



Three new species of *Achrysocharoides* Girault (Hymenoptera: Eulophidae) parasitoids of *Phyllonorycter* spp. (Lepidoptera: Gracillariidae) on *Acer platanoides* and *Robinia pseudoacacia*

CHRISTER HANSSON & EKATERINA SHEVTSOVA

Department of Biology, Zoology, Lund University, Helgonavägen 3, SE- 223 62 Lund, Sweden

E-mail: Christer.Hansson@cob.lu.se; Ekaterina.Shevtsova@cob.lu.se

Abstract

Three new species of *Achrysocharoides* are described, one from northern Europe, *A. platanoidae* **sp. nov.**, one from central Europe and the U.S.A., *A. robiniae* **sp. nov.**, and one from the U.S.A., *A. robinicolus* **sp. nov.** The descriptions are based on material reared from microlepidopterans of the genus *Phyllonorycter* Hübner (Gracillariidae): *A. platanoidae* from *P. platanoidella* (Joannis) on *Acer platanoides*, and *A. robiniae* and *A. robinicolus* from *P. robiniella* (Clemens) on *Robinia pseudoacacia* (black locust). The new species are very similar to previously described species, *A. platanoidae* to *A. acerianus* (Askew), and *A. robiniae* and *A. robinicolus* to *A. gahani* (Miller), but they are shown here to differ from their sibling species both in biology and in external morphology. The host of *A. robiniae* and *A. robinicolus*, *P. robiniella*, is a serious pest on the black locust tree in Europe, and the descriptions with diagnoses of these two species, and their scientific names, introduced here will aid the biological control efforts of this pest.

Key words: taxonomy, Chalcidoidea, Entedoninae, leafminer parasitoids, *Achrysocharoides acerianus*, *Achrysocharoides platanoidae*, *Achrysocharoides robiniae*, *Achrysocharoides robinicolus*, *Achrysocharoides gahani*, *Phyllonorycter robiniella*, *Phyllonorycter geniculella*, *Phyllonorycter platanoidella*, black locust, *Acer pseudoplatanus*, biological control

Introduction

Achrysocharoides Girault (Chalcidoidea: Eulophidae: Entedoninae) was originally described based on an Australian species (Girault 1913a) but its main distribution is now known to be the northern hemisphere (Bouček & Askew 1968; Burks 1979; Kamijo 1990a, 1990b, 1991). Worldwide, *Achrysocharoides* comprises 54 described species. Including the new species described here, 22 species are now known from Europe and 20 from North America.

Species of *Achrysocharoides* are unusually host specific. Most species of Entedoninae are polyphagous with broad host ranges (Askew & Shaw 1979; Hansson 1985), but *Achrysocharoides* species select their hosts among a very limited number of host species. They are larval endoparasitoids of leaf mining moths of the family Gracillariidae (Lepidoptera), mainly of species in *Phyllonorycter* Hübner (Askew & Ruse 1974). Apart from choosing their hosts from a very narrow range of moth species, the hosts are usually selected from only a few and related plant genera (Lopez-Vaamonde *et al.* 2005).

Two of the *Achrysocharoides* species described here are parasitoids of *Phyllonorycter robiniella* (Clemens), a small moth native to North America that is monophagous on black locust, *Robinia pseudoacacia* (Šefrov 2002). The black locust is a legume tree native to central and eastern U.S.A. (Mabberley 1997) that was introduced into most European countries (Polunin 1969). The introductions started in the beginning of the 17th century (Stojanović & Marković 2005) and the tree was introduced as an ornamental, for its resistant wood and fragrant flowers (used for honey and perfumery) (Polunin 1969). It is an economically important plant especially in central Europe (Melika *et al.* 2006). Since its introduction in Europe this tree has been considered free from serious pests. However, in 1983 *P. robiniella* was discovered in Switzerland (Whitebread

1990) and since then it has spread rapidly through most of Europe (Šefrová 2002). The moth larva constructs a blotch mine in the leaf and several larvae can be present in one leaf (Stojanović & Marković 2005), causing considerable damage that can cause premature leaf-fall. Because of the economic importance of black locust several investigations have been carried out to find natural enemies of *P. robiniella*. Lists of parasitoid complexes of the moth have been published from Hungary (Melika *et al.* 2006), Serbia (Stojanović & Marković 2005), and Switzerland (Girardoz *et al.* 2007). All these investigations have included *Achrysocharoides* species among the parasitoids on *P. robiniella*, and in one investigation (Melika *et al.* 2006) this genus was reported as dominant.

Material and methods

The majority of the specimens of *Achrysocharoides* from *Acer* spp. accounted for in this paper were collected in southern Sweden during the summer of 2007. Leaves with mines of *Phyllonorycter* spp. were collected from *Acer platanoides* and *A. pseudoplatanus* and processed in the lab. The areas of the leaves with mines were cut out from the leaf to prevent mold from forming, and thereafter were kept in polythene bags. When the imagines emerged from the mine they were killed and kept in 80% ethanol. The specimens were later dried using a critical point drier and mounted on cardboard rectangles as described by Noyes (1982). All imagines from *Acer* emerged during the summer they were collected. All material of *Achrysocharoides* from *P. robiniella* was borrowed from the collections listed below.

The SEM photos were made from uncoated specimens on their original cardboard mounting. This was possible to do in low vacuum mode on a JEOL JSM 5600LV SEM microscope. The colour photos were taken through a Nikon SMZ 1000 microscope with Nikon camera equipment DS-L1 & DS-5M. Each photo was made by merging several photos taken at different focus levels using the software Helicon Focus version 4.75.5 Pro.

The ratios are calculated based on measures from the holotype, and from a paratype with same label data as the holotype for the other sex.

The terminology used here follows Gibson *et al.* (1997).

Morphological abbreviations and acronyms

HE = height of eye; HW = height of forewing; LG = length of gaster; LM = length of marginal vein; LW = length of forewing, measured from base of marginal vein to apex of wing; MM = length of mesosoma; MS = malar space; OOL = distance between one posterior ocellus and eye; PM = length of postmarginal vein; POL = distance between posterior ocelli; POO = distance between posterior ocelli and occipital margin; ST = length of stigmal vein; WH = width of head; WM = width of mouth; WT = width of thorax. For illustrations of the morphological terms see www.neotropicaeulophidae.com.

BMNH = Natural History Museum, London, England; CH = collection of Christer Hansson, Lund, Sweden; CNC = Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa; CAES = Connecticut Agricultural Experiment Station, New Haven, U.S.A.; GG = collection of Giseler Grabenweger; HNHM = Hungarian Natural History Museum, Budapest; LUZM = Lund University Zoological Museum, Sweden; NHMV = Natural History Museum, Vienna, Austria; PDL = Pest Diagnostic Laboratory, Plant Protection and Soil Conservation Directorate of County Vas, Hungary.

Results

Achrysocharoides Girault

Achrysocharoides Girault, 1913a:168. Type species *Chrysocharis sarcophaga* Girault, 1913b:99, by original designation.

Neoderostenus Girault, 1913a:144. Type species *Neoderostenus australiensis* Girault, 1913a:144, by original designation. Synonymized by Peck (1951:464).

Enaysma Delucchi, 1954:1. Type species *Enaysma zwoelferi* Delucchi, 1954, by original designation. Synonymized by Yoshimoto (1977:907).

Diagnosis. Frontal suture almost straight, in females often replaced by a transverse ridge; males with a more or less developed frontal cross-carina (i.e. with a carina just below toruli), especially well developed in males with a strongly transverse head; eyes usually densely pubescent; pronotal collar without or with a transverse carina; forewing with postmarginal vein about as long as stigmal vein; petiole short with posterior raised portion short, never longer than broad.

Identification. To separate *Achrysocharoides* from other Eulophidae genera the keys in the following publications can be used: Bouček (1988) (Australasia), Gibson *et al.* (1997) (Nearctic), Graham (1959) (Europe). The key to European genera has a partly outdated nomenclature, e.g. *Achrysocharoides* is there referred to as *Enaysma* — now a synonym under *Achrysocharoides*, but this is the only available key for Europe. To separate the species-groups of *Achrysocharoides* the key in Kamijo (1991) can be used, and in the same publication there are detailed diagnoses for each species-group — this is excluding the *crassinervis*-group which is diagnosed in Kamijo (1990b).

Species-groups. The subdivision of *Achrysocharoides* was initiated by Graham (1959) who divided the European species into two subgenera, *Enaysma* Delucchi and *Pentenaysma* Graham. These correspond with the two species-groups, *atys*- and *latreilleii*-groups, which Bryan (1980) introduced for the European species, thus abandoning the formal subdivision into subgenera. Yoshimoto (1977) divided the Nearctic species into two species-groups, the *gahani*- and *guizoti*-groups. Kamijo (1991) transferred some of the Nearctic species from the *guizoti*-group to either of the two newly erected *clypeatus*- and *titiani*-groups, and removed the remaining species in the *guizoti*-group to the *latreilleii*-group, thus terminating the *guizoti*-group. Kamijo (1990b) established the *crassinervis*-group for two species from Japan and one undescribed species from Nepal. Hence there are currently six species-groups in *Achrysocharoides*: *atys*-, *clypeatus*-, *crassinervis*-, *gahani*-, *latreilleii*-, and *titiani*-groups. The two species described here belong to the *gahani*-group (*A. robiniae* and *A. robinicolus*) and the *latreilleii*-group (*A. platanoidae*) respectively.

Descriptions

Achrysocharoides platanoidae sp. nov.

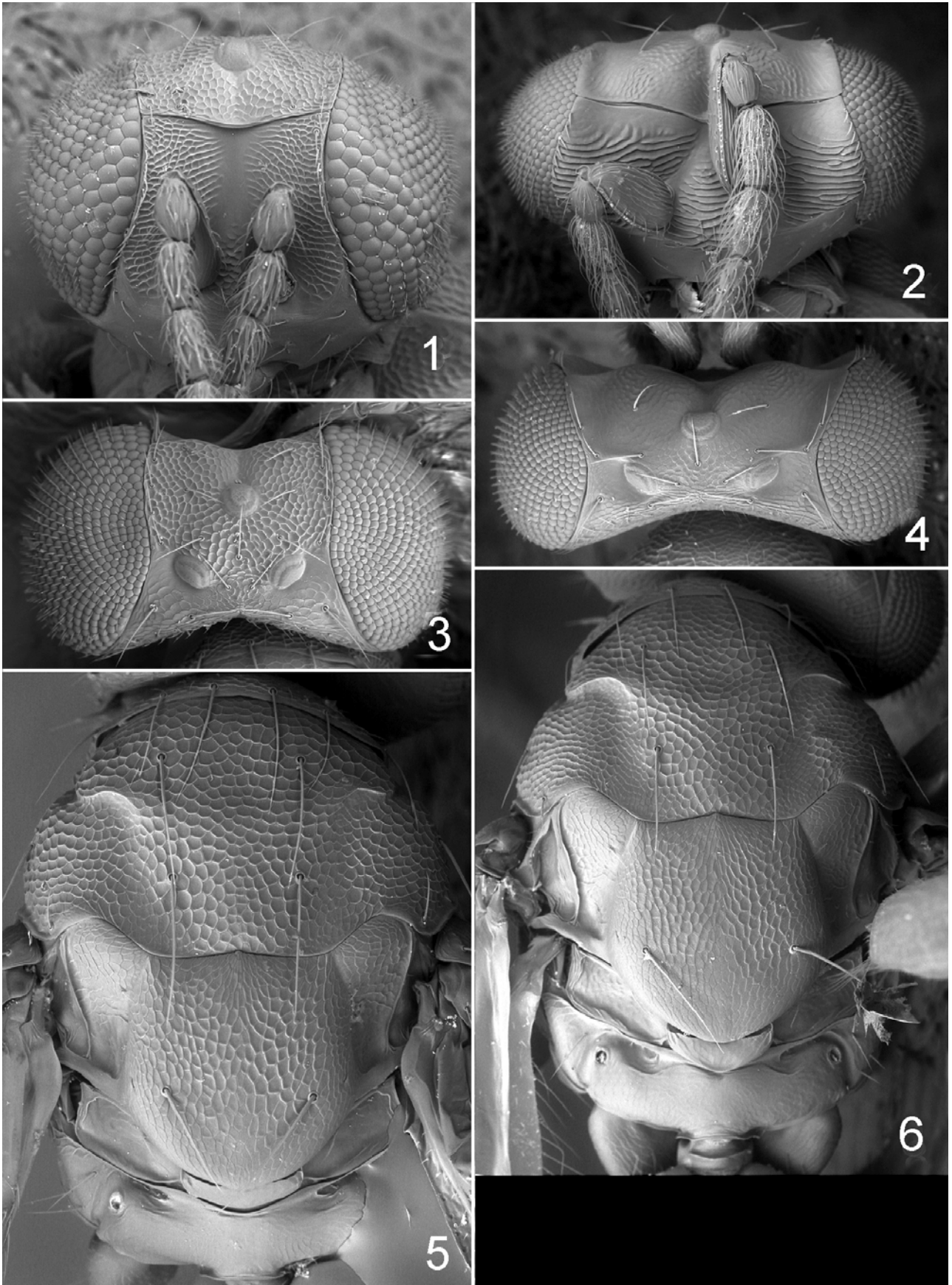
(Figs 1–12, 49, 63–64)

