♀ from *Noctua comes* on *Corylus avellana*.

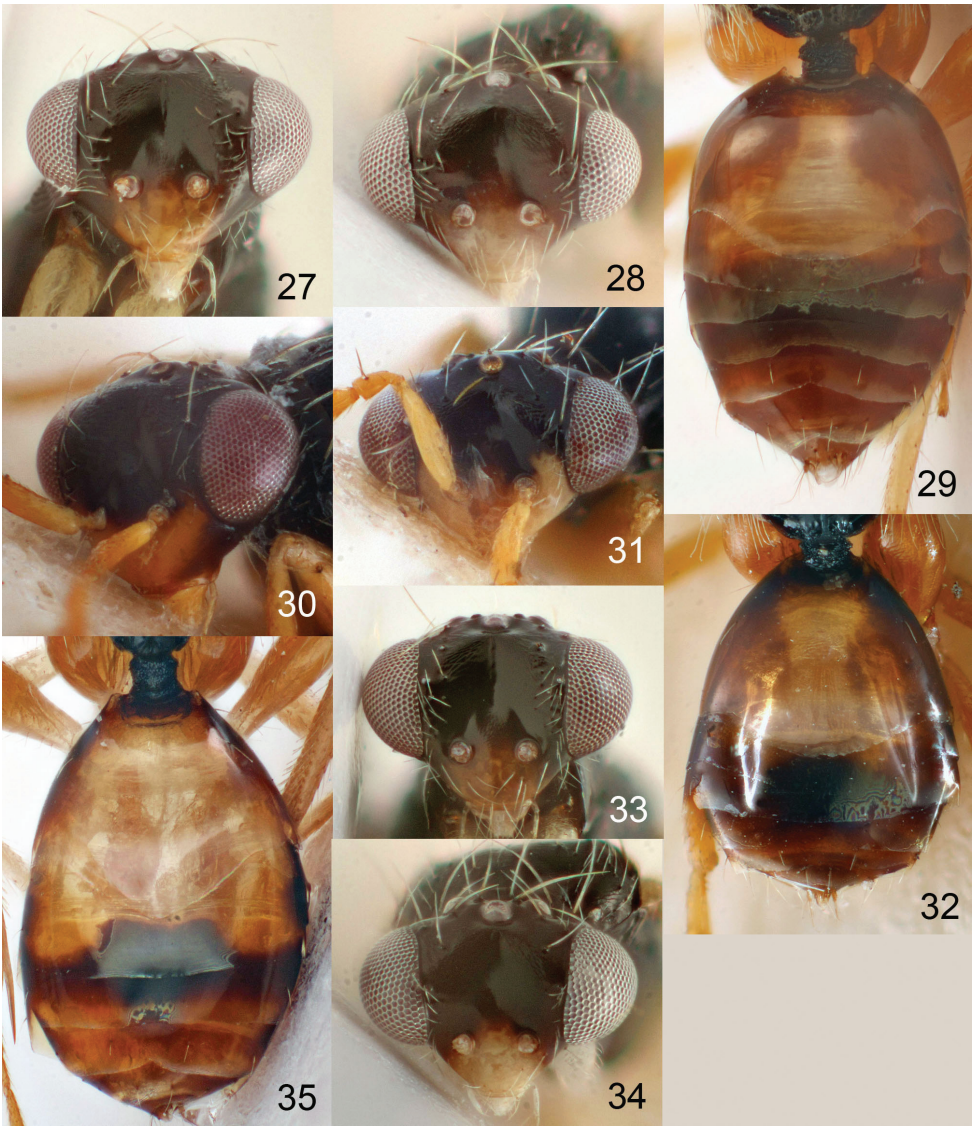
Diagnosis. Frons below level of toruli with pale area not extending laterally to the eye but with a wide dark stripe between pale area and eye in both sexes (Figs 27, 28); midlobe of mesoscutum usually without median groove or carina (Fig. 49, 56) (sometimes with a weak median groove at very base); posterior part of midlobe mesoscutum wide (Fig. 56), ratio width base of midlobe (a)/width base of sidelobe (b) = 0.80±0.048 (female), 0.80±0.054 (male), width base of midlobe/width base of entire mesoscutum = 0.29±0.018 (female), 0.28±0.014 (male), n=9 for female and male respectively. Very similar to *E. bicolor*, distinguished from this species by the wide posterior part of midlobe of mesoscutum.

Hosts. Noctuidae: *Noctua comes* Hübner on *Corylus avellana*. **Pieridae**: *Pieris rapae* (L.). From an unidentified caterpillar on *Artemisia vulgaris*.

Distribution. France (Corsica) (Walker 1872a), Belgium, Hungary, Romania, Sweden, United Kingdom (new/confirmed records).

Remarks. *Euplectrus intactus* was synonymized with *E. bicolor* by Bouček and Askew (1968), but DNA-data and a renewed analysis of the morphology both support that these are different species.

Genetic data. Barcoded specimens of *Euplectrus intactus* exhibited an intraspecific variation of 6.9% and a pronounced geographic subclustering (NJ-tree, Suppl. material S2). One of the nine different haplotypes in *E. intactus* was recorded from four countries (specimens with BIN BOLD:ACR7308 from Hungary and Romania, Sweden and the UK, Fig. 63). The other eight haplotypes were recorded from a single country each. More than one haplotype occurs in Sweden (four haplotypes), Belgium (two haplotypes), and Hungary (three haplotypes). As in the other *Euplectrus* species with high haplotype divergence, a broader sampling from different populations and geographic regions is required to clarify the status of different haplotypes of the species.



