JHR 28: 1–11 (2012)
doi: 10.3897/JHR.28.3044
www.pensoft.net/journals/jhr

RESEARCH ARTICLE

JOURNAL OF Hymenoptera RESEARCH
A peer-reviewed open-access journal
The International Society of Hymenopterists

# Host range testing and biology of *Abia sericea* (Cimbicidae), a candidate for biological control of invasive teasels (*Dipsacus* spp.) in North America

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Academic editor: *Stefan Schmidt* | Received 3 March 2012 | Accepted 30 May 2012 | Published 24 August 2012

**Citation:** Harizanova V, Stoeva A, Rector BG (2012) Host range testing and biology of *Abia sericea* (Cimbicidae), a candidate for biological control of invasive teasels (*Dipsacus* spp.) in North America. Journal of Hymenoptera Research 28: 1–11. doi: 10.3897/JHR.28.3044

## Abstract

Invasive teasels (*Dipsacus* spp., Dipsacaceae) are widespread in the USA, being present in 43 states and listed as noxious in five. The cimbicid sawfly *Abia sericea* (Linné, 1767) is under evaluation as a potential agent for classical biological control of teasels. The host range, biology, and life history of this insect were studied under laboratory conditions and in common garden experiments from 2006–2010 at the Agricultural University of Plovdiv, Bulgaria in order to determine if this biocontrol candidate justified the expense of further testing under quarantine conditions in the USA. In the laboratory, potted plants from twelve plant species belonging to seven families were tested in choice tests of oviposition and feeding. Eggs were laid only on *D. laciniatus* and *D. fullonum* plants with only one exception, on *Valeriana officinalis*, although the larvae that hatched from the latter did not feed on that plant. Larval feeding was observed only on *D. laciniatus*, *Knautia arvensis*, and *Scabiosa ochroleuca*, all in the family Dipsacaceae, which has no species native to the New World nor any of economic importance. In common garden tests into which adults and third- and fourth-instar larvae were released in separate tests, eggs were laid and larvae fed only on *D. laciniatus*. The results of these experiments indicate that *A. sericea* has a narrow host range, most likely limited to *Dipsacus* species, and a few other Dipsacaceae and that further pre-release studies in a US quarantine are warranted.

## Keywords

Biological control of weeds, host specificity, parthenogenesis, sawfly, Symphyta

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## Introduction

Fuller's teasel, *Dipsacus fullonum* L., and cutleaf teasel, *D. laciniatus* L., are both native to Europe and western Asia and have become invasive alien weeds in non-agricultural habitats in the United States, now present in 43 states, listed as noxious in five, and invasive in at least 12 more (Rector et al. 2006). Teasels are also present in four Canadian provinces and listed as noxious in Manitoba (Werner 1975, Province of Manitoba 2011). These invasive teasels were probably introduced as contaminated seed of cultivated teasel, *D. sativus* (L.) Honck., an obsolete crop plant formerly used in wool processing (Ryder 1994). All members of the family Dipsacaceae are native to the Old World (Verlaque 1985) and none are of agricultural importance (Bailey 2001); thus, classical biological control of invasive teasels in the New World using natural enemies imported from their native range is considered to be a worthwhile pursuit (Rector et al. 2006).

A handful of natural enemies have been recorded from the invaded range of teasels in North America although they appear to have little effect in limiting spread of teasel populations (Rector et al. 2006, Dugan and Rector 2007). Surveys of natural enemies from the native ranges of *D. fullonum* and *D. laciniatus* have yielded 102 insect species, as well as 27 fungi, four mites, one nematode, and two viruses (Rector et al. 2006, Rector and Petanović 2012). Candidate biological control agents under study to date include the eriophyid mite *Leipothrix dipsacivagus* Petanović et Rector, 2007, the leafmining fly *Chromatomyia ramosa* (Hendel, 1923), the flea beetle *Longitarsus strigicollis* Wollaston, 1864, and the sawfly *Abia sericea* (Linné, 1767) (Rector et al. 2008, Pećinar et al. 2009, 2011, Stoeva et al. 2011, BGR unpubl. data). Some fungi have also been identified as promising candidate agents (Rector et al. 2006).

The sawfly *Abia sericea* belongs to the family Cimbicidae (Hymenoptera: Symphyta), subfamily Abiinae, a group for which biological information is somewhat sparse (Liston and Späth 2006). In Europe approximately twelve species are listed; these have been divided into two groups according to their host-plant association (Savina and Liston 2009). All records for larval feeding by the *A. sericea* species group (Savina and Liston 2009) refer to a few genera in the family Dipsacaceae with the exception of *Fragaria* sp. (Rosaceae) (Konow 1901, Krishtal 1959) although this latter host record has been specifically tested and refuted (Rector et al. 2008). *Abia sericea* has been reported from across Europe, covering much of the known distributions of *D. fullonum* and *D. laciniatus* (Verlaque 1985, Taeger and Blank 2011). It is not known as an agricultural pest in Europe (Rector et al. 2008) and its presence is considered as an indicator of pristine natural habitat in parts of northern Europe where it is locally endangered (Savina and Liston 2009).

The purpose of this study was to investigate the biology and host range of *Abia sericea* in order to determine whether this candidate for biological control of invasive teasels merits the time and expense of undergoing a complete host-specificity assessment, including tests on rare and endangered North American plants, under quarantine conditions in the USA. Biological notes about *Abia sericea* that are pertinent to its potential importation into North America are also reported.

## Methods

### Host-specificity testing

A test plant species list was developed in consultation with the USDA-APHIS Technical Advisory Group for Biological Control Agents of Weeds, based mainly on phylogenetic relationships with the target weed but also including economically important species and rare or threatened plants in related families that are native to the invaded range of the target in North America (Wapshere 1974, APG II 2003, Briese and Walker 2008). This list includes 51 plant species from 24 genera in nine families. Since the family of the target weed, Dipsacaceae, is native only to the Old World and contains no species of great economic importance, the list consists largely of North American plant species from the most closely related families to the Dipsacaceae (viz. Adoxaceae, Caprifoliaceae, Valerianaceae). From this test plant list, thirteen species were chosen for this study for choice oviposition and larval feeding bioassays in the laboratory (Table 2). Nine of those species were included in subsequent common garden oviposition and feeding experiments (Table 3).

Of the plant species tested in these experiments, *Dipsacus laciniatus, D. fullonum, Knautia arvensis* L. (Coult.), *Scabiosa ochroleuca* L., and *Cephalaria transylvanica* (L.) Roemer & Schultes were grown in pots from field-collected seeds, whereas carrot (*Daucus carota* L.), lettuce (*Lactuca sativa* L.), cabbage (*Brassica oleracea* L.), sunflower (*Helianthus annuus* L.) and *Valeriana officinalis* L., plants were grown in pots from commercially available seeds. Young *Sambucus ebulus* L. plants were dug from the field and potted, while *Viburnum lantana* L., and *Lonicera caprifolium* L. were obtained as potted plants from a commercial nursery that did not use insecticides.