Diagnosis. *Achrysocharoides platanoidae* is similar to *A. acerianus* (Askew) but females differ in having the pedicel predominantly white to yellowish-white with base infuscate to brown (Fig. 49) (predominantly to completely infuscate in *A. acerianus*, Fig. 50), the hind coxa white with base infuscate to golden-green (Fig. 11) (basal third to half metallic in *A. acerianus*, Fig. 23), and longer flagellomeres, e.g. flagellomeres 1–3 together 5.4X as long as wide (Fig. 63) as compared to 4.4X as long as wide in *A. acerianus* (Fig. 61). Males also differ in having longer flagellomeres, e.g. flagellomeres 1–4 together 9.4X as long as wide (Fig. 64) as compared to 8.5X as long as wide in *A. acerianus* (Fig. 62) and the hind coxa white with the base infuscate to golden-green (Fig. 12) (basal third to half metallic in *A. acerianus*, Fig. 24).

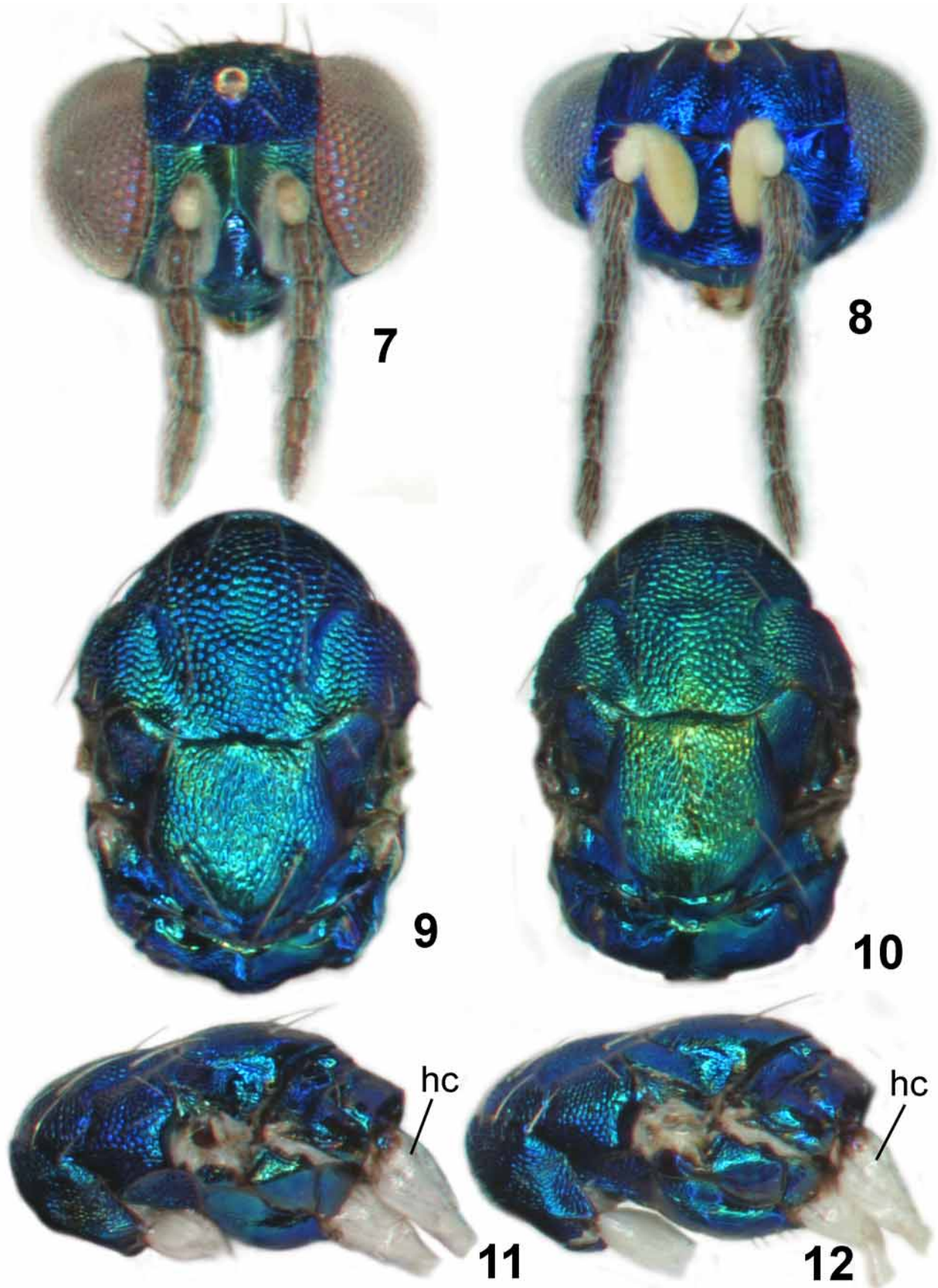
Description. FEMALE. Length 1.1–1.6 mm.

Scape white; pedicel white to yellowish-white with base infuscate to brown; flagellum dark brown. Frons below frontal suture golden-green with blue tinges, above frontal suture metallic blue. Vertex metallic bluish-green. Mesoscutum, scutellum and propodeum metallic bluish-green. Legs white, hind coxa with base infuscate to golden-green. Wings hyaline. Gaster metallic bluish-green.

Antenna as in Fig. 63. Frons with raised and strong reticulation, antennal scrobes smooth. Vertex inside ocellar triangle with raised and strong reticulation, outside ocellar triangle with raised and weak reticulation, partly smooth. Occipital margin rounded.



FIGURES 1–6. *Achrysocharoides platanoidae* sp. nov. 1. Head frontal, female. 2. Head frontal, male. 3. Vertex, female. 4. Vertex, male. 5. Thoracic dorsum, female. 6. Thoracic dorsum, male.



FIGURES 7–12. *Achrysocharoides platanoidae* sp. nov. 7. Head frontal, female. 8. Head frontal, male. 9. Thoracic dorsum, female. 10. Thoracic dorsum, male. 11. Mesosoma lateral, female. 12. Mesosoma lateral, male. Abbreviation: *hc* = hind coxa.

Mesoscutum with raised and strong reticulation; notauli as indistinct impressions in posterior 2/3. Scutellum with raised and strong reticulation, without scutellar pits. Dorsellum slightly convex, almost flat, and smooth. Propodeum smooth and shiny; propodeal callus with three setae. Forewing speculum closed below. Petiole conical without shoulders.

Ratios. HE/MS/WM = 3.2/1.0/1.6; POL/OOL/POO = 5.7/2.3/1.0; WH/WT = 1.2; LW/LM/HW = 1.8/1.0/1.2; PM/ST = 0.8; MM/LG = 0.8–0.9.

MALE. Length 1.3–1.7 mm.

Scape and pedicel yellowish-white; flagellum dark brown. Frons below level of toruli golden-green, above level of toruli metallic blue. Vertex golden-green. Mesoscutum and scutellum golden-green or metallic bluish-green. Propodeum metallic bluish-green. Legs white, hind coxa with base infuscate to golden-green. Wings hyaline. Gaster with first tergite with anterior 1/4 golden-green, posterior 3/4 dark brown, anteromedially with a large white spot; remaining tergites 3/4 dark brown.

Antenna as in Fig. 64. Frons below level of toruli smooth and shiny, between level of toruli and frontal suture with strong and transverse striae, above frontal suture medially with raised and rather weak reticulation and close to eyes smooth. Vertex inside ocellar triangle with engraved and weak reticulation, outside ocellar triangle predominantly smooth. Occipital margin rounded.

Mesoscutum with raised and strong reticulation; notauli as indistinct impressions in posterior 2/3. Scutellum with raised and strong reticulation, without scutellar pits. Dorsellum slightly convex, almost flat, and smooth. Propodeum smooth and shiny; propodeal callus with three setae. Forewing speculum closed below. Petiole conical without shoulders.

Ratios. HE/MS/WM = 1.8/1.0/1.1; POL/OOL/POO = 2.3/1.0/1.1; WH/WT = 1.3; LW/LM/HW = 1.9/1.0/1.3; PM/ST = 0.5; MM/LG = 0.9–1.1.

Distribution. Sweden and the United Kingdom.

Host. *Phyllonorycter platanoidella* (Joannis) (Lepidoptera: Gracillariidae) on *Acer platanoides*.

Material examined. Holotype female labeled SWEDEN: Skåne, Silvåkra, 55°41'N, 13°30'E, 26.vi.2007, C. Hansson & E. Shevtsova (LUZM). Paratypes: 17 females 5 males with same label data as holotype (BMNH, CH, LUZM, NHMV); 1 male from same locality as holotype but collected 17.x.1981 (CH); 1 male "SWEDEN: Skåne, Lake Kranke, Lottagården, 55°42'N, 13°29'E, 1.vii.2007, C. Hansson" (CH); 5 females "SWEDEN: Skåne, Torna Hällestad, 55°41'N, 13°25'E, 18.vii.1981, C. Hansson" (CH, LUZM); 5 females, 1 male from same locality as previous but collected 16.x.1981 (CH, BMNH); 7 females "SWEDEN: Skåne, Dalby, 9.vii.1981, C. Hansson" (CH, LUZM); 2 males "SWEDEN: Skåne, Höör, Jularp, 22.vii.1979, C. Hansson" (CH); 4 females 3 males "UNITED KINGDOM: Berkshire, Ascot, Silwood Park [no date], C.L. Vaamonde" (BMNH). All specimens are reared from *Phyllonorycter platanoidella* on *Acer platanoides*.