Figures 27–35. *Euplectrus* spp.: **27–29** *E. intactus* (Walker) **27** head frontal, female **28** head frontal, male **29** gaster dorsal, female **30–32** *E. maculiventris* Westwood **30** head frontal, female **31** head frontal, male **32** gaster dorsal, female **33–35** *E. flavipes* (Fonscolombe) **33** head frontal, female **34** head frontal, male **35** gaster dorsal, female.

Euplectrus liparidis **Ferrière**

Figures 36–38

Euplectrus liparidis Ferrière, 1941:43. Holotype female in NHM, examined.

Diagnosis. Female with frons below level of toruli completely pale, pale area reaching from eye to eye (Fig. 38); midlobe of mesoscutum without median groove or carina

(Fig. 37); reticulation on scutellum with elongate meshes (Fig. 37); without groove between dorsellum and scutellum (Fig. 37); female gaster with pale area in anterior part as a round spot about as wide as ½ the width of gaster (Fig. 37).

Hosts. From larva of *Lymantria dispar* (L.) (Erebidae) (Ferrière 1941). This host is odd as the larvae are hairy, whereas larvae of all other hosts accounted for in this article are naked.

Distribution. Algeria (Ferrière 1941), Czech Republic & Italy (Zhu and Huang 2003).

Genetic data. No specimens of the species were available for genetic analysis.

Euplectrus maculiventris Westwood

Figures 14, 30–32, 50

Euplectrus maculiventris Westwood, 1832:128. Lectotype female in OUMNH, examined. Combined to *Eulophus* by Haliday (1842:plateJ); synonymized with *E. bicolor* by Bouček and Askew (1968:14); revalidated by Zhu and Huang (2002:134).

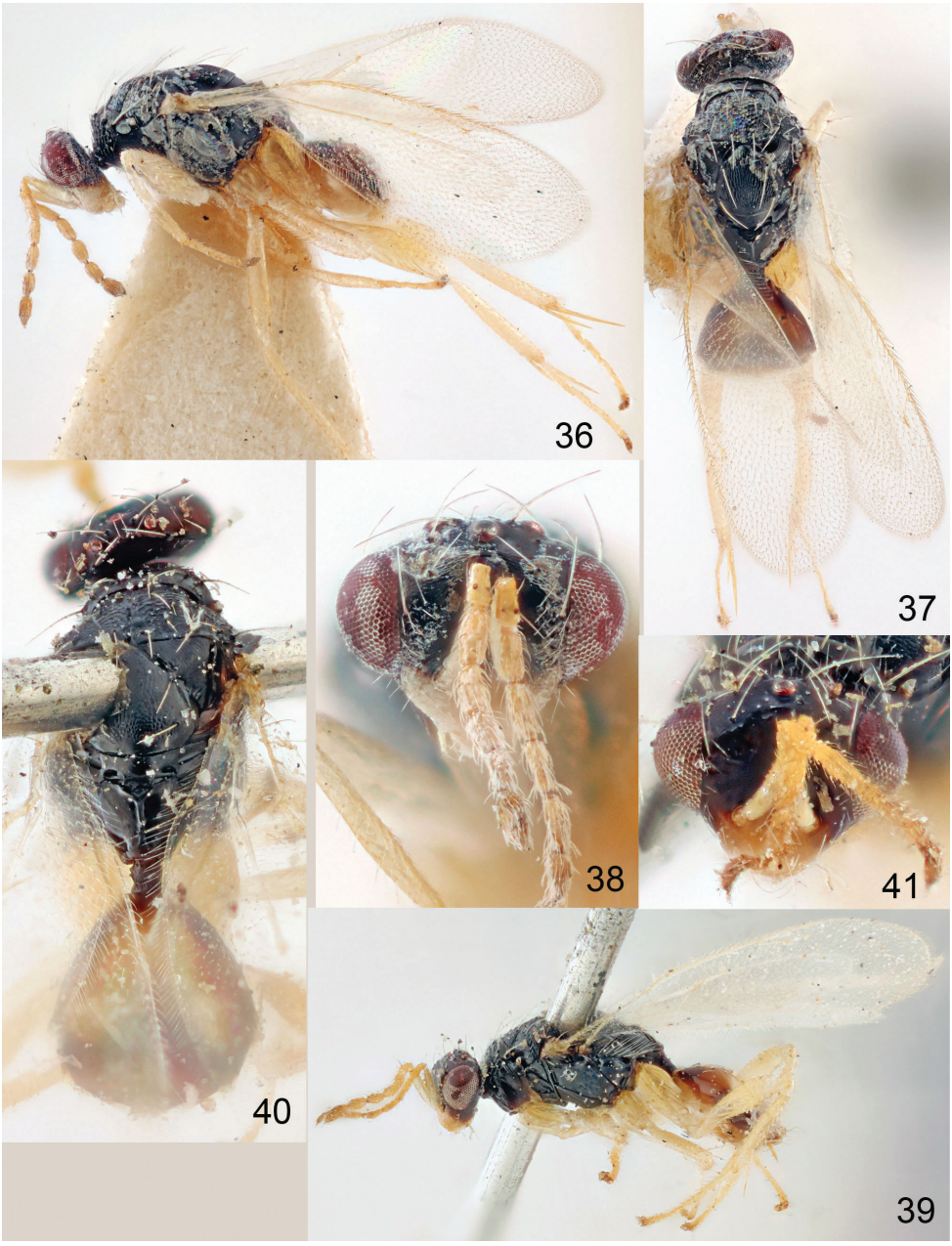
Material (249♀ 200♂). Finland: 15♀ 8♂ (VV), 153♀ 121♂ (MZH, MZLU, ZSM), this material includes 11♀ 4♂ from *Agrotis segetum*, 5♀ from *Eurois occulta*, 4♀ from *Lithomoia solidaginis*; France: 22♀ 9♂ (NHM); Spain: 1♀ 2♂ (MZLU, NHM); Sweden: 35♀ 43♂ (MZLU, NHM), this material includes 6♂ from *Mniotype satura*; United Kingdom: 23♀ 17♂ (NHM).