For the laboratory bioassays, potted plants from the test species were arranged in plastic cages measuring 40 × 40 × 20 cm, with each cage containing one *Dipsacus laciniatus* rosette and up to seven plants of different non-target species. Individual female sawflies that were reared in the laboratory were released into each cage to oviposit. Number of eggs laid and feeding by hatched larvae were recorded. For the larval feeding experiment, two laboratory-reared larvae were placed on each non-target plant in similar cages containing one teasel rosette and seven non-target plants. Plants were arranged with leaves of adjacent plants touching each other to allow larvae to move freely between them. The laboratory experiments were carried out at 24±2°C, RH 60–70% and photoperiod of 16L:8D.

The common garden bioassays tested the same plant species as in the laboratory bioassays with the exception of the non-target Dipsacaceae species, which were not included. Test plants in the same developmental stages as in the laboratory bioassays were transplanted into a Latin square design with a distance of 70 cm between the plants within rows. A total of 78 field-collected third- and fourth-instar larvae were released in early June 2010 at a rate of 1–2 per test plant; larvae were not released onto teasel plants. Nine adult female sawflies were released into the test plot to lay eggs on test plants on 24 June 2010 and three more were released on 1 July 2010.

Adults were collected from the field and released on the day of collection after 6:00 p.m. Leaves of the test plants were inspected for eggs and larval feeding during the three days following each release.

## Biological studies

Adult females were collected from the field from several sites in Bulgaria (Table 1) and released to oviposit in cages with *Dipsacus* plants to produce larvae for the laboratory colony and for larval feeding bioassays. The field-collected females were not used in the oviposition bioassays since their previous oviposition history was not known. Longevity, fecundity, and duration of the different stages were studied under laboratory conditions. The laboratory experiments were carried out at 24±2°C, RH 60–70% and photoperiod of 16L:8D.

For the oviposition studies one newly emerged adult female was released along with a newly emerged adult male into a plastic cage (20 × 20 × 40 cm) with a potted, laboratory grown *Dipsacus laciniatus* or *D. fullonum* plant in the rosette stage. Adult sex was easily determined by the presence on the male of a wide, black band down the center of the dorsal, posterior abdomen. There were 36 replicated cages each containing one pair of sawflies. After the death of a female sawfly the plants in the cages were carefully inspected for the presence of eggs using a magnifying glass and the number was recorded. The longevity of the females was recorded. The duration of the egg stage was measured as the number of days from the first observation of oviposition until the hatching of the first larvae in each cage.

The duration of the larval stage was studied by carefully placing two newly hatched larvae on the leaves of a young potted *Dipsacus* rosette in a cage (20 × 20 × 40 cm) using a small plastic spoon. The duration of the larval stage was defined as the number of days from hatching to pupation. The duration of the cocoon stage was studied under laboratory conditions in plastic containers (300 ml) covered with muslin. Cocoons of larvae made on the same day were placed together on a bed of senesced, crumbled teasel leaves in a container. Each container was checked daily beginning one week after setting up the experiment. The duration of the cocoon stage was defined as the number of days from the spinning of the cocoon until emergence of the adult. The amount of time from construction of the cocoon by the pre-pupal larva until pupation was not measured.

**Table 1.** Locations, in Bulgaria, of collection of *Abia sericea.* Life stage and purpose of collection are noted.

| Location | GPS coordinates | | Stage collected | Bioassays |
|---|---|---|---|---|
| Galabovo | 42°01.49'N | 24°42.28'E | Adult | Biological studies/colony establishment |
| Klokotnitsa | 42°24.25'N | 25°27.41'E | Adult | Biological studies/colony establishment |
| Lovech | 43°04.12'N | 24°44.09'E | Adult | Biological studies/colony establishment |
| Lozen | 42°37.56'N | 23°30.36'E | Adult | Biological studies/colony establishment |
| Pleven | 43°24.25'N | 24°28.79'E | Adult | Biological studies/colony establishment |
| Porojna | 42°03.11'N | 25°08.59'E | Larva | Common garden host-specificity experiment |
| Trud | 42°12.29'N | 24°45.57'E | Larva | Common garden host-specificity experiment |

### Field observations

During field collections of *A. sericea* adults or larvae from 2006–2010, notes were made on their behavior and other characteristics. In addition, sympatric plants that are on the test plant list or congeners of those plants were identified in the field and examined for the presence of adults, larvae, or eggs of the sawfly. These plants included *Knautia* spp., *Lonicera* spp., *Sambucus ebulus,* and *Scabiosa* spp.

## Results

### Host-specificity tests

In the laboratory oviposition host-specificity bioassays, eggs were laid only on *Dipsacus laciniatus* and *D. fullonum* plants with one exception: a single female that laid eggs on a *Valeriana officinalis* plant (Table 2). In one replicate, no eggs were laid on any plant. In laboratory larval feeding choice bioassays, *A. sericea* fed only on plants in the family Dipsacaceae. This included all *Dipsacus* plants in 71 replicates, five of 43 *Knautia arvensis* plants, and one of 18 *Scabiosa ochroleuca* plants (Table 2). None of 28 *Cephalaria transylvanica* plants were fed upon nor were any plant species outside of the family Dipsacaceae (Table 2). In the common garden larval feeding bioassay in which larvae were placed on all plants other than teasels, all larvae left their plants within one day, with 24 of them moving to teasel plants where they remained and fed on teasel foliage (Table 3). The fate of the other 54 larvae was unknown. No larval feeding was observed on any test plants other than *D. laciniatus* in this test. In the common garden oviposition test, eggs of the sawfly were found on two of the *D. laciniatus* plants and on no non-target plants (Table 3).

**Table 2.** Choice trials for oviposition of adults and feeding of *A. sericea* larvae under laboratory conditions.

| Test plants | | Oviposition | | | Larval feeding | |
|---|---|---|---|---|---|---|
| **Family** | **Genus/species** | **No. of plants** | **No. of plants with eggs** | **Total no. of eggs laid** | **No. of plants** | **No. of plants fed on** |
| Dipsacaceae | *Cephalaria transylvanica* | 28 | 0 | 0 | 28 | 0 |
| | *Dipsacus fullonum/ Dipsacus laciniatus* | 71 | 70 | 2769 | 71 | 71 |
| | *Knautia arvensis* | 43 | 0 | 0 | 43 | 5 |
| | *Scabiosa ochroleuca* | 18 | 0 | 0 | 18 | 1 |
| Adoxacea**e** | *Sambucus ebulus* | 28 | 0 | 0 | 28 | 0 |
| | *Viburnum lantana* | 8 | 0 | 0 | 8 | 0 |
| Caprifoliaceae | *Lonicera caprifolium* | 18 | 0 | 0 | 18 | 0 |
| Valerianaceae | *Valeriana officinalis* | 28 | 1 | 47 | 28 | 0 |
| Apiaceae | *Daucus carota* | 25 | 0 | 0 | 25 | 0 |
| Asteraceae | *Lactuca sativa* | 25 | 0 | 0 | 25 | 0 |
| | *Helianthus annuus* | 25 | 0 | 0 | 25 | 0 |
| Brassicaceae | *Brassica oleracea* | 25 | 0 | 0 | 25 | 0 |

**Table 3.** Choice trials for ovipostion of adults and feeding of *A. sericea* larvae in a common garden experiment. The test plot consisted of nine plants of each test species.