Identification. To include *A. platanoidae* in the latest key to European *Achrysocharoides* (Bryan 1980) the following additions should be made for females:

- 6. Hind coxa white with basal 1/3 to 1/2 metallic 7
- Hind coxa white with only dorso-basal 1/5 metallic 7a
- 7. Scape white with inner-apical part pale brown; on *Acer* *acerianus* (Askew)
- Entire scape white or yellowish-white; on *Quercus* *latreilleii* (Curtis)
- 7a. Pedicel white to yellowish-white with base infuscate to brown (Fig. 49) *platanoidae* **sp. nov.**
- Pedicel dark brown as flagellomeres *butus* (Walker)

and for males:

- 10. Scutellar pits absent and mesoscutum with strong reticulation (Figs 6, 18) 10a
- Scutellar pits usually present (see fig. 1 in Bryan 1980), but if absent then mesoscutum with weak reticulation ... 11
- 10a. Flagellomeres 1–4 together 9.4X as long as wide (Fig. 64); hind coxa with dorso-basal 1/5 infuscate to metallic (Fig. 12) *platanoidae* **sp. nov.**
- Flagellomeres 1–4 together 8.5X as long as wide (Fig. 62); hind coxa with basal 1/3 to 1/2 metallic (Fig. 24) *acerianus* (Askew)

Etymology. Named after the host plant, *Acer platanoides*, of its lepidopteran host.

Remarks. Askew & Ruse (1974) mention some additional material under the treatment of *A. acerianus*, two males and eight females from *Phyllonorycter acerifoliella* (Zeller) on *Acer campestre*. These specimens were not included in the description of *A. acerianus*, and hence not included in the type material, but were nevertheless regarded as conspecific with *A. acerianus*. This material differed from “typical” *A. acerianus* in having completely pale hind coxae and slightly longer funicle segments. We were not able to examine these specimens but in view of the diagnostic characters given above, it is possible that they belong to *A. platanoidae*, or to a new species close to *A. platanoidae*.

The species cited as *A. acerianus* in Lopez-Vaamonde *et al.* (2005) is actually *A. platanoidae*, and the gene sequences accounted for in that paper, and deposited in GeneBank, concern *A. platanoidae* not *A. acerianus*.

***Achrysocharoides acerianus* (Askew)**

(Figs 13–24, 50, 61–62)

Enaysma aceriana Askew in Askew & Ruse, 1974:264. Holotype female in BMNH, examined.

Achrysocharoides acerianus (Askew); Bouček & Graham (1978:232).

Hosts. *Phyllonorycter geniculella* (Ragonot) (Lepidoptera: Gracillariidae) on *Acer pseudoplatanus*.

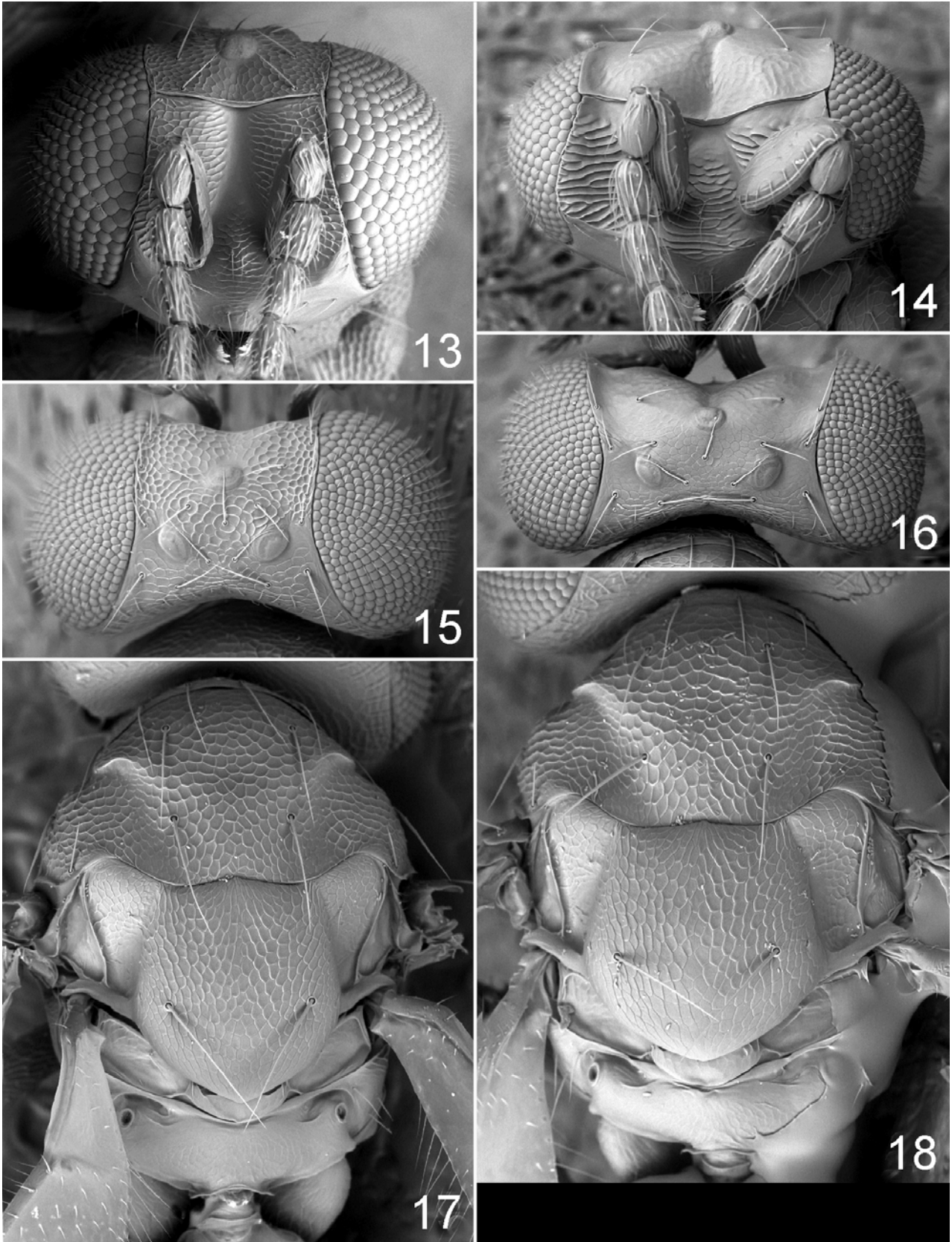
Material examined. SWEDEN: Skåne, 155 females and 54 males from *Phyllonorycter geniculella* on *Acer pseudoplatanus* (CH).

Remarks. The species cited as *Achrysocharoides sp.* from *Acer pseudoplatanus* in Lopez-Vaamonde *et al.* (2005) is *A. acerianus*, and the gene sequences accounted for in that paper, and deposited in GeneBank, are for *A. acerianus*.

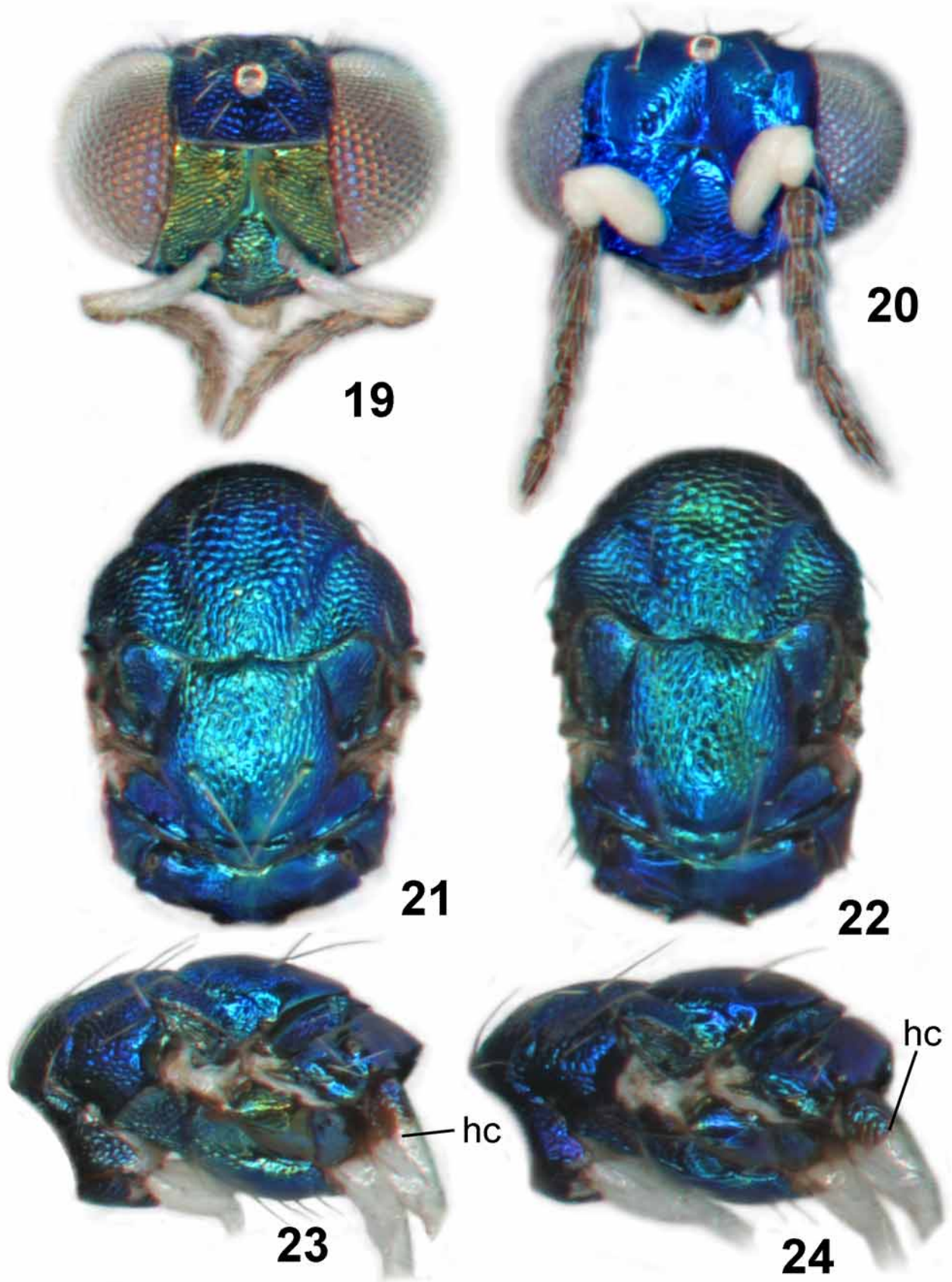
***Achrysocharoides robiniae* sp. nov.**

(Figs 25–36, 51–52, 56, 59, 65–66)