Diagnosis. Female with clypeal area pale, and with pale colour drawn out towards eye and almost reaches eye but with part below the eye dark (Fig. 30), male with entire frons below level of toruli pale and with parts lateral to toruli pale (Fig. 31); female with reticulation on scutellum with isodiametric meshes (Fig. 50), reticulation usually strong but there is some variation in this and some specimens have weak reticulation; male scape 2.8–3.0× (mean 2.86, n=10) as long as wide (Fig. 14). Similar to *E. bicolor*, including the narrow posterior part of midlobe of mesoscutum, but can be distinguished from this species through the colour of lower face (both sexes) – pale area confined to clypeal region in *E. bicolor,* and through the reticulation on the scutellum (females only) – meshes elongate in *E. bicolor*. Males are similar to males of *E. geometricida*, but can be distinguished through the relatively long and slender scape.

Hosts. *Agrotis segetum* (Denis & Schiffermüller), *Eurois occulta* (L.), *Lithomoia solidaginis* (Hübner), *Mniotype satura* (Denis & Schiffermüller). All records are from caterpillars of the Noctuidae.

Distribution. United Kingdom (Westwood 1832), Finland, France, Spain, Sweden (new/confirmed records).

Genetic data. The single barcoded specimen of *E. maculiventris* was assigned a distinct BIN and shows a distance of 11.3% to the next neighbour species, *E. bicolor* (Fig. 63).



Figures 36–41. *Euplectrus* spp.: **36–38** *E. liparidis* Ferrière, holotype female **36** habitus lateral **37** habitus dorsal **38** head frontal **39–41** *E. phthorimaeae* Ferrière, holotype female **39** habitus lateral **40** habitus dorsal **41** head frontal.

Euplectrus nigriceps Ferrière revised status

Figures 42–46

Euplectrus nigriceps Ferrière, 1941:42. Holotype female in NHM, examined. Synonymized with *E. platyhypenae* Howard by Bouček and Graham (1978).

Material (1♀). Sweden: Öland, Ismantorp, 56°44'45.8N, 16°38'29.0E, 30.vi.2014, C. Hansson (MZLU).

Diagnosis. Head including clypeal area completely black (Figs 44, 45); midlobe of mesoscutum with a complete median carina (Figs 43, 46); scutellum shiny, with very weak reticulation (Figs 43, 46).

Hosts. Unknown.

Distribution. Sweden (new record). This is the only geographical record for the species as the type material did not have information about collecting locality.

Remarks. *Euplectrus nigriceps* was described from two females and one male that stood together with British material of *E. bicolor* in NHM, but all three specimens lacked locality information (Ferrière 1941). In spite of this lack of information *E. nigriceps* was regarded as European by Ferrière. Graham (1963) included *E. nigriceps* in an addition to the British species of the Eulophidae, but because of the lack of information on the type specimens he expressed doubts about the record. Later Bouček and Graham (1978) synonymised *E. nigriceps* with *E. platyhypenae,* a species found in the Nearctic and Neotropical regions (Hansson et al. 2015). These two species are very similar, e.g. through the completely dark head, complete median carina on midlobe of mesoscutum, and the shiny scutellum with very weak reticulation. But they also differ. The female gaster is different: in *E. platyhypenae* the gaster is pale with narrow dark lateral margins (Fig. 47), but in *E. nigriceps* it is dark brown in posterior ½, in anterior ½ pale with wide dark lateral margins (Fig. 46).