| Test plants | | Oviposition | | Larval feeding |
|---|---|---|---|---|
| **Family** | **Genus/species** | **No. of plants with eggs** | **No of eggs laid** | **No. of plants fed on** |
| Dipsacaceae | *Dipsacus laciniatus* | 2 | 57 | 9 |
| Adoxaceae | *Sambucus ebulus* | 0 | 0 | 0 |
| | *Viburnum lantana* | 0 | 0 | 0 |
| Caprifoliaceae | *Lonicera caprifolium* | 0 | 0 | 0 |
| Valerianaceae | *Valeriana officinalis* | 0 | 0 | 0 |
| Apiaceae | *Daucus carota* | 0 | 0 | 0 |
| Asteraceae | *Lactuca sativa* | 0 | 0 | 0 |
| | *Helianthus annuus* | 0 | 0 | 0 |
| Brassicaceae | *Brassica oleracea* | 0 | 0 | 0 |

## Biological studies and observations

The duration of the developmental stages of *Abia sericea* is presented in Table 4. Under laboratory conditions *A. sericea* spent approximately three weeks in both the larval (23.6 ± 3.2 d) and cocoon (20.3 ± 2.7 d) stages. By contrast, the adult female (4.7 ± 1.1 d) and egg (4.3 ± 0.6 d) stages combined for just over one week. Fecundity of unfertilized females averaged 86.1 ± 36.0 eggs with a minimum of 35 and a maximum of 194.

*Abia sericea* females typically lay their eggs into the leaf margin, in groups of two to seven, inserting the ovipositor under the epidermis of the leaf while straddling the leaf edge (i.e. with three legs each on the upper and lower leaf surfaces). The eggs are elongate and oval in shape. When freshly laid they appear greenish and are inconspicuous within the leaf but prior to hatching they turn beige or bronze-colored and seem to protrude more.

On teasel plants, neonate larvae begin eating immediately upon hatching, entirely consuming their egg cases in the course of feeding on the foliage. It was noted that in the case of eggs laid into *V. officinalis* leaves (Table 2), no feeding of any kind was observed by the larvae on this plant. Their empty egg cases remained after they vacated the *V. officinalis* plant to feed on an adjacent teasel plant in the same cage.

Larvae from a single clutch of *A. sericea* eggs hatch within one day of each other and begin to feed immediately, most frequently eating at the margins of the leaf on which they hatch or making small holes near the leaf margins. The larvae feed on the leaves of the rosette and of bolted teasel plants, chewing through the entire thickness of the leaves. Young larvae feed gregariously on all but the main veins of the leaves, while later instars feed individually. A detailed description of the morphology of the larval stadia of *A. sericea* is provided by Savina and Liston (2009).

When resting the larvae have a specific pose, with their abdomen coiled, usually on the lower side of the leaf. When disturbed, larvae typically drop to the ground where they can be difficult to spot in leaf litter, due to their broken coloration. When touched the larvae release a defensive liquid, a reaction known as “reflex bleeding” similar to that described by Savina and Liston (2009) for the larvae of *Abia fulgens* Zaddach, 1863.

**Table 4.** Duration of developmental stages and fecundity of *A. sericea* females under laboratory conditions. The egg-to-adult mean is the sum of the durations of the component life stages and is presented as an estimate since individual insects were not tracked from egg to adult.

| Stage | Duration of stages (days) | | | | |
|---|---|---|---|---|---|
| | **Mean** | **SD** | **min** | **max** | **N** |
| Egg stage | 4.3 | 0.6 | 2 | 5 | 936 |
| Larval stage | 23.6 | 3.2 | 17 | 31 | 45 |
| Pupal stage (cocoon) | 20.3 | 2.7 | 15 | 26 | 24 |
| From egg to adult | 48.2 | | | | 24 |
| | Longevity (days) | | | | |
| Unfertilized adult female | 4.7 | 1.1 | 2 | 6 | 36 |
| | Egg productivity (number/female) | | | | |
| Unfertilized adult female | 86.1 | 36.0 | 35 | 194 | 36 |

The larvae of *Abia sericea* pupate in double-layered, light brown to dark brown cocoons, similar to those described by Liston and Späth (2006) for the sawfly *A. nitens* (Linné, 1758). Under laboratory conditions pupation took place most frequently on the soil surface in the pots or at the base of or under the pots where the pre-pupal larvae had crawled. At emergence the adult sawfly cuts a circular opening in the cocoon.

Under laboratory conditions, adult females began laying eggs immediately after emergence without mating, despite the presence of males in the cages. Providing cotton soaked in a 5% sugar solution or inflorescences of dipsacaceous plants did not stimulate the adults to copulate. Laboratory-raised adult females in this experiment laid their eggs parthenogenetically and the progeny were all male. Adults of *A. sericea* were active during the day and rested at night.

Larvae of the sawfly collected from various locations in Bulgaria frequently displayed symptoms of viral infection, e.g. lethargy, cessation of feeding, shrinking and darkening of the body, excretion of viscous exudates by which they sometimes became glued by their anal segment to the floor of the experimental cage. A virus from the family Iridoviridae was isolated from larvae with these symptoms but it has not been indentified further. Under laboratory conditions the rate of mortality was quite high when virus symptoms were present, particularly for younger larvae (data not shown). Parasitism by the endoparasitoid *Himerta defectiva* Gravenhorst (Hymenoptera: Ichneumonidae) was also observed. In 2008, six *H. defectiva* adults emerged from cocoons made in the laboratory by 34 *A. sericea* larvae collected in the vicinity of Parvomay, Bulgaria.

## Field observations

Adult *A. sericea* begin to emerge in the field at the end of April and are most abundant from May to mid-July and in September. In August no adults were found in the field. In the field, *A. sericea* larvae feed most actively at dusk, and throughout cloudy or overcast days. During sunny weather, especially with high temperatures and intense light

the larvae tend to rest on the undersides of the leaves. Pupae in the field were observed on the soil surface under teasel rosettes or under the ground litter and plant debris. In fields where natural populations of *A. sericea* were collected from *Dipsacus*, neither eggs, larvae, nor adults of *A. sericea* were ever found on sympatric plants of *Knautia*, *Lonicera*, *Sambucus ebulus*, or *Scabiosa*.

## Discussion

There are two possible explanations for the lone occurrence of *A. sericea* oviposition on *V. officinalis*. The female in question may have been stimulated to mistakenly oviposit on a non-target plant by the presence of the adjacent normal host plant, viz. *D. laciniatus*, in the same cage (Marohasy 1998). Indeed, the same female also laid more than 100 eggs on that teasel plant. Alternatively, this female may have been naturally stimulated to oviposit on *V. officinalis* although her offspring were apparently not stimulated to feed on that plant nor did they feed on their egg cases, as all other neonate *A. sericea* larvae in this study were observed to do. Instead, all of them moved to an adjacent teasel plant to feed. It is not known whether feeding on egg cases provides any nutrition or feeding stimulation to the neonate larva. Taken together, these data suggest that *V. officinalis* is not a genuine host for *A. sericea.* However, several North American *Valeriana* species, that are rare or endangered are included on the full test plant list and should be thoroughly tested in both choice and no-choice feeding and oviposition studies in subsequent pre-release evaluations.

It is not known whether *A. sericea* overwinters as a pupa or as an eonymph in its cocoon. Such data would require destructive sampling of the cocoons, which was not undertaken in this study due to the need for adults in the oviposition bioassays. Likewise, the point at which the larva becomes a pupa, during the three-week period within the cocoon, was not determined.