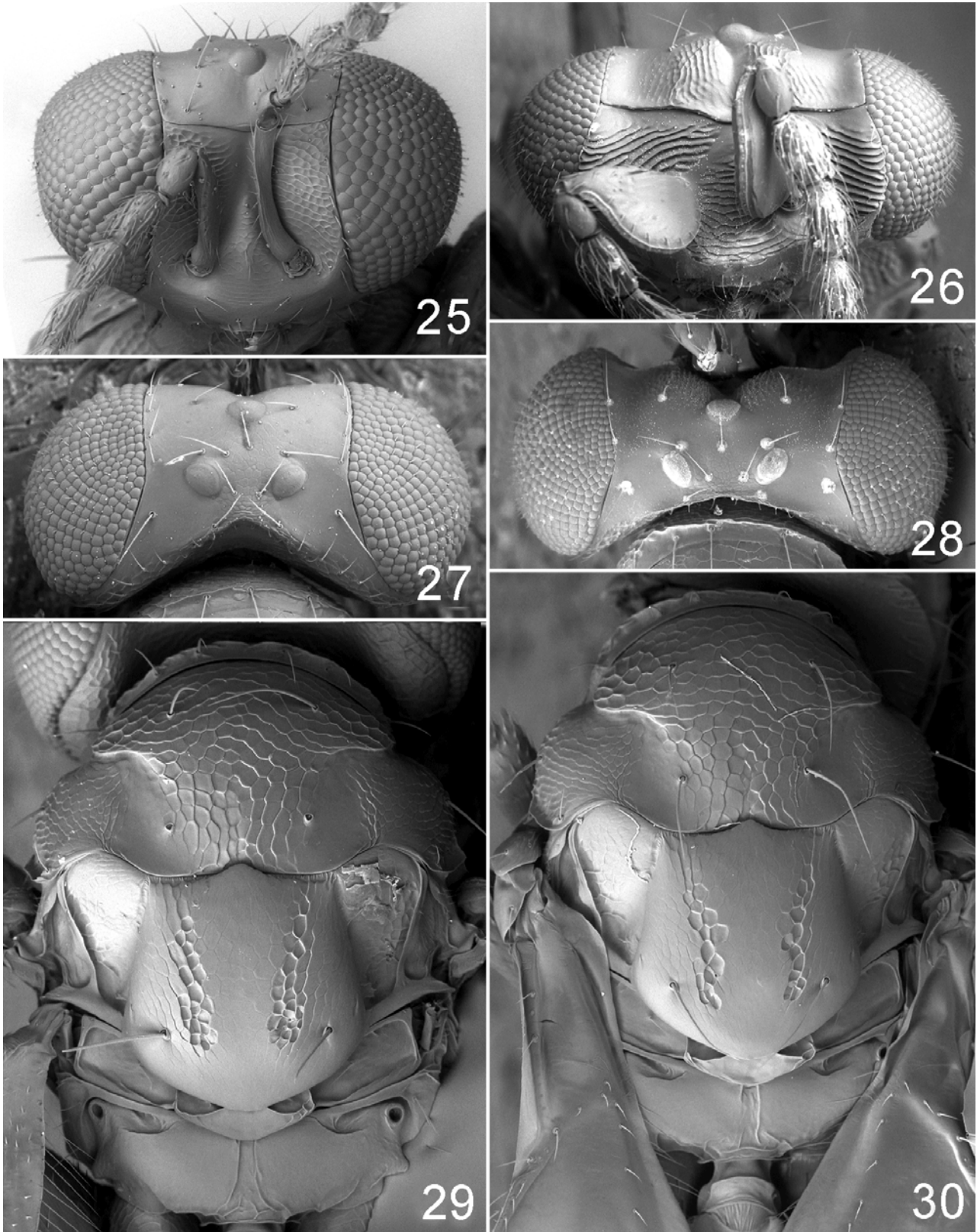
Diagnosis. *Achrysocharoides robiniae* belongs to the *gahani*-group sensu Kamijo (1991), i.e. with the pronotal collar sharply margined (Figs 29–30), the occipital margin carinate (Figs 27–28), the propodeum with submedian carinae that diverge posteriorly (Figs 29–30), and the male scape widest at base (Figs 32, 66). These features differentiate *A. robiniae* from all known European species of *Achrysocharoides*. This group also includes *A. gahani* (Miller), *A. reticulatus* Yoshimoto, *A. villosus* Kamijo, and the new species *A. robinicolus* described below, from North America, and *A. littoralis* Kamijo from Japan. *Achrysocharoides robiniae* differs from all but *A. gahani* and *A. robinicolus* in having the following combination of characters: scutellum more or less smooth with rows of punctate-reticulate pits on each side (Figs 29–30) (*A. littoralis* and *A. villosus* with scutellum completely reticulate without pits), and forewing rounded (*A. reticulatus* with forewing truncate). We are currently unable to distinguish females of *A. gahani* and *A. robiniae* from each other with certainty, but males do differ morphologically. Males of *A. robiniae* and *A. robinicolus* have the frons below the frontal suture bright blue (Figs 32, 44, 51–52), whereas males of *A. gahani* have this part bright green (Figs 53–54), males of *A. robiniae* and *A. robinicolus* have the white anteromedian spot on gaster with posterior margin straight (spot is shaped like a pentagon or a triangle respectively) and extending over tergites 1 and 2 (Figs 56–57, 59–60), whereas males of *A. gahani* have posterior margin of this spot rounded (spot is oval-shaped), extending over tergites 1–3 (Figs 55, 58). The host information is also an important diagnostic tool to separate *A. robiniae* and *A. robinicolus* from *A. gahani*, as accounted for below in the discussion. *Achrysocharoides robiniae* is very similar to *A. robinicolus* but differs in having hind coxae completely white in both sexes (Figs 35–36) (coxae completely white also in *A. gahani*, but base brown to metallic in both sexes of *A. robinicolus*, Figs 47–48), a wider male scape (Fig. 66) which is 1.8X as long as wide (holotype) (3.0X as long as wide in holotype of *A. robinicolus*, Fig. 68), white anteromedian spot in male gaster shaped like a pentagon (Figs 56, 59) (shaped like a triangle in *A. robinicolus*, Figs 57, 60).



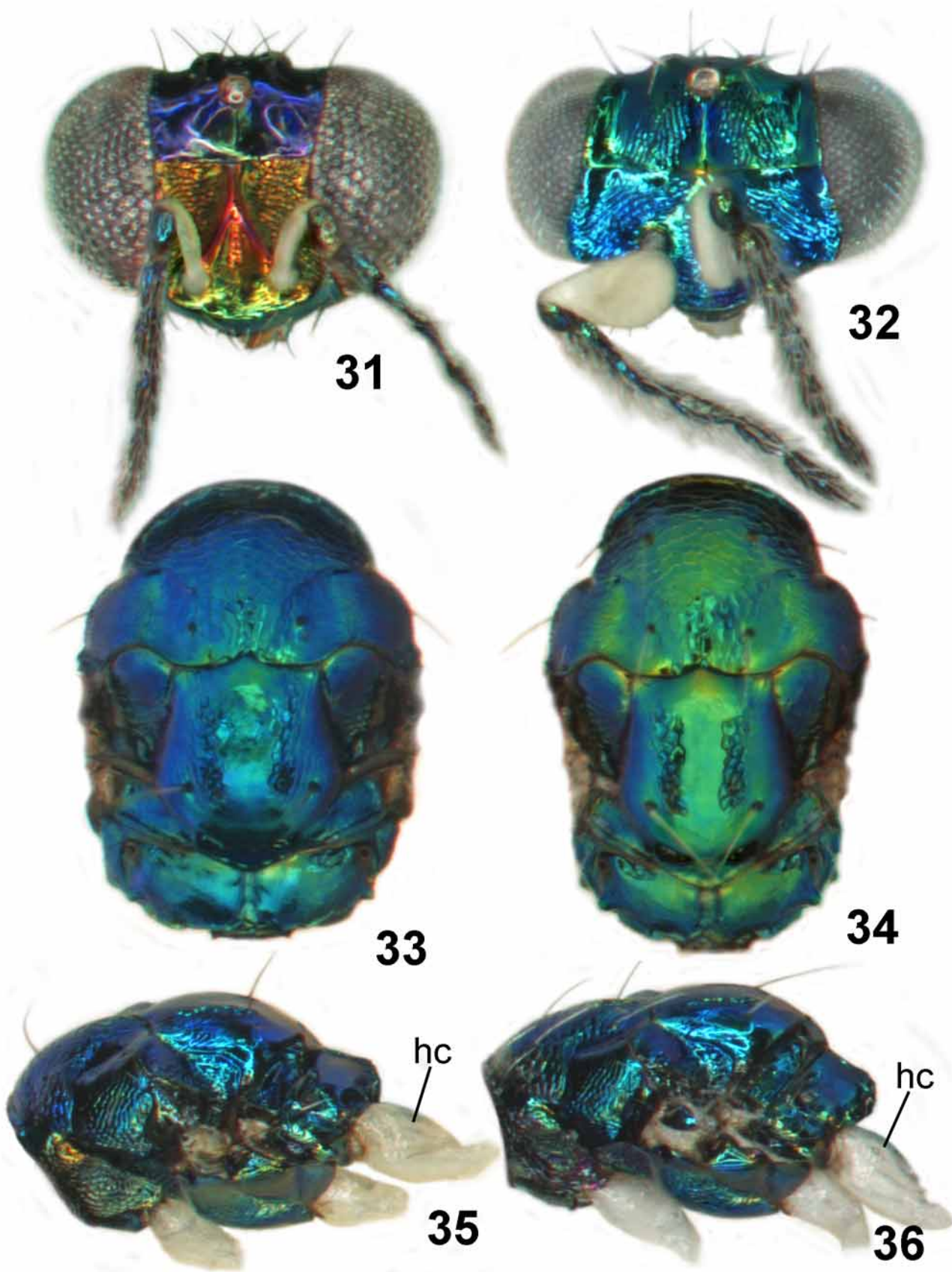
FIGURES 13–18. *Achrysocharoides acerianus* (Askew). 13. Head frontal, female. 14. Head frontal, male. 15. Vertex, female. 16. Vertex, male. 17. Thoracic dorsum, female. 18. Thoracic dorsum, male.



FIGURES 19–24. *Achrysocharoides acerianus* (Askew). 19. Head frontal, female. 20. Head frontal, male. 21. Thoracic dorsum, female. 22. Thoracic dorsum, male. 23. Mesosoma lateral, female. 24. Mesosoma lateral, male. Abbreviation: *hc* = hind coxa.



FIGURES 25–30. *Achrysocharoides robiniae* sp. nov. 25. Head frontal, female. 26. Head frontal, male. 27. Vertex, female. 28. Vertex, male. 29. Thoracic dorsum, female. 30. Thoracic dorsum, male.



FIGURES 31–36. *Achrysocharoides robiniae* sp. nov. 31. Head frontal, female. 32. Head frontal, male. 33. Thoracic dorsum, female. 34. Thoracic dorsum, male. 35. Mesosoma lateral, female. 36. Mesosoma lateral, male. Abbreviation: *hc* = hind coxa.

Description. FEMALE. Length 1.0–1.4 mm.

Scape white; pedicel and flagellum dark brown with metallic blue shine, pedicel with ventral side pale. Frons below level of toruli golden-green, between level of toruli up to frontal suture golden-green to golden-red, antennal scrobes golden-red, above frontal suture metallic bluish-purple. Vertex inside ocellar triangle golden-red, outside ocellar triangle golden-green with blue tinges. Mesoscutum and scutellum metallic bluish-green. Propodeum golden-green. Legs white. Wings hyaline. Gaster with first two tergites metallic green, remaining tergites dark brown with metallic tinges.

Antenna as in Fig. 65. Frons below level of toruli smooth and shiny, between level of toruli and frontal suture with raised and strong reticulation with antennal scrobes smooth, above frontal suture smooth and shiny. Vertex inside ocellar triangle with engraved and very weak reticulation, outside ocellar triangle smooth and shiny. Occipital margin with a sharp edge behind ocellar triangle.

Pronotal collar with a sharp carina. Mesoscutum with midlobe with raised and strong reticulation, sidelobes with fine and weak reticulation; notauli as smooth impressions in posterior 2/3. Scutellum smooth and shiny with rows of punctate-reticulate pits on each side. Dorsellum flat and smooth, anterolaterally with two foveae. Propodeum smooth and shiny with two submedian carinae which are more or less parallel and diverging posteriorly; propodeal callus with 3–4 setae. Forewing speculum closed below. Petiole conical without shoulders.