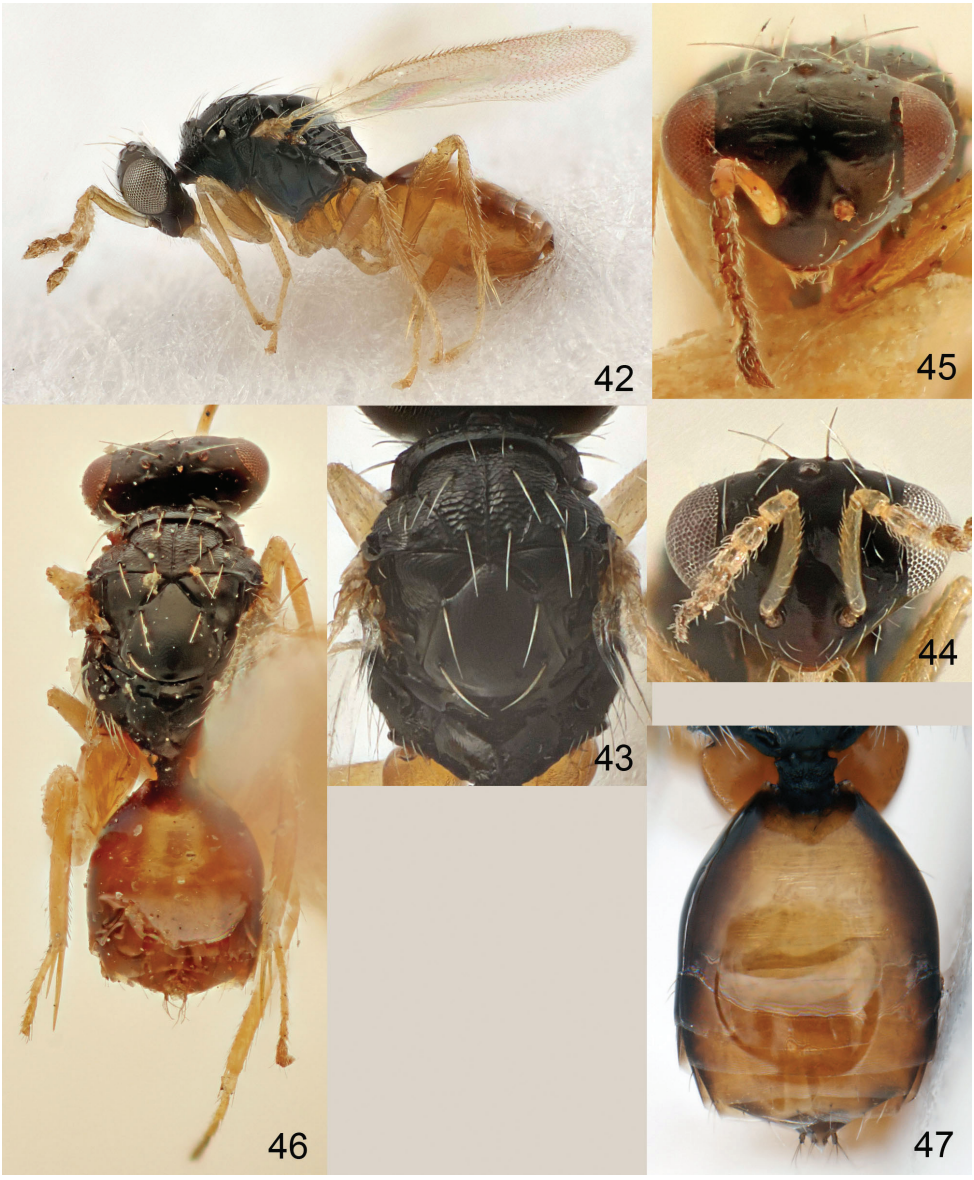
Genetic data. The single genetically examined specimen of *E. nigriceps* (BC-ZSM-HYM-29751-A01) has a distance of 11.4% to the next neighbour species, *E. bicolor*.

Euplectrus phthorimaeae Ferrière

Figures 39–41

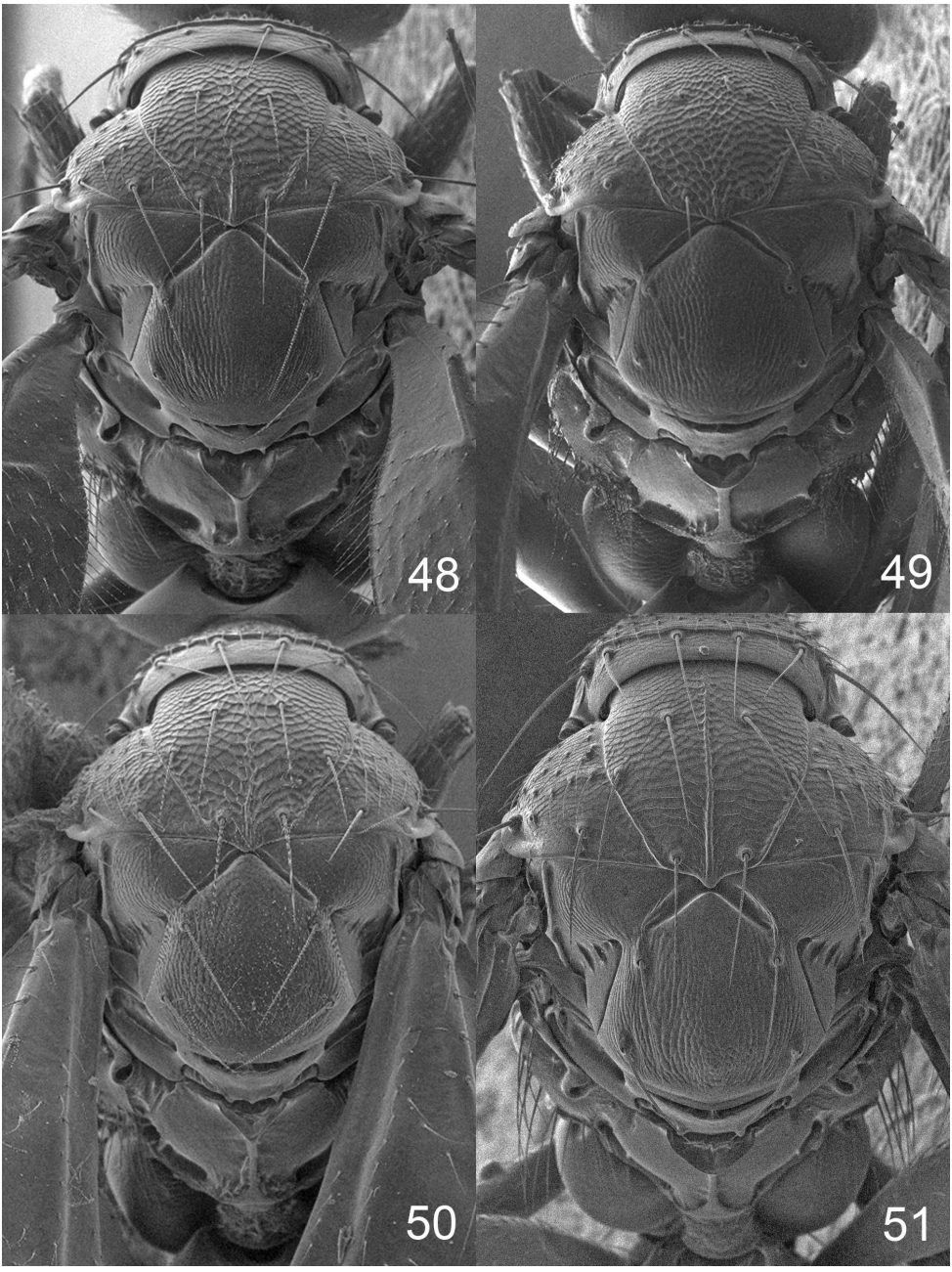
Euplectrus phthorimaeae Ferrière, 1941:42–43. Holotype female in NHM, examined.