In the laboratory bioassays the males seemed disinterested in copulation. Savina and Liston (2009) reported an observed copulation in the field while the female was feeding from a flower. Parthenogenesis was observed in this study and was also reported for *Abia lonicerae* (Linné, 1758) (Kangas 1945) and *A. mutica* Thomson, 1871(Kangas 1946). Further studies of adult reproductive behavior will be necessary to achieve successful copulation of *A. sericea* in the laboratory in order to facilitate mass-rearing for possible exportation and release for biological control purposes.

The observation of diurnal adult activity in this study was consistent with observations of other *Abia* species (Liston and Späth 2006, Savina and Liston 2009). The absence of adults in the field in the hottest part of the summer may be due to high temperatures and low humidity. It is notable that the adults reappear at the end of summer.

The larvae of the first (spring) generation, developing in May and June, and of the third (autumn) generation, developing in September and October, should have greater impact on *Dipsacus* populations than those of the second (summer) generation since the spring and fall generations have only rosettes to feed on, whereas the summer larvae can also feed on leaves of the bolting plants. Teasels are monocarpic perennials and

damage to rosettes may delay or prevent subsequent bolting, whereas damage to the large, bolting plant is unlikely to significantly reduce seed production.

## Conclusions

The purpose of these experiments was to make a preliminary estimate of the host range of *A. sericea*. Regulators are charged with judging from this type of data whether an insect is likely to become a nuisance to non-target plants or other species, particularly those of economic or ecological importance, if the insect is imported and released for the purpose of controlling a targeted weed species. Depending on the perceived importance of a given non-target plant, any amount of feeding or other damage by a candidate biological control agent may be cause for concern, especially if the insect is able to complete its life-cycle on the non-target plant, regardless of marked preference for the target weed. Some may interpret such a result as an indication of sufficient genetic variability for host-acceptance in the tested insect that would ultimately allow it to include the non-target plant as a host. Under this interpretation, a new host association could be selected for over time after release of the insect into a new environment containing the non-target plant.

The results of the host-specificity tests reported here suggest that the tested *Abia sericea* populations from Bulgaria are highly host specific and likely to be restricted to host species from the family Dipsacaceae. While plants from other genera within this family have been recorded as hosts for populations of *A. sericea* from other parts of Europe (Savina and Liston 2009), the populations studied here fed mainly on *Dipsacus* species. Based on these results, more comprehensive host-specificity testing is warranted, including tests in US quarantine facilities on rare or endangered plants that are sympatric with invasive teasels in their North American range, particularly *Valeriana* species.

## Acknowledgments

Thanks to Prof. M. Velichkova, Plant Protection Institute, Kostinbrod, Bulgaria, who kindly identified the iridovirus, and Prof. Y. Kolarov, University of Plovdiv, Bulgaria, who kindly identified the parasitoids. The authors would also like to gratefully acknowledge the contributions of colleagues who reviewed this manuscript and provided critical insights.

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JHR 28: 13–35 (2012)
doi: 10.3897/JHR.28.3010
www.pensoft.net/journals/jhr

RESEARCH ARTICLE

JOURNAL OF Hymenoptera RESEARCH
A peer-reviewed open-access journal
The International Society of Hymenopterists

# Observations on the nesting behavior of two agenielline spider wasps (Hymenoptera, Pompilidae) in Hong Kong, China: *Macromerella honesta* (Smith) and an *Auplopus* species

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Academic editor: *Jack Neff* | Received 24 February 2012 | Accepted 10 July 2012 | Published 24 August 2012

**Citation:** Barthélémy C, Pitts J (2012) Observations on the nesting behavior of two agenielline spider wasps (Hymenoptera, Pompilidae) in Hong Kong, China: *Macromerella honesta* (Smith) and an *Auplopus* species. Journal of Hymenoptera Research 28: 13–35. doi: 10.3897/JHR.28.3010

## Abstract

Field observations and rearing observations of five nests of *Macromerella honesta* (Smith) and four nests of *Auplopus* sp. were carried out in Hong Kong, China, in 2006, 2009, 2011 and 2012.

Nests of *Macromerella honesta* were composed of two rows of exposed ovoid mud cells, affixed to broad leafs while nests of *Auplopus* sp. were constructed as variable masses of mortar affixed to a linear substrate (thorns, wire-mesh, etc.). Cells of the nests of *Auplopus* sp. were more or less cylindrical and covered with a layer of hardened mud finished with a plant gum coating. Both species used a single dismembered spider, transported ventrally to the nesting site, for cell provisioning. Active guarding was observed at all nesting sites. Overlap of generation was also recorded with active nest cooperation (construction and prey provisioning) between individuals of different generations on the same nesting site. The two species were inferred to be at least bivoltine in Hong Kong.

## Keywords

*Macromerella honesta*, *Auplopus,* Pepsinae, cooperative behavior, defensive behavior, resin

## Introduction

Spider wasps (Hymenoptera: Pompilidae) are an interesting aculeate family, especially due to their diverse and varied natural histories with species ranging from ectoparasitoids of spiders to cleptoparasitic species, and from solitary to communal or parasocial.

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Species of the tribe Ageniellini (Pepsinae) are known to exhibit some of the most intricate nesting behaviors within the family, particularly with regards to nest construction. There is a general consensus on the steps that may have led from soil nesting to the building of more complex nests above ground, in some cases occupied by several individuals, in Ageniellini (Evans and Shimizu 1996, 1998; Shimizu et al. 2010). Here we add to this knowledge by providing comparative field observations on the nesting behavior of two common pepsine wasps in Hong Kong, *Macromerella honesta* (Smith, 1855) and *Auplopus* sp., of which both display possible communal nesting behavior.

## Materials and methods

Observations by C.B on the nesting behavior of the two species of spider wasps were primarily carried out from April to November 2006 on a daily basis, weather permitting, mostly in this author's former garden, Pak Sha O, Sai Kung, Hong Kong (22.15N-114.13E; UTM: 50Q KK 242 849, alt. 70 m asl.). Additional observations were carried out in September and October 2009, May and September 2010 and November 2011. Specimens of both spider wasp species are deposited in the collections of the Department of Biology Entomological at Utah State University, Logan, UT, USA (EMUS). Identification of *Macromerella honesta* was obtained using Yamane (1999) and J.P.P. identified *Auplopus* sp.

Five nests of *Macromerella honesta* were observed. Four nests, referenced *Macromerella* Nest 1, 3, 4 and 5 (Table 1), were located at Pak Sha O, while *Macromerella* Nest 2 was observed at Kau Lung Hang Shan; Fanling (UTM: 50Q KK 089 884, alt. 400m asl ). Also, four nests of *Auplopus* sp. were observed at Pak Sha O, and referenced *Auplopus* sp. 1 to 4 (Table 1).