Ratios. HE/MS/WM = 4.2/1.0/2.0; POL/OOL/POO = 1.6/1.4/1.0; WH/WT = 1.3; LW/LM/HW = 1.7/1.0/1.0; PM/ST = 1.1; MM/LG = 1.0.

MALE. Length 0.9–1.4 mm.

Scape yellowish-white; pedicel dark brown with ventral side white; flagellum dark brown with golden-green shine. Frons below level of toruli golden-green or golden-red, above level of toruli metallic blue. Vertex inside ocellar triangle golden-red, outside metallic blue. Mesoscutum and scutellum golden-green with blue tinges. Propodeum golden-green with red tinges. Legs white. Wings hyaline. Gaster with first tergite metallic green, anteromedially with a white spot shaped like a pentagon that extends over tergites 1 and 2; remaining tergites dark brown with metallic tinges.

Antenna as in Fig. 66. Frons below level of toruli smooth and shiny, between level of toruli and frontal suture with strong and transverse striae, above frontal suture medially with raised and rather weak reticulation and close to eyes smooth. Vertex inside ocellar triangle with engraved and very weak reticulation, outside ocellar triangle smooth and shiny. Occipital margin with a sharp edge.

Pronotal collar with a sharp carina. Mesoscutum with midlobe with raised and strong reticulation, sidelobes with fine and weak reticulation; notauli as smooth impressions in posterior 2/3. Scutellum smooth and shiny with rows of punctate-reticulate pits on each side. Dorsellum flat and smooth, anterolaterally with two foveae. Propodeum smooth and shiny with two submedian carinae which more or less parallel and diverging posteriorly; propodeal callus with 3–4 setae. Forewing speculum closed below. Petiole conical without shoulders.

Ratios. HE/MS/WM = 2.1/1.0/1.3; POL/OOL/POO = 3.3/2.5/1.0; WH/WT = 1.3; LW/LM/HW = 1.6/1.0/1.0; PM/ST = 1.0; MM/LG = 1.2–1.6.

Distribution. Austria, Germany, Hungary, Italy, U.S.A.

Host. *Phyllonorycter robiniella* (Clemens) (Lepidoptera: Gracillariidae) on *Robinia pseudoacacia*. In three previous investigations of the parasitoids associated with *P. robiniella* two different species of *Achrysocharoides* were reported. Stojanović & Marković (2005) and Melika *et al.* (2006) reported *A. cilla* (Walker) as a parasitoid of *P. robiniella*, and Navone (2003) and Girardo *et al.* (2007) reported *A. gahani* from the same host, although Navone was not adamant in his identification and left the possibility open for alternate interpretations. We examined material used in Navone (2003) and Melika *et al.* (2006) and this material belongs to *A. robiniae*. So very likely neither *A. cilla*, nor *A. gahani* are parasitoids on *P. robiniella*.

Material examined. Holotype male labeled “HUNGARY: Pest Co., Gödöllő, 14.viii.2003, Balács Klára”, “*Robinia pseudoacacia*”, “ex *Phyllonorycter robiniella*, em. 1.ix.2003” (HNHM); 2 females with same label data as holotype (HNHM); 9 females 6 males” HUNGARY: Vas Co., Meszlen, 6.viii.2002, leg. I. Mikó”, “Ex. *Phyllonorycter robiniella*” (BMNH, CH, PDL); 6 females 5 males “HUNGARY: Vas Co., Köszeg, Als-erd,

23.vi.2002, leg. Zs. Péntzes”, “Ex. *Phyllonorycter robiniella*” (BMNH, CH, PDL); 2 females 5 males” AUSTRIA: Vienna, Laaer Berg, 48°10'N, 16°24'E, 20.vi.2007”, “*Phyllonorycter robiniella*, G. Grabenweger” (CH, GG, NHMV); 1 female 2 males “GERMANY: Berlin, Wönnichstrasse, 5.ix.2005”, “*Phyllonorycter robiniella* on *Robinia pseudoacacia*, G. Grabenweger” (GG, NHMV); 1 female and 1 male “ITALY: Torino, Pianezza, em. 21-27.iv.2003, P. Navone”, “Host: *Phyllonorycter robiniella*” (Clemens) (CNC); 1 female “U.S.A.: Connecticut, Hartford Co., Farmington, near jct. State Road 4 and River Road, 18.x. 2002, C.T. Maier”, “Host: *Phyllonorycter robiniella*” (CNC); 2 females 2 males from same locality and host as previous but collected 26.vi.2002 (CAES, USNM); 1 male “U.S.A.: New Hampshire, Cheshire Co., Town of Hinsdale, 1.5 km S jct. State Highways 63 and 119, 17.x. 2002, C.T. Maier”, “Host: *Phyllonorycter robiniella*” (CNC); 2 females 3 males from same locality and host as previous but collected 28.vi.2002 (CAES, CH).

Identification. To include *A. robiniae* in the latest key to European *Achrysocharoides* (Bryan 1980) the following addition should be made:

Start with

- 1a. Pronotal collar sharply margined (Figs 29–30); propodeum with submedian carinae (Figs 29–30) ..*robiniae* **sp. nov.**
- Pronotal collar without sharp margin (e.g. Figs 5–6); propodeum without submedian carinae (e.g. Figs 5–6) 1

To include *A. robiniae* and *A. robinicolus* in the latest key to Nearctic *Achrysocharoides* (Kamijo 1991) the following addition should be made:

In the key to the species of the *gahani*-group (starts on page 27) the second alternative in couplet 2 should run to 3 instead of *gahani*

- 3. Male frons below frontal suture bright green (Figs 53–54); male gaster with white spot oval-shaped and reaching over tergites 1–3 (Figs 55, 58) *gahani* (Miller)
- Male frons below frontal suture bright blue (Figs 32, 44, 51–52); male gaster with white spot triangular or shaped like a pentagon and reaching over tergites 1–2 (Figs 56–57, 59–60) 4
- 4. Both sexes with hind coxae completely white (Figs 35–36); male scape 1.8X as long as wide (Fig. 66); male gaster with white spot shaped like a pentagon (Figs 56, 59) *robiniae* **sp. nov.**
- Both sexes with hind coxae with base (up to 1/3) brown (Figs 47–48); male scape 3.0X as long as wide (Fig. 68); male gaster with white spot shaped like a triangle (Figs 57, 60) *robinicolus* **sp. nov.**

Etymology. Named after the host plant, *Robinia pseudoacacia*, of its lepidopteran host.

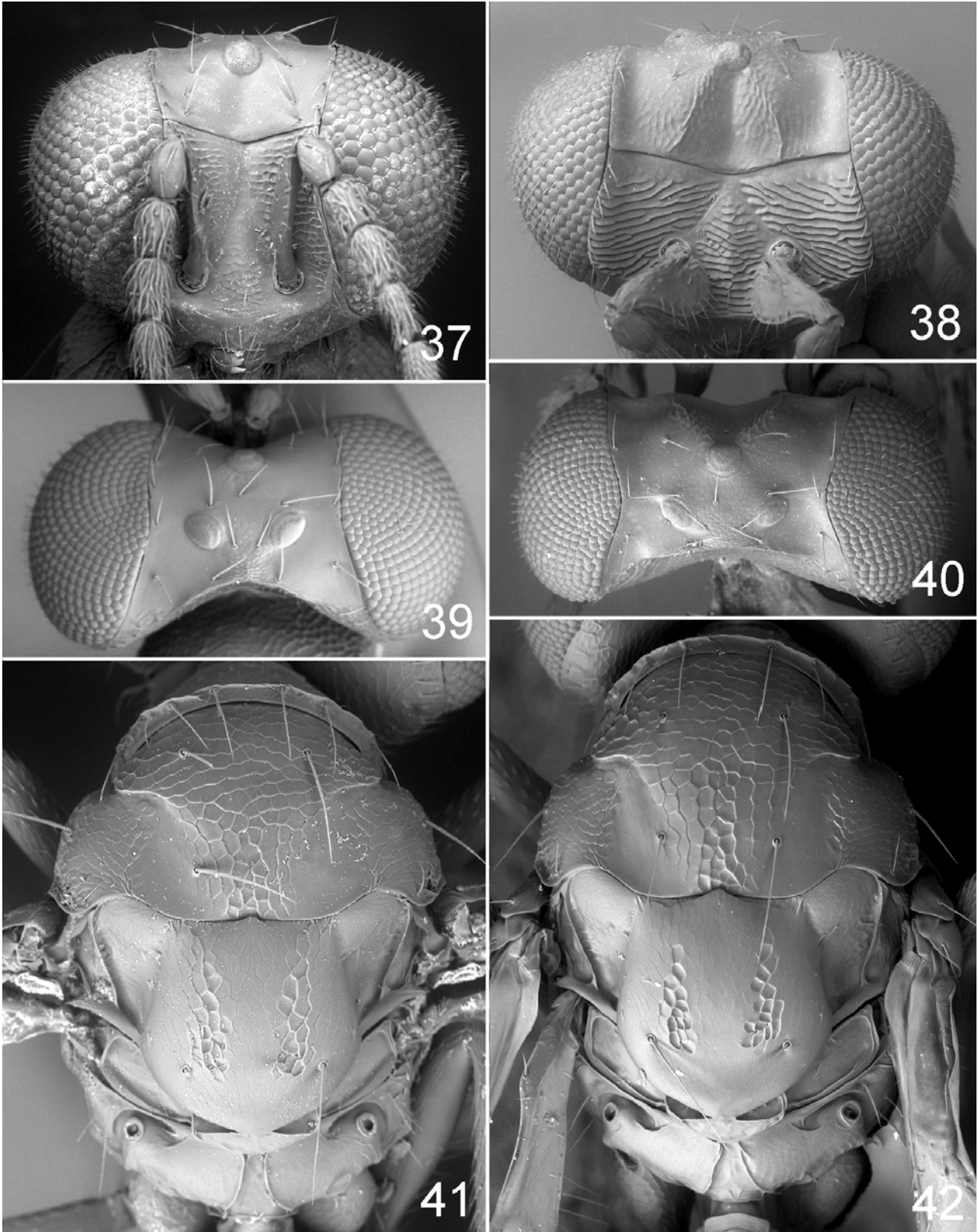
***Achrysocharoides robinicolus* sp. nov.**

(Figs 37–48, 57, 60, 67–68)