Diagnosis. Female with frons below level of toruli with pale area not extending laterally to the eye but with a wide dark stripe between pale area and eye (Fig. 41); midline on midlobe of mesoscutum indicated by a median groove in posterior ½ (Fig. 40); posterior part of midlobe of mesoscutum narrow as in *E. bicolor*; scutellum with isodiametric meshes in posterior part (Fig. 40).

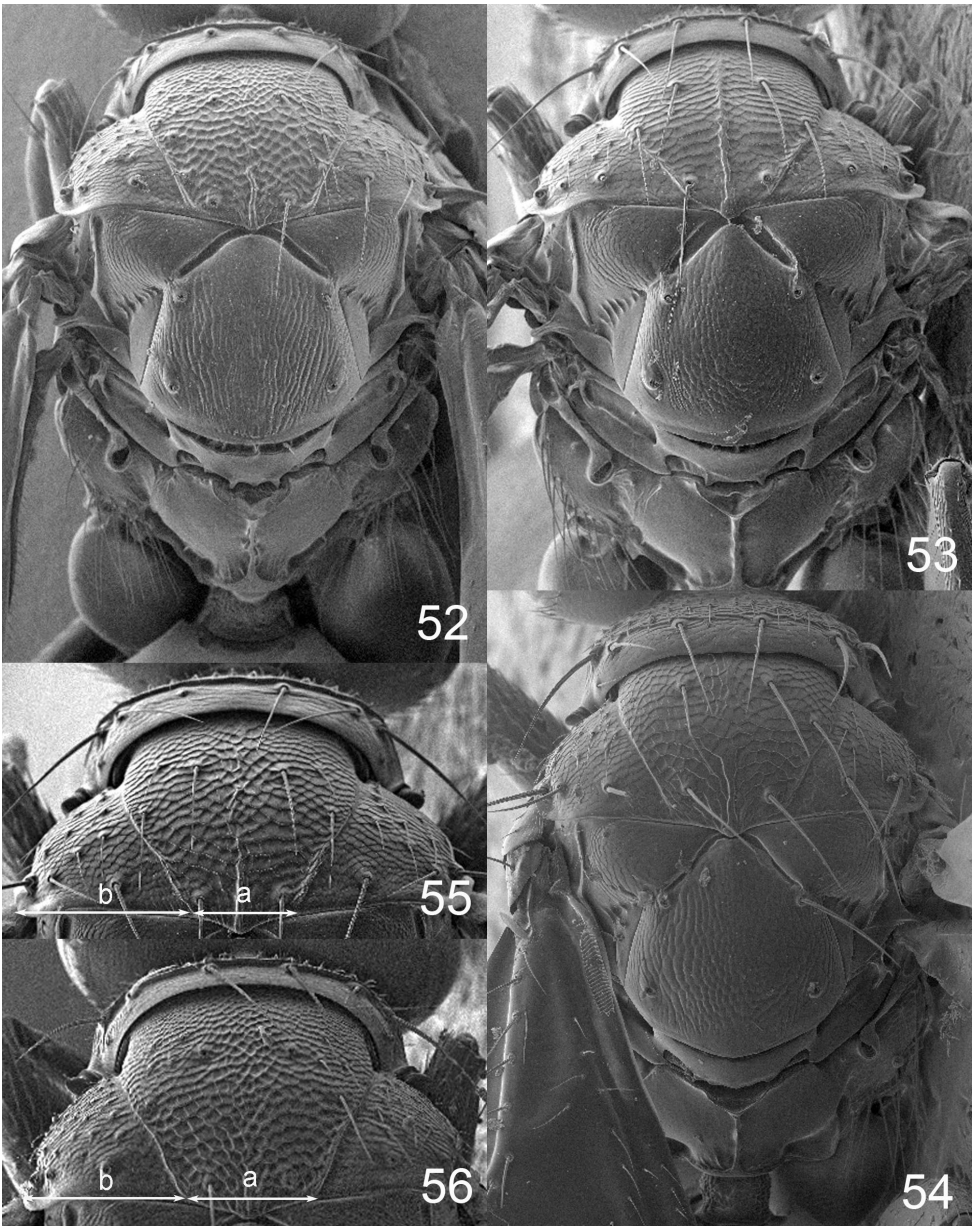


Figures 42–47. *Euplectrus* spp.: **42–46** *E. nigriceps* Ferrière, female **42–44** non-type specimens from Sweden **42** habitus lateral **43** thoracic dorsum **44** head frontal **45–46** holotype **45** head frontal **46** habitus dorsal **47** *E. platyhypenae* Howard, gaster dorsal, female specimen from Costa Rica.