**Table 1.** Observation and collection periods for both species.

| Species | Nest Reference | Observation period | |
|---|---|---|---|
| | | Start | Finish |
| ***M. honesta*** | Macromerella-Nest 1 | 23 Apr-2006 | 16 May 2006 |
| | Macromerella-Nest 2 | 31-Aug-2006 | 31-Aug-2006 |
| | Macromerella-Nest 3 | 17-Jul-2006 | 17-Jul-2006 |
| | Macromerella-Nest 4. (Nest collected 17-Oct-2009 and reared) | 08-Oct-2009 | Nov-2009 |
| | Macromerella-Nest 5 | 12 June 2010 | 03 July 2010 |
| ***Auplopus sp.*** | Auplopus sp-Nest 1 | 11-May 2006 | 14-Jun-2006 |
| | Auplopus sp-Nest 2 | 02-Jun 2006 | 22-Jul-2006 |
| | Auplopus sp-Nest 3 | 28-Jun-2006 | 30-Jun-2006 |
| | Auplopus sp-Nest 4. (Nest collected 20-Sep-2009 and reared) | 20-Sep-2009 | Sep-2009 |

## Description of *Auplopus* sp.

The female has a body length of 12.2–16.7 mm (mean = 15.2 mm, *n* = 7) and a fore wing length of 11.7–13.4 mm (mean = 12.9 mm, *n* = 7). The head, mesosoma, coxae and metasoma are brilliant metallic bluish green as in Figs 11–12. The legs are brown with slight metallic bluish green reflections, while the antennae are black (Fig. 12). The wings are clear and have venation as in Fig. 13. The clypeus is convex in lateral view with the anterior margin rounded medially and sinuate laterally (Fig. 12). The body is covered in short white setae, which is most dense on the clypeus, face laterally and ventral to antennal scrobes, fore coxae, and mesosternum (Figs 11–12).

The male has a body length of 11.2–14.1 mm (mean = 12.7, *n* = 2) and a fore wing length of 10–11.8 mm (mean = 10.9, *n* = 2). Frons, mesosoma, dorsal side of mid and hind coxae, dorsal side of first terga and metasoma segments 2-7 are brilliant metallic bluish green as in Figs 14–15. The ventral side of coxae are light brown. The fore coxa are light brown with a brilliant metallic bluish green longitudinal band dorsally, while the ventral portion of the mid and hind coxae light brown. The front legs are light brown, the mid legs are brown with diffuse metallic bluish green reflection, and the hind legs are slightly darker. The face has two yellow bands along the eye margins terminating at the frons. The antennae are light brown with diffuse metallic bluish green reflection. The wings are clear and have venation as in Fig 16. The clypeus is strongly convex in lateral view with the anterior margin flat medially and oblique laterally (Fig 14–15). The body is covered in short white setae which is most dense on clypeus, gena, ventral part of pronotum and lateroventral sides of fore coxae.

## Results

### Description of nest and behavior of *Macromerella honesta* (Smith, 1855)

***Macromerella* Nest 1** (Figs 1–3): This nest was initiated around 23 April 2006 and completed around 5 May 2006 at Pak Sha O; it was composed of nine cells in two rows. On 3 May 2006 one cell was found open and by 7 May a female wasp was seen rebuilding this cell using material from adjacent cells. The wasp remained on the cluster until the end of this observation. Normally the female wasp would rest on the dorsal part of the nest and inspect the surface at more or less regular intervals. The female wasp showed clear defensive behavior when the nest was approached closely by the observer. On 3 May the first individual (female) emerged and both females remained on the nesting site for another week. By 8 May adults had emerged from four cells, but only two individuals remained on the nesting site.

After emergence of the first offspring, the two individuals shared the nesting site and even provisioned one of the open cells with a new prey (Fig. 2). Neither oviposition nor feeding on the haemolymph of this prey by the adults was observed,

**Figure 1.** *Macromerella* Nest 1 with founding mother guarding the nesting site (7 May 2006).

**Figure 2.** *Macromerella* Nest 1 with overlap of generation on the nesting site (8 June 2006).

although commonly reported (Wcislo 1987; Krombein 1991). This cell was never closed and the prey was later discarded; afterwards the cell was used as a shelter by one of the other individuals (Fig. 3).

***Macromerella* Nest 2** (Fig. 4): This nest was observed at Kau Lung Hang Shan on 31 August 2006 and photographed; it was affixed to a broad leaf of an unidentified bush/tree and was composed of 15–16 cells forming a large surface (no rows). Most cells were open but the nesting site was still occupied by one individual (male). This was most likely an early season nesting site, re-used by successive generations.

***Macromerella* Nest 3**: One wasp was seen initiating a cell on the underside of a broad leaf bush at Pak Sha O on 17 July 2006. No further observations were made.

**Figure 3.** *Macromerella* Nest 1 with individual sheltering in an empty cell (5 June 2006).

***Macromerella* Nest 4** (Fig. 5): On 8 October 2009 one female wasp was seen guarding a nesting site at Pak Sha O composed of two mud cells and one unfinished cell located on the underside of a leaf of *Lagerstroemia speciosa* L, Queen Crape Myrtle; the nest was most likely initiated a short time earlier. The wasp was guarding the nest until 15 October 2009 and then disappeared. One female emerged on 2 November 2009 and one male on 5 November 2009.

***Macromerella* Nest 5**: In mid June 2010 two wasps were seen on a nest composed of six cells pasted on the upper side of a leaf of a Pomelo tree (*Citrus grandis* (L.) Osbeck) at Pak Sha O. By 23 June 2010 three wasps were seen although apparently no adults had yet emerged. The gender of the three adults was not ascertained. By 3 July 2010 wasps had emerged from five cells, the sixth cell containing a dead pupa in her cocoon.

*Macromerella honesta* supplied each cell with a single mature specimen of a large unidentified spider species. Prey transportation was not observed. Although the unused item of nest *Macromerella* Nest 1 was likely amputated, it is interesting to note that Shimizu et al. (2010) reported that *M. honesta* did not amputate the legs of its prey.

**Figure 4.** *Macromerella* Nest 2 showing irregular shaped structure possibly due to overlap of construction following occupation by two or more generations (31 August 2006).

**Figure 5.** *Macromerella* Nest 4. A small nest with a guarding female (8 October 2009).

This species builds multi-cellular nests on either side of broad leaves, bushes, or trees. The cells were composed of a plastic mud mixture (clay and sand grains) drying into an effective mortar. The cell walls were relatively thin, measuring approximately 1.5 mm at the apex of the dome and 2–4 mm at the base.

The construction materials were carried from the acquisition site to the nest in the mandibles of the wasps and most likely softened with regurgitated water. It was also noted on *Macromerella* Nest 1 that remoistened mortar from adjacent cells was used to re-model/re-construct other cells, the wasp having carried water in her crop to the nest-

ing site. When applying the mortar to the cells, the wasp flexed its metasoma under the mesosoma and transferred a droplet of mortar to the tip of the metasoma; she then applied the mixture to the cell rim with a rapid back and forth motion of the metasoma.

Cells had an elliptical base and were broadly hemispherical; they were assembled in a cluster generally formed by two regular interlocking rows of 2–15 cells. The arrangement became unclear in re-used nesting sites, as additional cells were added and original ones remodeled (see Fig. 4). The external walls of the cells were not protected by an additional clay layer enclosing all the cells together as in other mud-nesting pepsine wasps (Krombein 1991).

The brood development time seemed to vary greatly in this species with larvae in *Macromerella* Nest 1 completing development in two weeks they took approximately one month in *Macromerella* Nest 4 .

The female actively defended the nest and C.B. directly experienced this behavior when a nesting site was disturbed. At the end of September 2009 while cutting down vines along a path C.B. was stung first on the hand by a defensive female and less than five minutes later on the head by the same individual. The sting was not overly painful, but soreness was felt the next day and for a few days afterwards.