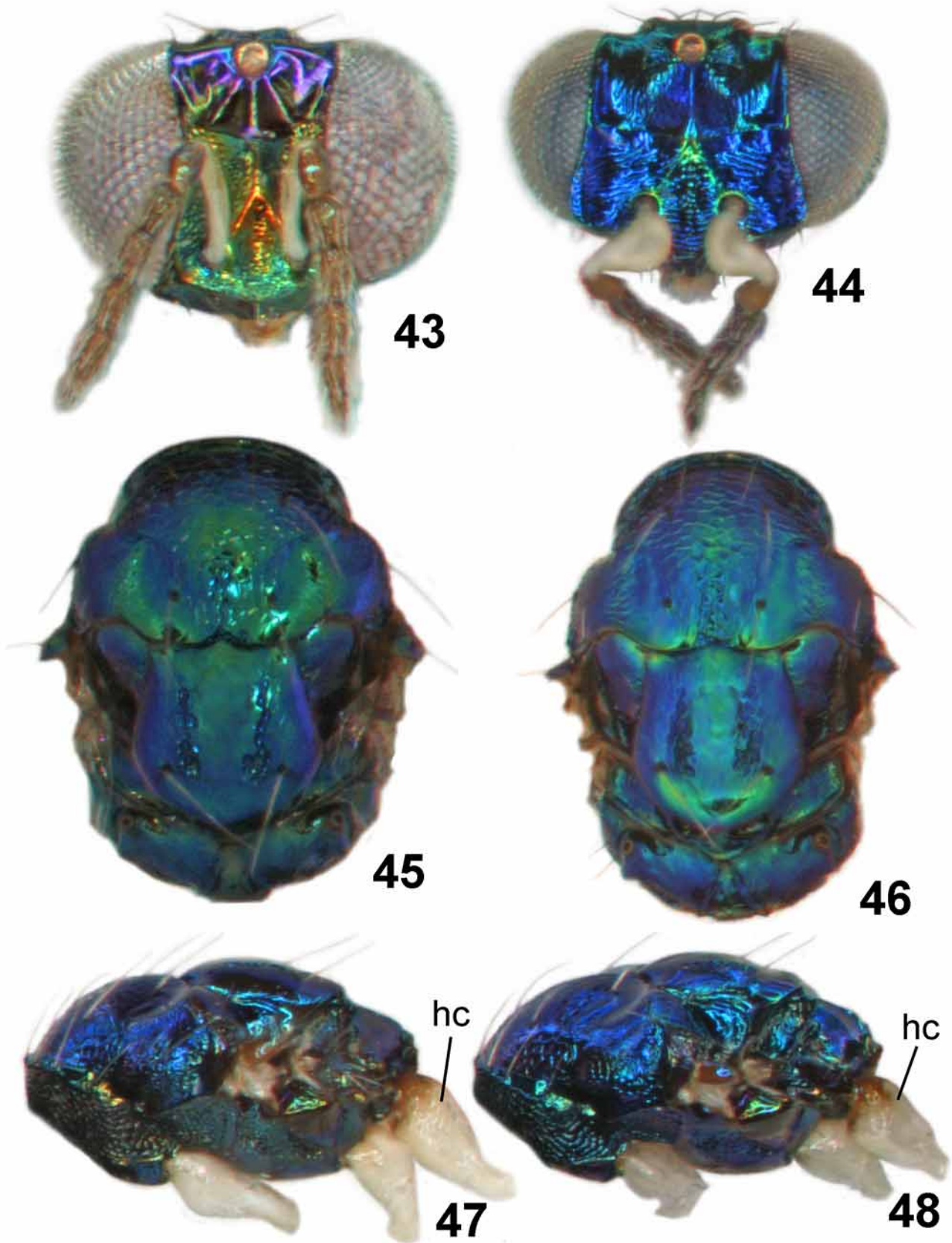
Diagnosis. *Achrysocharoides robinicolus* is very similar to *A. robiniae* but differs in having a narrower male scape (Figs 44, 68), which is 3.0X as long as wide (holotype) (1.8X as long as wide in holotype of *A. robiniae*, Figs 32, 66), anteromedian white spot in male gaster triangular and small, reaching to posterior margin of 1st or 2nd tergites (Figs 57, 60) (shaped as a pentagon in *A. robiniae*, Figs 56, 59), hind coxae in both sexes with base brown to metallic (Figs 47–48) (completely white in both sexes of *A. robiniae*, Figs 35–36).

Description. FEMALE. Length 1.2–1.4 mm.

Scape white with apical 1/3 infusate; pedicel and flagellum brown with weak metallic tinges. Frons below frontal suture golden-green to golden-red, antennal scrobes golden-red, above frontal suture metallic bluish-purple with metallic green tinges. Vertex inside ocellar triangle golden-red, outside ocellar triangle golden-green. Mesoscutum and scutellum metallic bluish-green. Propodeum metallic blue with green tinges. Legs white, hind coxa with base brown to metallic. Wings hyaline. Gaster with first two tergites golden-green, remaining tergites dark brown with metallic green tinges.

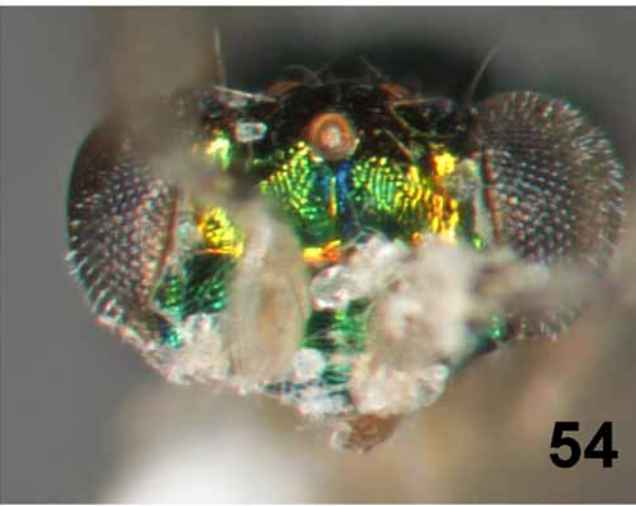
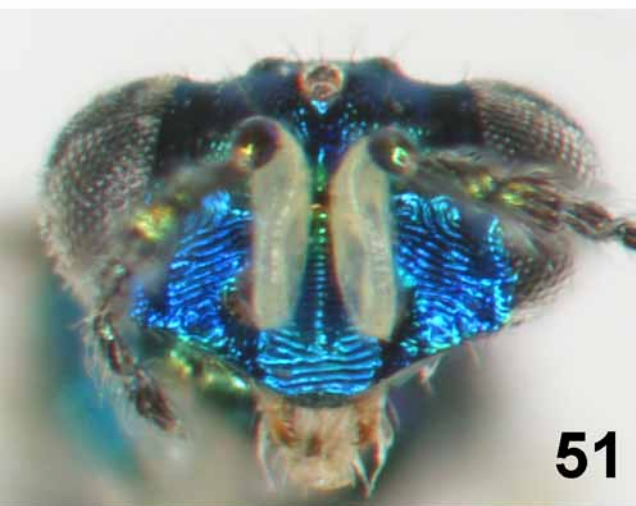
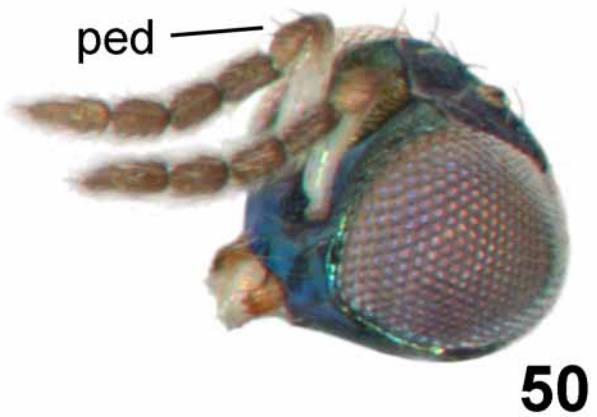
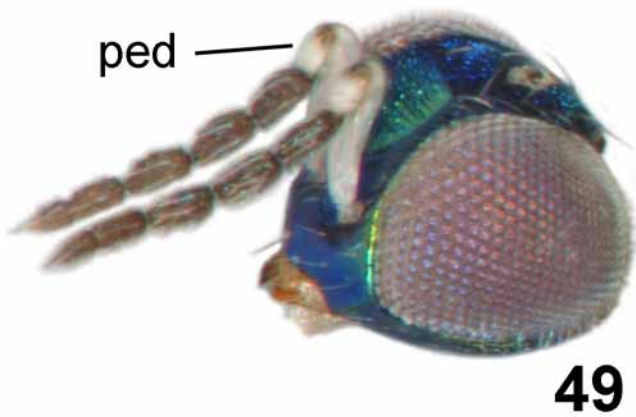


FIGURES 37–42. *Achrysocharoides robinicolus* sp. nov. 37. Head frontal, female. 38. Head frontal, male. 39. Vertex, female. 40. Vertex, male. 41. Thoracic dorsum, female. 42. Thoracic dorsum, male.

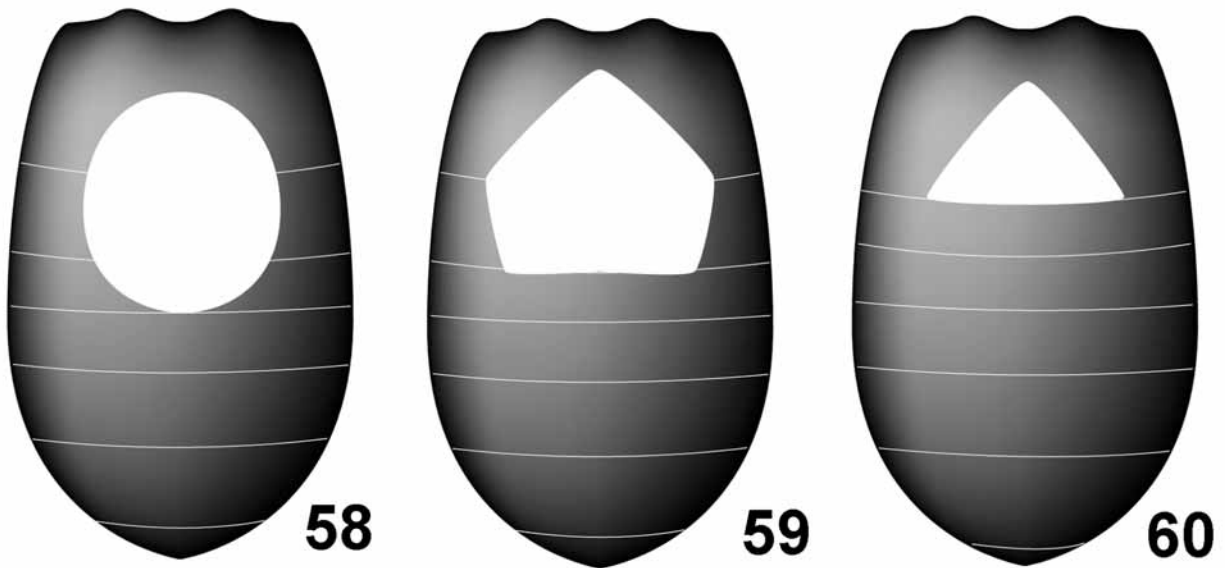
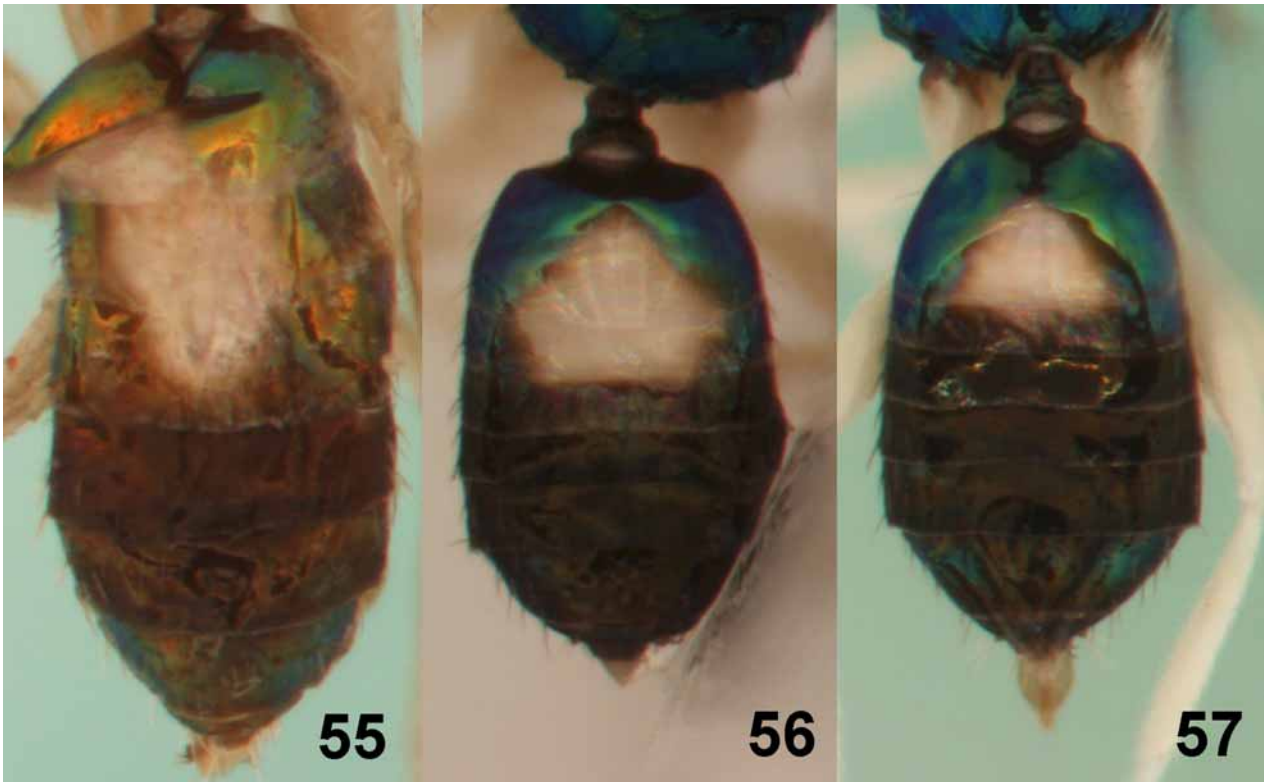