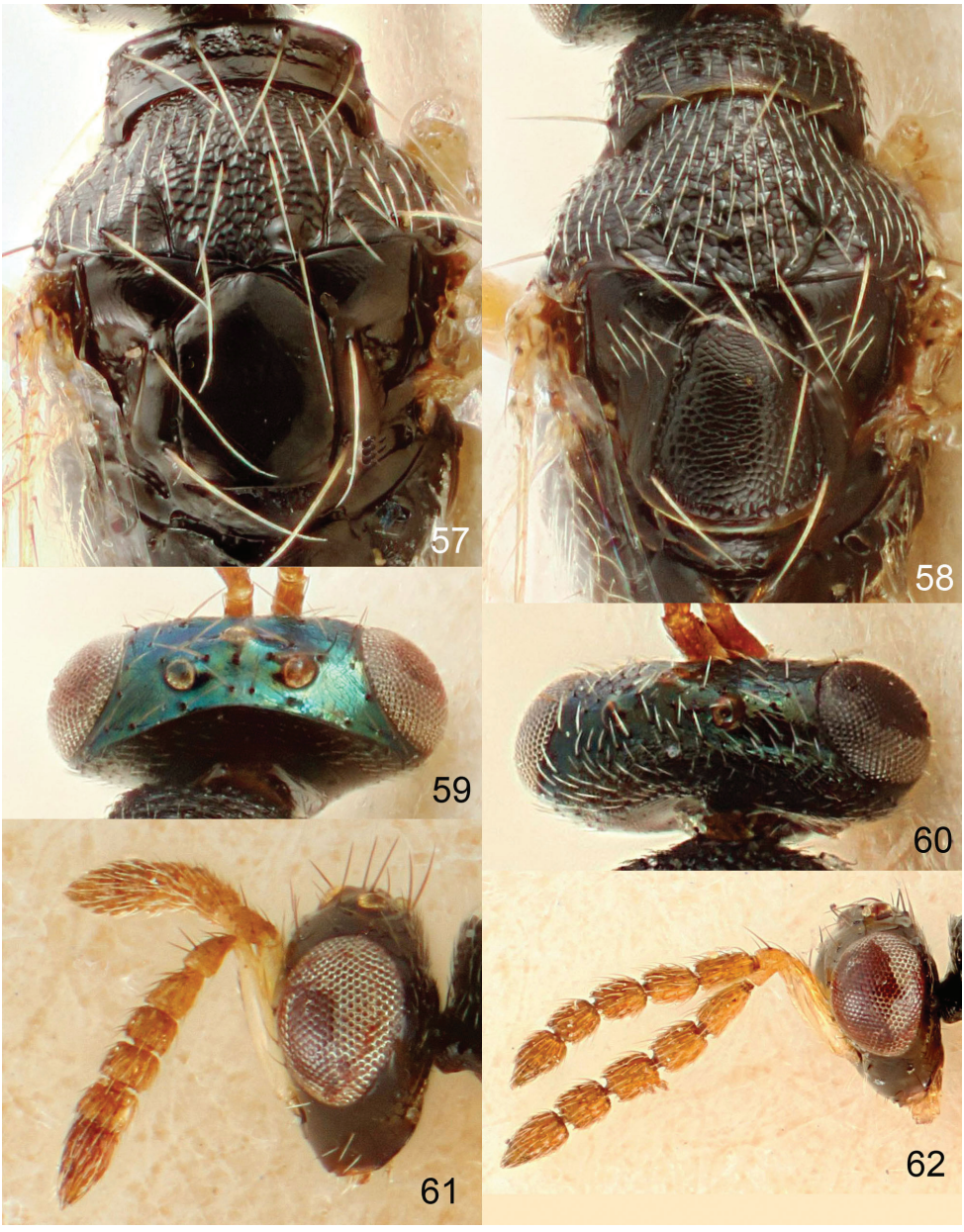
Hosts. *Phthorimaea operculella* (Zeller) (Gelechiidae) (Ferrière 1941).
Distribution. Cyprus & Israel (Ferrière 1941).
Genetic data. No specimens of the species were available for genetic analysis.



Figures 48–51. *Euplectrus* spp., mesosoma dorsal, female: **48** *E. bicolor* (Swederus) **49** *E. intactus* (Walker) **50** *E. maculiventris* Westwood **51** *E. flavipes* (Fonscolombe).



Figures 52–56. *Euplectrus* spp. **52–54** mesosoma dorsal, female **52** *E. geometricida* sp. n. **53** *E. carinifer* sp. n. **54** *E. pallidigaster* sp. n. **55–56** mesoscutum, female, a = width of base of midlobe, b = width of base of sidelobe **55** *E. bicolor* (Swederus) **56** *E. intactus* (Walker).



Figures 57–62. *Platyplectrus* spp., females: **57–58** mesoscutum and scutellum, dorsal **57** *P. laeviscuta* (Thomson) **58** *P. pannonica* Erdös **59–60** vertex **59** *P. pannonica* **60** *P. chlorocephala* (Nees) **61–62** head including antenna, lateral **61** *P. bouceki* (Erdös) **62** *P. laeviscuta*.