## Description of nest and behavior of *Auplopus* sp.

***Auplopus* Nest 1**, (Figs 6–8): This nest was first observed on 11 May 2006 at Pak Sha O. Field observations showed that nest building could be time consuming: the construction and provisioning of one cell would take a minimum of one day, sometimes more depending on the weather conditions. Therefore, with approximately eight cells completed at time of first observation we can infer that the nest was initiated around 1 May. It was affixed to a small branch of an unknown bush. At completion the nest had approximately 10 mud cells encased in an additional layer of mortar. The top of the structure was finished with a resinous plant gum or "lacquer" applied by the wasp.

The nest was guarded by the initiating female at least until the first offspring emerged, which was assumed to be between the 3 and 7 June 2006, based on recorded observations. The emerging adults chewed a small hole (2–3 mm diameter) in the mortar layers and appeared head first. Although two exit holes were counted on the nest, only two individuals were present; one was small and presumably a male, while the other was larger and presumably a female, the other specimen(s) probably having left the site. Both individuals were present on the nest until 7 June 2006 and both were defensive of the nesting site when observations were being made. The female seemed to be the more aggressive of the two and held her ground while the male would fly off to a neighbouring position after repeated encounters. By 14 June all brood had emerged and the nesting site was abandoned.

***Auplopus* Nest 2**, (Fig. 9): The nest was first observed on 2 June 2006 it had approximately four cells completed and the wasp was actively building new cells,

**Figure 6.** *Auplopus* Nest 1 with unfinished cell at the bottom of the structure (11 May 2006).

therefore one can infer that it was initiated several days before (28 May). It was affixed to a young branch of a *Citrus grandis* tree. By 25 June there were 8–9 cells constructed in the same fashion as Nest 1, although here the resinous material was

**Figure 7.** *Auplopus* Nest 1 with original female provisioning a cell with a dismembered single prey (26 June 2006).

applied to the whole structure. Construction was hampered by a bout of inclement weather (seasonal rains from the 8 until 13, with a few heavy showers on 17 or so). On the 25th, the initiating female brought back to the nest a large spider with all appendages amputated save for the pedipalps (Fig. 7). By the 28th an adult wasp had emerged and was cooperating with the initiating female in nest building activities; both individuals were seen carrying construction materials to the nest; mortar for one individual and resin for the other. It could not be ascertained if each individual solely collected one type of construction material or not. This new individual also defended the nest and was presumed to be female, although the sex was not established with confidence.

The nest was collected on 30 June 2006 and placed in a plastic aquarium. From it emerged in chronological sequence: one female on 14 July, one female and two males on 18 July and one female on 22 July. One male never managed to exit com-

**Figure 8.** *Auplopus* Nest 1 with original female building a ventral cell (11 May 2006).

pletely and died. A total of six adults emerged from the nest of which four were female and two were male.

***Auplopus* Nest 3** (Fig. 10): The nest was first observed on 28 June 2006, it had approximately 10 cells completed and the wasp was actively initiating new cells, therefore one can infer that it was initiated at least 10 days before at a rate of approximately one cell a day. The structure was hanging from a large thorn of a citrus tree (*Citrus grandis*). The female was still adding cells and by 30 June 2006 observations were halted. This nest was the longest structure witnessed, reaching 12–15 cm and having approximately 12 cells. The construction was identical to Nest 1 and 2 and the resinous material covered the entire structure. By the time of observations later in the season, a few adults had emerged, evidenced by four exit holes, although the usage of the same exit hole by several specimens cannot be ruled out. No additional adults had emerged by the spring of the following year.

***Auplopus* Nest 4:** The nest was discovered on 20 September 2009 affixed to wire mesh (1.5 × 1.5cm) inside an open garden shed. The nest was broken when detached revealing three cells out of a total of five. One of the open cells contained a live pupa but the other two were empty. The nest was reared inside a Ziploc bag and one male emerged on 21 September 2009 and one female on 25 September 2009. Plant gum was apparently not applied to the outer surface.

**Figure 9.** *Auplopus* Nest 2 with resinous material applied to the entire structure, appearing as darker shades of yellow to red 30 June 2006).

**Figure 10.** *Auplopus* Nest 3, it was the largest nest encountered (30 June 2006).

**Figure 11.** Female *Auplopus* sp., head, frontal view.

## Additional observations

**May 2010**: C.B. observed *Auplopus* sp. transporting a spider in Pak Sha O, The spider was grasped by its spinnerets and carried ventrally with the ventral side of its abdomen up. The wasp had not amputated the prey, which was of small size. The wasp was not observed to fly with the spider.

**September 2010 and November 2011**: Observations by C.B in Pak Sha O revealed that wasps would gather construction material from termite nests, and would rehydrate the dirt to form a ball of material, suggesting that water or nectar was acquired beforehand. Three nests affixed to wire mesh in a garden shed did not have any plant gum applied externally.

**May 2012**: C.B. found a nest at Pak Sha O affixed to wire mesh in a garden shed. The initiating wasp was present building a new cell. The nest was covered with plant gum.

**Figure 12.** Female *Auplopus* sp., lateral view.

The *Auplopus* sp., as with other Pompilids, supplied each cell with a single mature prey specimen. The wasp often amputated the legs of the spider; the wasp carried the spider ventrally, abdomen up, grasped by the spinnerets. The female deposited the paralyzed prey in a pre-constructed cell, oviposited on it and sealed the cell.

This species constructed a cluster of 5–12 near cylindrical cells hanging from a linear (curvy-linear) substrate (twig, thorns, petioles, etc.). The cells were further aggregated in an additional layer of mortar enclosing the whole structure. The whole construction was of irregular shape, although elongated. The construction material was obtained from dry sources rehydrated with regurgitated water.

In addition *Auplopus* sp. sometimes applied a resinous material to the hard external envelope of the nest. This material was applied first to the dorsal surface of the nest and formed a varnish-like, brownish, translucent layer. The wasp carried

**Figure 13.** Female *Auplopus* sp., fore wing.

**Figure 14.** Male *Auplopus* sp., head, frontal view.

the resinous material c in her mandibles and applied it as she would mortar. This substance was sticky at first, but hardened over a period of 10–15 days. The mode of transportation and application of the construction materials was identical to that of *Macromerella honesta* (Fig. 8).

**Figure 15.** Male *Auplopus* sp., lateral view.

**Figure 16.** Male *Auplopus* sp., fore wing.

*Auplopus* sp.'s development time (oviposition to emergence of adult) was between one month and 1.5 months, as inferred from the small set of observation (*Auplopus* Nest 1 and 2). The species was active at building nests from at least May to November.

## Discussion

Particular behavioral characteristics of *Macromerella honesta* and *Auplopus* sp. are worthy of mention. The nesting hierarchy of both species strictly follows Evans and West Eberhard's (1970) presociality scale at stage 4b: nest – prey – egg - [cell closed & new cell prepared – prey-egg]$^{n}$ – closure. The usage of plant gum by *Auplopus* sp. being a derived sequence of "closure".