FIGURES 43–48. *Achrysocharoides robinicolus* sp. nov. 43. Head frontal, female. 44. Head frontal, male. 45. Thoracic dorsum, female. 46. Thoracic dorsum, male. 47. Mesosoma lateral, female. 48. Mesosoma lateral, male. Abbreviation: *hc* = hind coxa.

Antenna as in Fig. 67. Frons below level of toruli smooth and shiny, between level of toruli and frontal suture with raised and strong reticulation with antennal scrobes smooth, above frontal suture smooth and shiny. Vertex inside ocellar triangle with engraved and very weak reticulation, outside ocellar triangle smooth and shiny. Occipital margin with a sharp edge behind ocellar triangle.

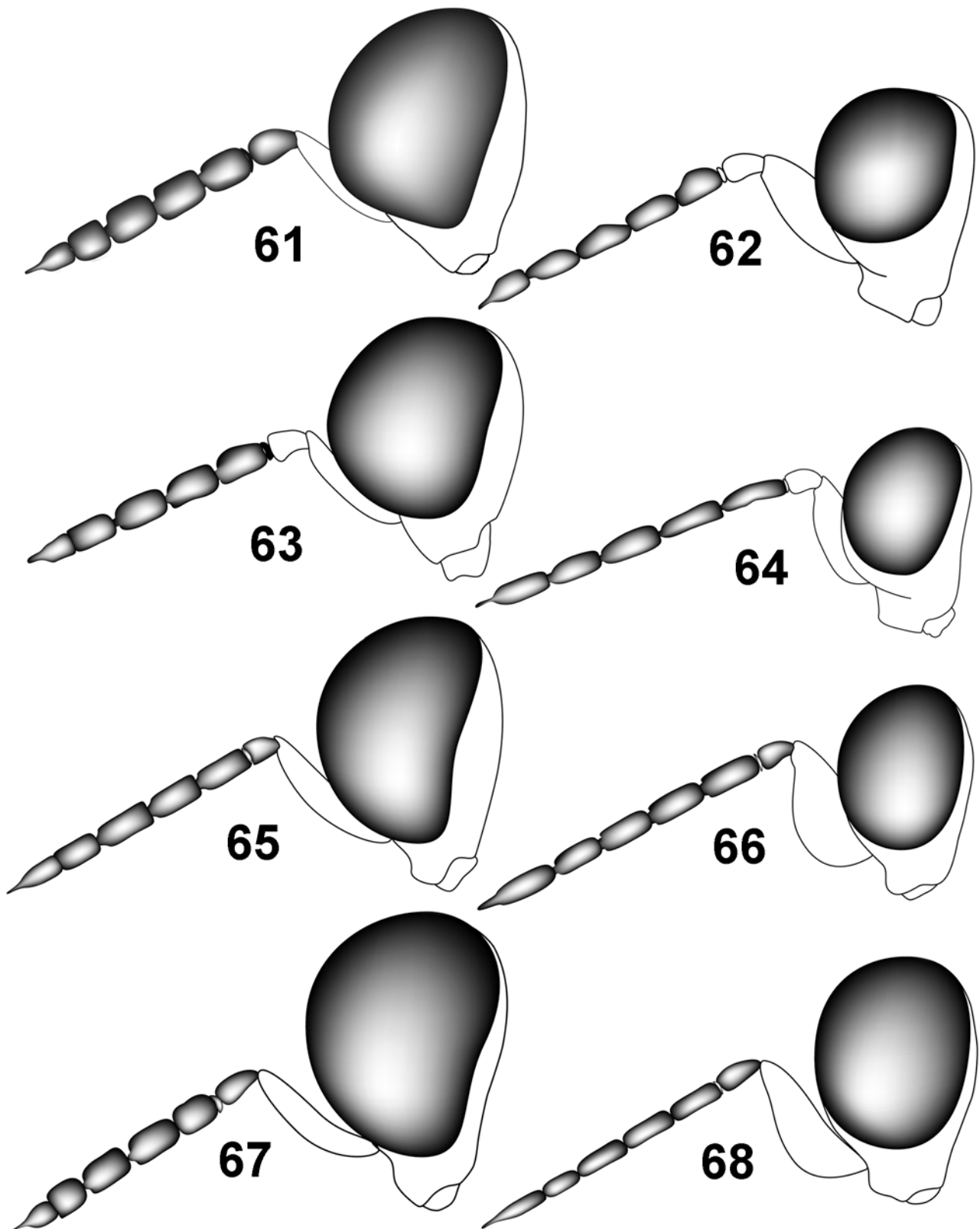


FIGURES 49–54. 49–50. Head and antenna lateral, female. 49. *Achrysocharoides platanoidae* sp. nov. 50. *A. acerianus* (Askew). 51–54. Head frontal, male. 51. *A. robiniae* sp. nov., holotype. 52. *A. robiniae*, paratype from U.S.A., New Hampshire. 53. *A. gahani* (Miller), paratype from Canada, Ottawa, on *Tilia americana*. 54. *A. gahani*, non-type specimen from Canada, Ottawa, on *Tilia americana*. Abbreviation: ped = pedicel.



FIGURES 55–60. Gaster dorsal, male. 55. *Achrysocharoides gahani* (Miller), paratype from Canada, Ottawa, on *Tilia americana*. 56. *A. robiniae* **sp. nov.**, paratype from Hinsdale, New Hampshire. 57. *A. robinicolus* **sp. nov.**, paratype from Highland Falls, New York, 58. *A. gahani*, schematic drawing. 59. *A. robiniae*, schematic drawing. 60. *A. robinicolus*, schematic drawing

Pronotal collar with a sharp carina. Mesoscutum with midlobe with raised and strong reticulation, sidelobes with fine and weak reticulation; notauli as smooth impressions in posterior 2/3. Scutellum with rows of punctate-reticulate pits on each side, remaining surfaces with very weak and engraved reticulation to smooth. Dorsellum flat and smooth, anterolaterally with two foveae. Propodeum smooth and shiny with two submedian carinae that diverge towards posterior margin of propodeum; propodeal callus with three setae. Forewing speculum closed below. Petiole conical without shoulders.



FIGURES 61–68. Head and antenna lateral. 61. *Achrysocharoides acerianus* (Askew), female. 62. *A. acerianus*, male. 63. *A. platanoidae* **sp. nov.**, female. 64. *A. platanoidae*, male. 65. *A. robiniae* **sp. nov.**, female. 66. *A. robiniae*, male. 67. *A. robinicolus* **sp. nov.**, female. 68. *A. robinicolus*, male.

Ratios. HE/MS/WM = 3.9/1.0/1.7; POL/OOL/POO = 1.4/1.0/1.0; WH/WT = 1.2; LW/LM/HW = 1.7/1.0/1.1; PM/ST = 1.0; MM/LG = 1.1–1.2.

MALE. Length 1.3–1.4 mm.

Scape white; pedicel brown with metallic tinges and with ventral side white; flagellum dark brown with golden-green tinges. Frons below level of toruli golden-green or golden-red, above level of toruli metallic blue. Vertex inside ocellar triangle golden-red, outside ocellar triangle metallic bluish-green. Mesoscutum and scutellum metallic blue with green tinges. Propodeum metallic blue with green tinges. Legs white, hind coxae with base brown to metallic. Wings hyaline. Gaster with tergites 1, 2, 6, 7 golden-green, 3–5 dark brown with metallic tinges, anteromedially with a triangular white spot that extends over first tergite, sometimes reaching posterior margin of 2nd tergite.

Antenna as in Fig. 68. Frons below level of toruli smooth and shiny, between level of toruli and frontal suture with strong and transverse striae, above frontal suture medially with raised and rather weak reticulation and close to eyes smooth. Vertex inside ocellar triangle with engraved and very weak reticulation, outside ocellar triangle smooth and shiny. Occipital margin with a sharp edge behind ocellar triangle.

Pronotal collar with a sharp carina. Mesoscutum with midlobe with raised and strong reticulation, sidelobes with fine and weak reticulation; notauli as smooth impressions in posterior 2/3. Scutellum with rows of punctate-reticulate pits on each side, remaining surfaces with very weak and engraved reticulation to smooth. Dorsellum flat and smooth, anterolaterally with two foveae. Propodeum smooth and shiny with two submedian carinae that diverge towards posterior margin of propodeum; propodeal callus with three setae. Forewing speculum closed below. Petiole conical without shoulders.

Ratios. HE/MS/WM = 2.5/1.0/1.2; POL/OOL/POO = 3.2/1.8/1.0; WH/WT = 1.3; LW/LM/HW = 1.7/1.0/1.1; PM/ST = 1.1; MM/LG = 1.1–1.2.

Distribution. U.S.A.

Host. *Phyllonorycter robiniella* (Clemens) (Lepidoptera: Gracillariidae) on *Robinia pseudoacacia*.

Material examined. Holotype male labeled “U.S.A.: New York, Orange Co., Town of Highlands, Highland Falls, along US highway 9W near Catholic Cemetery, 6.vi.2002, C.T. Maier”, “Tentiform mine of *Phyllonorycter robiniella* collected on *Robinia pseudoacacia*, emerged in laboratory within 3 weeks” (CNC); 2 females 2 males with same label data as holotype (CAES, USNM); 1 female from same locality and host as holotype but collected 6.vi.2001 (CNC); 1 female 1 male from same locality and same host as holotype but collected 30.viii.2002 (CNC).

Identification. See above under *A. robiniae*.

Etymology. Named after the host plant, *Robinia pseudoacacia*, of its lepidopteran host.