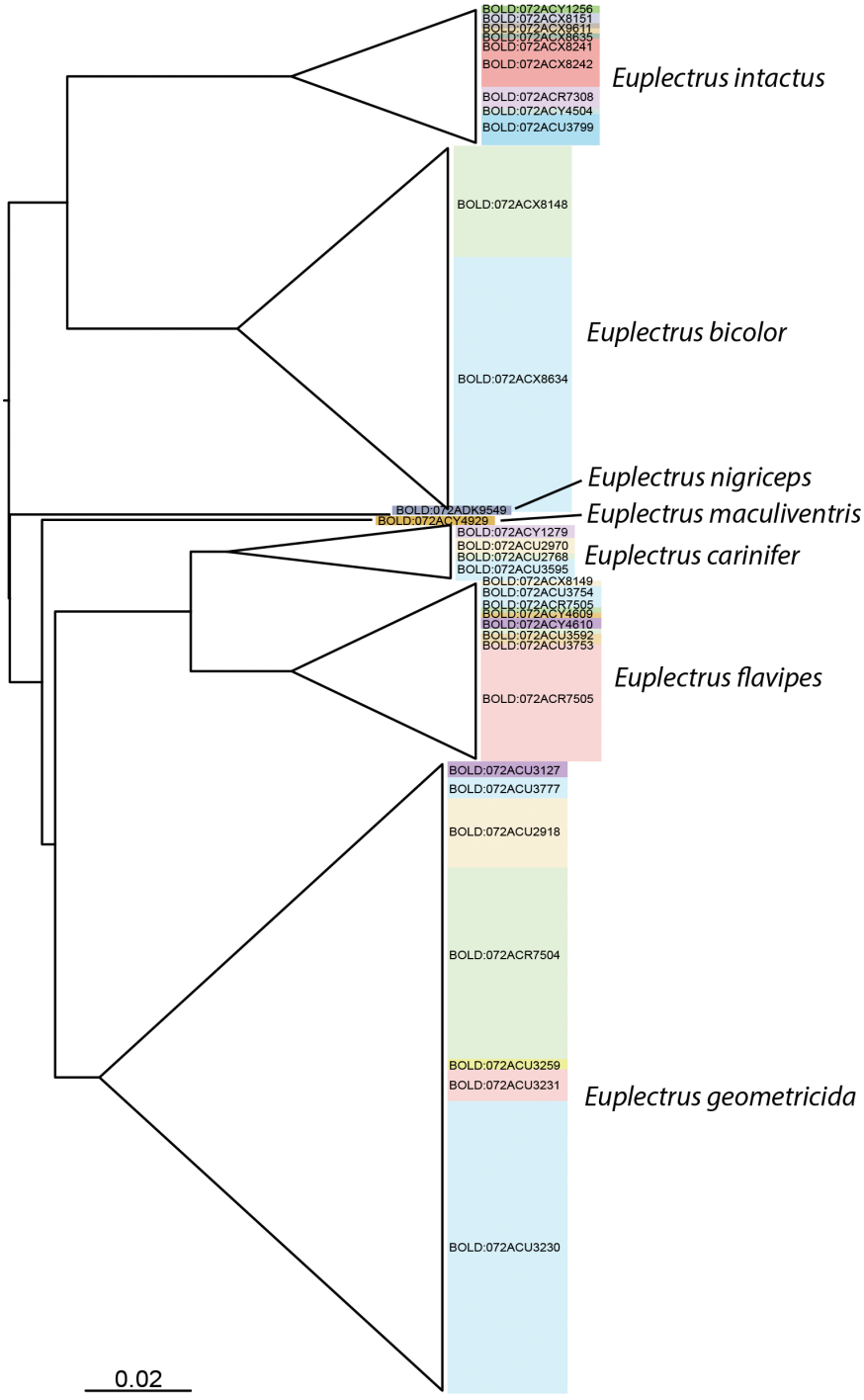


Figure 63. Neighbour-joining tree of *Euplectrus*, with colours indicating different Barcode Index Numbers (BINs). For a fully resolved tree with additional terminal taxa information, including sequence length and country of origin, see Suppl. material S2.

Discussion

Analysis of molecular and morphological data

Euplectrus is a cosmopolitan group currently including 203 species and because of the interspecific morphological similarity the species are easily recognizable as belonging to *Euplectrus*. Members of *Euplectrus* thus seem to be very conservative regarding the evolution of morphological features. This similarity between species frequently causes problems when specimens are identified using morphological features. And yet the intra- and interspecific variation of DNA barcode sequences are, compared to most other groups of insects, very large – at least among some of the European species treated here. Consider for instance *E. bicolor* and *E. intactus*, two morphologically very similar species, almost identical, that prior to this article were regarded as one species. They can be separated by just one morphological character and yet the minimum genetic distance between them using data from CO1 is 10.9%, which compared to species from other insect groups is a very large gap. Both species also exhibit large intraspecific variation in CO1, 6.5% in *E. bicolor* (including two sympatric subclusters) and 6.9% in *E. intactus* (including nine subclusters, each with a different BIN). The large intraspecific variations of the COI barcode fragment, also present in some other species treated here, may indicate the presence of more species in the material included. However, pending more sampling from different populations and geographical regions, and further analyses using more gene regions, we prefer to regard as species only those that show consistent morphological differences, no matter how small these differences may be. Considering the high intraspecific variation within most species and the virtual absence of diagnostic characters it seems mandatory for accurate identification of *Euplectrus* to provide DNA barcodes with each identification at species level.

Hosts

The hosts presented in this article (Table 1) are all from information given on pins of the *Euplectrus* specimens examined. This is a potential source of error as we cannot verify the identity of these host names. Nevertheless, we accept these as they are presented, with the nomenclature updated. Using this, probably very incomplete information on host range for each species, following can be speculated upon.