### Cell architecture and construction

Many aerial nests of members of Ageniellini described in the literature, such as the *Auplopus* sp. described here, are generally an aggregation of several cells covered by an additional mortar layer (Wcislo 1987; Krombein 1991), although many species are known to build a succession of mud cells in pre-existing cavities (Kurczewski and Spofford 1986; Kurczewski 1989; Weaving 1994; Shimizu et al. 2010). These wasps use plastic material, which was acquired by moistening various substrates with liquid carried in the crop which is consistent with observations by others (Williams 1919; Kimsey 1980; Wcislo 1988; Weaving 1994; Shimizu et al. 2010). The nests generally hang (intersect) from the substrate or are elongate cylinders lying perpendicular to the surface of the substrate. However, for *Macromerella honesta,* as well as for a few species in the genus *Ageniella* (Evans and Shimizu 1996; Shimizu et al. 2010), the nest architecture – geometrically aggregated near hemispherical clay cells laid upon an aerial flattish substrate – resembles the nests of potter wasps such as species of *Eumenes* or *Delta* (Hymenoptera: Vespidae).

*Macromerella honesta* and *Auplopus* sp. constructed brood cells by transferring material from the mandibles to the tip of the metasoma, which was used as trowel, a behavioral trait seen in other species of pompilid wasps, either to plaster mud or ram soil at the nesting site (Williams 1919; Evans 1953; Evans and West-Eberhard 1970; Harris 1999). The smooth pygidial area surrounded by long setae undoubtedly helps the wasp hold the fresh (viscous) mortar on the tip the metasoma. This behavior has been observed in other Ageniellini (Williams 1919; Iwata 1976; Wcislo 1987; Shimizu et al. 2010).

Using an additional finishing layer of resinous plant gum, as seen here in the *Auplopus* sp., has rarely been described before in the tribe, although *A. nyemitawa* (Rowher 1919) is known to use both a resinous gum and lichens applied as a finishing layer on nest structures (Williams 1919; O'Neill 2001) and *Fabriogenia canberra* Evans (1972) is known to use eucalyptus resin to coat the outer cells of nests (Evans and Matthews 1973). This layer might provide additional waterproofing to the mud construction or a barrier to predators and parasitoids, but this is clearly conjecture. However, it is interesting to note that for nests that were in sheltered location (*Auplopus* Nest 4 and further nests observed in the same location in 2011) this resinous layer was not used with the exception of one nest observed in May 2012. Hence, the application of plant gum may function as a water repellant.

The construction of the nest in both species generally was carried out solely by the initiating female, although nesting sites might be reused by overlapping generations (*Macromerella* Nest 1 and *Auplopus* Nest 2). Data on the communal construction activity noted for *Auplopus* sp. is insufficient to ascertain if this behavior was productive of a viable and durable new nesting site or if it was just incidental.

Active nest construction for both species generally ends towards September/October locally, although C.B saw one individual of *Auplopus* sp. actively building a nest in November 2011, a year that was particularly mild in Hong Kong.

## The overlap of generations on the nesting site

Generational overlap is rarely described in wasps other than in Vespidae and Sphecidae. However, a number of species in the Pompilidae are known for having a communal nesting biology, such as communal defense or nest building (Kimsey 1980; Weaving 1994; Evans and Shimizu 1996; Shimizu et al. 2010), but also primitively social behavior (Wcislo et al. 1988). *Macromerella honesta* in Hong Kong showed a varying degree of communal behavior, besides the overlap of two generations, on the same nesting site and included communal nest defense and re-use of the natal nesting site. However, there was no evidence of communal nest building. The presence of three adults on a nest while all cells were still intact was difficult to explain and could have been the result of either males gathering around an active, or possibly emerging, female as is observed for the tribe (Harris 1999) or, less probably, other opportunistic females using a pre-existing nesting site.

For the *Auplopus* sp., however, the generational overlap seemed to involve more elaborate behaviors than those of *Macromerella honesta*. Besides communal defense, the *Auplopus* sp. also exhibited communal nest building, with two individuals performing separate tasks: one building cells, and the other varnishing the structure, although roles may well have be exchanged in the course of construction.

## Prey transportation

Both species carried their prey ventrally, with the spider's abdomen up. Amputation, however, seemed to vary in *Auplopus* sp. and may have depended on the size of the prey. Whether or not *Macromerella honesta* amputates the legs of its host was not ascertained. Carrying prey ventrally is recognized as being a derived condition evolving from the more primitive condition of dragging the prey by its appendages to the nesting site, which is seen in many Ageniellini (Iwata 1976; Evans and Shimizu 1996). This needs to be tested within a phylogenetic framework, however.

While the pedipalps of both species were intact, *Auplopus* sp. has been observed holding the spider's spinnerets to place the prey in an empty cell (Fig. 7).

### Voltinism

The two weeks to one month development period of *Macromerella honesta*, combined with continuous observations of the species during the summer months (May to October) in Hong Kong and the presence of an active nest in early October suggests that this species was at least bivoltine if not multivoltine in Hong Kong. A single observation of a female actively searching leaves of a camel foot tree (*Bauhinia* sp.) in a garden in Pak Sha O, Hong Kong on 17 December 2006, long after the emergence of the last generation, may suggests that some females overwinter, although no such observation has been directly recorded with the nesting individuals. The development stage in which this species over-winters has not been established. However, it most likely does so as a diapausing pre-pupal larva.

Similarly, the one month development time for *Auplopus* sp. combined with observation of nesting individuals in November, suggest that this species was at least bivoltine if not multivoltine in Hong Kong. The development stage in which this species over-winters has not been established, but likely does so as a diapausing prepupa.

## Conclusion

Nest location, nest construction, prey transportation and prey provisioning of *Macromerella honesta* and *Auplopus* sp. are highly complex when compared to other members of the family.

While the two species described here adhere quite tightly to the widely accepted nesting hierarchy of agenielline wasps, it is interesting to note that many species are known to exhibit a relative plasticity of nesting behavior intraspecifically (Evans 1953; Wcislo et al. 1988; Evans and Shimizu 1996; Harris 1999; Shimizu et al. 2010) as displayed by *Auplopus* sp. in connection with prey amputation and usage of plant gum. Only additional ethological data could ascertain behavioral plasticity for the two studied species.

The location and the construction of the cell aggregates and the transportation of the prey items are traits that place *M. honesta* and *Auplopus* sp. among the more complex of Pompilidae. Indeed some authors view the evolution of the nesting biology from ground cavity dwellings to aerial abodes as a precursor of presocial or parasocial behavior (Evans 1996, Shimizu 1998). It would be tempting to categorize these two species as presocial, but the data gathered here is inconclusive and rather suggest probable communal nesting.

## Acknowledgements

We are grateful to one anonymous reviewer and the editor JHR who suggested useful modifications to the original manuscript. This work was also supported by the

National Science Foundation award DEB-0743763 to J.P.P. This research was also supported by the Utah Agricultural Experiment Station, Utah State University, Logan, Utah 84322-4810. Approved as journal paper no. 8411.