***Achrysocharoides gahani* (Miller)**

(Figs 53–54, 55, 58)

Enaysma gahani Miller, 1962:1041. Holotype female in CNC, not examined.

Achrysocharoides gahani (Miller) (Yoshimoto 1977:928).

Hosts. The type material of *A. gahani* was reared from *Phyllonorycter* spp. on *Fagus grandifolia*, *Tilia americana* and *Quercus alba* (Miller 1962). Kamijo (1991) transferred the material from *Quercus alba* to *A. reticulatus* Yoshimoto. Apart from these records *A. gahani* has also been reported from *Phyllonorycter* sp. on *Rhus toxicodendron* (Kamijo 1991), *P. blancardella* (Fabricius) on *Malus* sp. (Maier 1984), *P. crataegella* (Clemens) on *Prunus pensylvanica* (Maier 1988) and *P. propinquella* (Braun) on *Prunus serotina* (Maier 1988). We have examined 4 female paratypes of *A. gahani* from *Q. alba* and we agree with Kamijo that these do not belong to this species. We have also been able to examine 3 females and 7 males from *P. propinquella* on *P. serotina* and 5 females and 1 male from *P. crataegella* on *P. pensylvanica* reared by Chris T. Maier (specimens in CAES and CNC). These specimens belong to species-group *clypeatus*, i.e. they do not have a transverse carina on pronotum or submedian carinae on propodeum — characteristics of the *gahani*-group, and are hence not *A. gahani*. Furthermore, we have seen a single female from *Phyllonorycter* sp. on *Rhus*

radicans (in CNC) identified as *A. gahani* by Kamijo. This female is similar to paratypes of *A. gahani* from *Fagus* and *Tilia*, but females of *Achrysocharoides* are difficult to separate and we would like to see a male from *Rhus* before confirming microlepidopterans on *Rhus* as hosts for *A. gahani*. We have not been able to examine any material from *P. blancardella* on *Malus* and we can not state anything regarding the validity of this record. However, in view of our findings regarding *Achrysocharoides* from *Phyllonorycter* spp. on *Prunus* spp. this record needs confirmation.

Material examined. Type material: 10 female paratypes (2 from *Fagus*, 4 from *Quercus*, 4 from *Tilia*) and 2 male paratypes (1 from *Fagus* and 1 from *Tilia*) (CNC).

Discussion

The establishment of *A. platanoidae*, *A. robiniae* and *A. robinicolus* further emphasizes the host/host plant specificity of *Achrysocharoides* species described previously (e.g. Lopez-Vaamonde *et al.* 2005). *Achrysocharoides platanoidae* and *A. acerianus* both have an obligate association with *Phyllonorycter* spp. on the plant genus *Acer*, *A. platanoidae* with *P. platanoidella* on *A. platanoides* (and possibly *A. campestre* — see above under remarks for *A. platanoidae*) and *A. acerianus* with *P. geniculella* on *A. pseudoplatanus*. Previously *A. acerianus* has been recorded also from *Acer platanoides*, but these records are either confirmed misidentifications (Hansson 1983, Lopez-Vaamonde *et al.* 2005), or (Bryan 1980) need confirmation. *Achrysocharoides robiniae* and *A. robinicolus* are both exclusively associated with *P. robiniella* on *Robinia pseudoacacia*. As potential biological control agents against *P. robiniella*, a serious pest on the economically important black locust tree in Europe, it is essential to supply tools for the identification of *Achrysocharoides* species from *Robinia*, which previous misidentifications clearly demonstrate. Using the information in this article: the diagnoses, the well-illustrated descriptions with biological information, and the alterations to already existing keys, it is now possible to unambiguously identify the species of *Achrysocharoides* parasitizing *Phyllonorycter robiniella* on *Robinia*.

Acknowledgements

Our foremost thanks to the Swedish Taxonomy Initiative for funding the PhD position for the junior author. Thanks to Drs Giselher Grabenweger (Institut für Pflanzengesundheit, Vienna, Austria), Carlos Lopez-Vaamonde (Institut National de la Recherche Agronomique, Orleans, France), Chris T. Maier (CAES), George Melika (PDL) and Csaba Thuroczky (Közseg, Hungary) who generously sent us their material of *Achrysocharoides*, and to Gary Gibson (CNC) for sending the type material and additional material of *Achrysocharoides gahani* in CNC. The valuable comments on the manuscript by Gary Gibson, Richard Askew and John Noyes are duly acknowledged. Our thanks also to the microscopy unit at our department for the use of their facilities to do the SEM photos.

References

- Askew, R.R. & Ruse, J.M. (1974) Biology and taxonomy of the genus *Enaysma* Delucchi (Hym., Eulophidae, Entedontinae) with special reference to the British fauna. *Transactions of the Royal Entomological Society of London*, 125(3), 257–294.
- Askew, R.R. & Shaw, M.R. (1979) Mortality factors affecting the leaf-mining stages of *Phyllonorycter* (Lepidoptera: Gracillariidae) on oak and birch, 2: An analysis of the mortality factors. *Zoological Journal of the Linnean Society*, 67, 51–64.
- Bouček, Z. (1988) *Australasian Chalcidoidea (Hymenoptera), a biosystematic revision of genera of fourteen families, with a reclassification of species*. CAB International, Wallingford, 832 pp.
- Bouček, Z. & Askew, R.R. (1968) Palaearctic Eulophidae excl. Tetrastichinae. *Index of Entomophagous Insects*, 3, 1–260.

- Bouček, Z. & Graham, M.W.R. de V. (1978) British check-list of Chalcidoidea (Hymenoptera): taxonomic notes and additions. *Entomologist's Gazette*, 29(4), 225–235.
- Bryan, G. (1980) The British species of *Achrysocharoides* (Hymenoptera, Eulophidae). *Systematic Entomology*, 5(3), 245–262.
- Burks, B.D. (1979) *Torymidae (Agaoninae) and all other families of Chalcidoidea (excluding Encyrtidae)*. In: Krombein, K.V., Hurd, P.D. jr., Smith, D.R. & Burks, B.D. (Eds), *Catalog of Hymenoptera in America North of Mexico*. 1:748–749, 768–889, 967–1043. Smithsonian Institution Press, Washington, D.C.
- Gibson, G.A.P., Huber, J.T. & Woolley, J.B. (1997) *Annotated Keys to the Genera of Nearctic Chalcidoidea (Hymenoptera)*. NRC Research Press, Ottawa, 794 pp.
- Girardo, S., Volter, L., Tomov, R., Quicke, D.L.J. & Kenis, M. (2007) Variations in parasitism in sympatric populations of three invasive leaf miners. *Journal of Applied Entomology*, 131, 603–612.
- Girault, A.A. (1913a) New genera and species of chalcidoid Hymenoptera in the South Australia Museum, Adelaide. *Transactions of the Royal Society of South Australia*, 37, 67–115.
- Girault, A.A. (1913b) New genera and species of chalcidoid Hymenoptera belonging to the family Eulophidae from Australia. *Societas Entomologica*, 28, 99–100.
- Graham, M.W.R. de V. (1959) Keys to the British genera and species of Elachertinae, Eulophinae, Entedontinae, and Euderinae (Hym., Chalcidoidea). *Transactions of the Society for British Entomology*, 13:169–204.
- Hansson, C. (1983) Taxonomic notes on the genus *Achrysocharoides* Girault, 1913 (Hymenoptera: Eulophidae), with a redescription and a description of a new species. *Entomologica Scandinavica*, 14, 281–291.
- Hansson, C. (1985) Taxonomy and biology of the Palearctic species of *Chrysocharis* Förster, 1856 (Hymenoptera: Eulophidae). *Entomologica Scandinavica Supplement*, 26, 1–130.
- Kamijo, K. (1990a) Five new species of *Achrysocharoides* (Hymenoptera, Eulophidae) associated with Leguminosae in Japan. *Japanese Journal of Entomology*, 58(2), 293–302.
- Kamijo, K. (1990b) Descriptions of five new species of *Achrysocharoides* (Hymenoptera: Eulophidae) from Japan, with notes on species-groups. *Akitsu (new series)*, 119, 1–16.
- Kamijo, K. (1991) Revision of North American *Achrysocharoides* (Hymenoptera: Eulophidae). *Akitsu (new series)*, 124, 1–34.
- Lopez-Vaamonde, C., Godfray, H.C.J., West, S.A., Hansson, C. & Cook, J.M. (2005) The evolution of host use and unusual reproductive strategies in *Achrysocharoides* parasitoid wasps. *Journal of Evolutionary Biology*, 18, 1029–1041.
- Mabberley, D.J. (1997) *The Plant-Book*. Cambridge University Press, 858 pp.
- Maier, C.T. (1984) Abundance and phenology of parasitoids of the spotted tentiform leafminer, *Phyllonorycter blancardella* (Lepidoptera: Gracillariidae), in Connecticut. *The Canadian Entomologist*, 116, 443–449.
- Maier, C.T. (1988) Parasitoid fauna of two *Phyllonorycter* spp. (Lepidoptera: Gracillariidae) on wild cherries, and similarity to fauna of apple leafminers. *Annals of the Entomological Society of America*, 81, 460–466.
- Melika, G., Péntzes, Z., Mik, I., Csóka, G., Hirka, A. & Bechtold, M. (2006) Two invading black locust leaf miners, *Parectopa robiniella* and *Phyllonorycter robiniella* and their native parasitoid assemblages in Hungary. In: Csóka, G., Hirka, A. & Koltay, A. (Eds), *Biotic damage in forests. Proceedings of the IUFRO (WP 7.03.10)*. Symposium in Mátrafüred, Hungary, September 12–16, 2004.
- Miller, C.D.F. (1962) Some Nearctic species of the chalcid genus *Enaysma* Delucchi (Eulophidae: Entedontinae). *The Canadian Entomologist*, 94, 1039–1052.
- Navone, P. (2003) Occurrence of a Nearctic Hymenoptera Eulophidae belonging to the genus *Achrysocharoides* (Hymenoptera Eulophidae) on *Phyllonorycter robiniella* (Clemens) in Italy. *Bollettino di Zoologia Agraria e di Bachicoltura* 35, 79–82 (in Italian).
- Noyes, J.S. (1982) Collecting and preserving chalcid wasps (Hymenoptera: Chalcidoidea). *Journal of Natural History*, 16, 315–334.
- Peck, O. (1951) Superfamily Chalcidoidea, pp. 410–594. In Muesebeck, Krombein & Townes (Eds). *Hymenoptera of America north of Mexico. United States Department of Agriculture Monographs*, 2, 1–1420.
- Polunin, O. (1969) *Flowers of Europe, a field guide*. Oxford University Press, London, 662 pp.
- Šefrov, H. (2002) *Phyllonorycter robiniella* (Clemens, 1859) – egg, larva, bionomics and its spread in Europe (Lepidoptera, Gracillariidae). *Acta Universitatis Agriculturae et Silviculturae Mendelinae Brunensis* 50, 7–12.
- Stojanović, A. & Marković, C. (2005) Parasitoid complex of *Phyllonorycter robiniella* (Clemens, 1859) (Lepidoptera, Gracillariidae) in Serbia. *Journal of Pest Science*, 78, 109–114.
- Whitebread, S.E. (1990) *Phyllonorycter robiniella* (Clemens, 1859) in Europe (Lepidoptera, Gracillariidae). *Nota Lepidopterologica*, 12, 344–353.
- Yoshimoto, C.M. (1977) The North American species of the genus *A.* (Hymenoptera: Eulophidae). *The Canadian Entomologist*, 109, 907–930.