The host range for European *Euplectrus* species where we have been able to examine a larger material (Table 1) seems to be extensive, and hosts from either Noctuidae or Geometridae are the dominant target groups. Apart from having wide host spectra, species can also overlap in their host preferences. Sometimes two *Euplectrus* species have been recorded from the same host species. *Euplectrus geometricida* seems to favour geometrids and share this host group with *E. flavipes*. Both species also parasitize noctuids, which is also the target group for *E. bicolor* and *E. maculiventris*. *Euplectrus flavipes*, a species that probably only occurs in Central and South Europe, has been recorded from four Lepidoptera families, including geometrids and noctuids. This wide host spectrum

Table 1. Host records for examined specimens of *Euplectrus* (host records in the literature are not included due to uncertainty regarding previous identifications of *Euplectrus* species).

Host	*Euplectrus* species
Depressariidae:	
Carcina quercana (Fabricius)	*E. carinifer, E. flavipes*
Erebidae:	
Colobochyla salicalis (D. & S.)	*E. flavipes*
Lymantria dispar (L.)	*E. liparidis*
Gelechiidae:	
Phthorimaea operculella (Zeller)	*E. phthorimaeae*
Geometridae:	
Agriopis aurantiaria (Hübner)	*E. geometricida*
Agriopis marginaria (Fabricius)	*E. geometricida*
Alcis repandata (L.)	*E. geometricida*
Alsophila aescularia (D. & S.)	*E. flavipes*, *E. geometricida*
Angerona prunaria (L.)	*E. geometricida*
Cyclophora annularia (Fabricius)	*E. flavipes*
Colotois pennaria (L.)	*E. geometricida*
Epirrita dilutata (D. & S.)	*E. geometricida*
Macaria brunneata (Thunberg)	*E. geometricida*
Operophtera brumata (L.)	*E. geometricida*
Phigalia pilusaria (D. & S.)	*E. geometricida*
Noctuidae:	
Agrotis segetum (D. & S.)	*E. geometricida*, *E. maculiventris*
Agrotis sp.	*E. bicolor*
Amphipyra pyramidea (L.)	*E. carinifer*
Anarta myrtilli (L.)	*E. geometricida*
Autographa gamma (L.)	*E. carinifer*
Cosmia trapezina (L.)	*E. flavipes*
Diarsia mendica (Fabr.)	*E. bicolor*
Eugraphe subrosea (Stephens)	*E. bicolor*
Eurois occulta (L.)	*E. maculiventris*
Heliothis sp. on *Medicago sativa*	*E. flavipes*
Lithomoia solidaginis (Hübner)	*E. maculiventris*
Mamestra brassicae (L.)	*E. bicolor*, *E. flavipes*
Mniotype satura (D. & S.)	*E. maculiventris*
Noctua comes Hübner	*E. intactus*
Orthosia cruda (D. & S.)	*E. carinifer*
Orthosia opima (Hübner)	*E. bicolor*, *E. geometricida*
Orthosia sp.	*E. bicolor*
Perigrapha munda (D. & S.)	*E. carinifer*
Plusia sp. on *Medicago sativa*	*E. flavipes*
Polia hepatica (Clerck)	*E. bicolor*
Polia nebulosa (Hüfnagel)	*E. bicolor*
Spodoptera exigua Hübner	*E. flavipes*
Spodoptera litura Fabricius	*E. flavipes*
Xylina sp.	*E. bicolor*
Pieridae:	
Pieris rapae (L.)	*E. intactus*
Tortricidae:	
Archips rosana (L.)	*E. flavipes*

and host overlap in European *Euplectrus* species is in stark contrast to the situation in some tropical areas, as presented by Hansson et al. (2015). Analysing the *Euplectrus* fauna in the Área de Conservación Guanacaste, a comparatively small area (1470 km^2) in north-western Costa Rica, they recognized 75 *Euplectrus* species, diagnosed through data from both the morphology of the adult wasps and from CO1, i.e. the same set of characters we have used for European species in this article. The species were either (usually) host-specific to a particular species of caterpillar or (occasionally) to a particular life-form of caterpillar within a genus or family, and those usually feeding on a narrow range of food plants. Host overlap between species were rare, occasionally two *Euplectrus* species parasitized the same host species. The differences between tropical and temperate patterns of diversity in *Euplectrus* are in conformity with other groups of parasitic wasps (e.g. Fernandez-Triana et al. 2014, Smith et al. 2008). The results found here for European species compared to the results for tropical species accounted for in Hansson et al. (2015) suggest that a more refined niche separation in tropical areas is at least part of the explanation for the much higher species diversity in such areas.

The host larvae presented here are with one exception naked. The exception is *Lymantria dispar*, the only known host for *E. liparidis*, which has distinctly hairy caterpillars in all stages. The presence of hairs presents a mechanical obstacle, and the lack of such hairs is possibly a prerequisite for the female wasp to walk about on the host and enabling her to anchor her eggs in the cuticle of the host. Either the record for *E. liparidis* is a mistake, or females of this species use a different approach when laying eggs on the host. Apart from the host name very little is known about the biology for this species.

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Supplementary material 1

List of voucher specimens with species of *Euplectrus*

Authors: Christer Hansson, Stefan Schmidt

Data type: specimens data

Explanation note: List of voucher specimens with species of *Euplectrus*, specimen ID, country of origin, Barcode Index Number (BIN), GenBank accession number and host information for reared specimens.

Link: https://doi.org/10.3897/jhr.67.28810.suppl1

Supplementary material 2

BOLD TaxonID Tree

Authors: Christer Hansson, Stefan Schmidt

Data type: phylogenetic data

Link: https://doi.org/10.3897/jhr.67.28810.suppl2