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JHR 28: 37–65 (2012)
doi: 10.3897/JHR.28.3514
www.pensoft.net/journals/jhr

RESEARCH ARTICLE

JOURNAL OF Hymenoptera RESEARCH
A peer-reviewed open-access journal
The International Society of Hymenopterists

# The Vespinae of North America (Vespidae, Hymenoptera)

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Academic editor: *Wojciech Pulawski* | Received 12 June 2012 | Accepted 30 July 2012 | Published 24 August 2012

**Citation:** Kimsey LS, Carpenter JM (2012) The Vespinae of North America (Vespidae, Hymenoptera). Journal of Hymenoptera Research 28: 37–65. doi: 10.3897/JHR.28.3514

**Abstract**

The species of paper wasps in the tribe Vespini, family Vespidae from America North of Mexico are reviewed, including a new identification key to the genera and species, complete synonymy, distribution and biology. This fauna includes six species of *Dolichovespula* Rohwer, three species of *Vespa* Linnaeus and 13 species of *Vespula* Thomson. No Holarctic species are recognized, with the result that *Dolichovespula arctica* (Rohwer) and Vespula *intermedia* (du Buysson) are again recognized as species, while *Vespula infernalis* (de Saussure) is given new status as a species.

**Keywords**

*Vespa*, *Dolichovespula*, *Vespula*

## Introduction

Vespinae, or the yellow jackets and hornets, are among the most recognizable wasps in North America. All of the species are either social or are social parasites of other congeners. They construct their nests out of a mixture of plant fibers and salivary secretions, and the nests can range from baseball-sized, with a few thousand cells, to nests with hundreds of thousands of cells. Nests are generally annual but a few species will develop large perennial nests in warm climates. A number of species, such as *Vespula alascensis* and *Vespula germanica*, are considered to be pests because of their willingness

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to build nests in structures and to scavenge a variety of food materials other than live insects, which brings them into frequent contact with humans and because the majority of sting-caused deaths are attributable to yellow jackets.

There have been a number of changes in the North American social vespine fauna since the widely used key published by Akre et al. (1981). Two exotic *Vespa affinis* Linnaeus and *simillima* (Smith) have been introduced into North America. One new species has been described, *Dolichovespula alpicola* Eck (Eck, 1984). In addition, there have been a number of other taxonomic changes based on reevaluation of specimens and study of male genitalia. The most notable of these is the discovery that two species previously considered Holarctic are not in fact found in both North America and the Palearctic. *Vespula vulgaris* (Linnaeus) and *Dolichovespula norwegica* (Fabricius) are not conspecific with the species in North America, necessitating name changes for these taxa (Carpenter et al. 2011, Carpenter and Glare 2010): *Vespula alascensis* (Packard) and *Dolichovespula albida* (Sladen) are valid species. There are morphological differences now known between North American and Eurasian specimens of another supposed Holarctic species, *Vespula austriaca*, and the North American species should therefore be known as *Vespula infernalis* (de Saussure). Another of the supposed Holarctic species, *Dolichovespula adulterina* (du Buysson) is a social parasite, which does not have the same hosts in Eurasia and North America, hence is probably not conspecific in the Old World and New, and *D. arctica* (Rohwer) should be treated as a species. Most likely no Holarctic species should be recognized, with the exception of the introduced *Vespula germanica*, therefore *Vespula intermedia* (du Buysson) should be used instead of *V. rufa* (Linnaeus).

Given these changes, and the difficulty of using many of the existing keys, which rely heavily on coloration, we have developed a new key incorporating these taxonomic changes and attempting to place more emphasis on structural features, such as male genitalia. The key by Akre et al. (1981) was also incomplete, not including socially parasitic species, as it was based only on workers. The key below includes all species and castes.

## Materials and methods

North America as construed here is America north of Mexico. Thus two species recently described from central Mexico (*Vespula inexspectata* Eck; Eck 1994) and Guatemala (*V. akrei* Landolt; Landolt et al. 2010) are not included in the key, nor is *Vespa orientalis* Linnaeus, recently recorded from Mexico (Dvořák 2006).

Specimens used in the development of this key were from the collections of the American Museum of Natural History, New York; Bohart Museum of Entomology, University of California, Davis; California State Collection of Arthropods, California

Department of Food & Agriculture, Sacramento, and the U. S. National Museum of Natural History, Washington, D. C.

Type repositories listed in the synonymies include: BUDAPEST – Hungarian Natural History Museum, Budapest; CAMBRIDGE – Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, USA; COPENHAGEN – Zoologisk Museum, Universitetsparken, Copenhagen, Denmark; DRESDEN – Staatliches Museum für Tierkunde, Dresden, Germany; GAINESVILLE – Florida State Collection of Arthropods, Gainesville, USA; GENEVA – Museum of Natural History, Geneva, Switzerland; GENOA – Museo Civico di Storia Naturale "Giacomo Doria", Génova, Italy; LEIDEN – Rijksmuseum van Natuurlijke Historie, Leiden, Netherlands; LINNAEAN SOCIETY – Linnaean Society, London, UK; LONDON – The Museum of Natural History, London, UK; OTTAWA – Canadian National Collection of Insects, Agriculture Canada, Ottawa; OXFORD – Hope Entomological Collections, Oxford University, England; PARIS – Muséum National d'Histoire Naturelle, Paris, France; PHILADELPHIA – Academy of Natural Sciences, Philadelphia, Pennsylvania, USA; ST. PETERSBURG – Zoological Institute, St. Petersburg, Russia; STOCKHOLM – Naturhistoriska Riksmuseet, Stockholm, Sweden; TAICHUNG – National Museum of Natural Sciences, Taichung, Taiwan; TURIN – Instituto di Zoologia Sistematica, Universita di Torino, Turin, Italy; UPPSALA – Uppsala University Zoological Museum, Uppsala, Sweden; WASHINGTON - U. S. Museum of Natural History, Washington, D. C., USA.

## Key to the Yellow Jackets and Hornets of North America

1 Head in dorsal view greatly expanded behind eyes, postocular distance more than twice as broad as distance between hindocelli (as in Fig. 5); *Vespa* Linnaeus ..... **2**

– Head in dorsal view not expanded behind eyes, postocular distance subequal to distance between hindocelli (as in Figs 6, 7)..... **4**

2 Metasomal segments I and II orange or red, posterior segments black, without sublateral free or connected blackish spots (Fig. 26); metapleural punctures ventrally well-defined, nearly contiguous; southern California? ..... ..... ***Vespa affinis* (Linnaeus)**

– Metasomal segments basally blackish to brown and apically yellow; metapleural punctures ventrally shallow, separated by 1 puncture diameter or more ..... **3**

3 Female clypeal punctures clearly defined, contiguous or nearly so; male metasomal sterna VI-VII apicomedial margin straight or shallowly indented; metasomal terga III–VI transverse basal black band with sublateral free or connected black spot (Fig. 27); eastern United States..... ***Vespa crabro* Linnaeus**

– Female clypeal punctures medially, shallow, separated by 1 puncture diameter or more; male metasomal sterna VI-VII apicomedial margin deeply emarginate; metasomal terga III transverse basal black band simple, barely undulating (Fig. 28); British Columbia? ..... ***Vespa simillima*** **(Smith)**

4 Malar space long, one fifth eye height or longer (Figs 2, 9); pronotum with transverse anterodorsal carina; *Dolichovespula* Rohwer ..... **5**

– Malar space short, one-tenth eye height (Figs 4, 10); pronotum without transverse anterodorsal carina; *Vespula* Thomson..... **10**

5 Metasomal terga I-III entirely black (Fig. 33); pronotal lateral angle finely rugose; widespread..... ***Dolichovespula maculata*** **(Linnaeus)**

– Metasomal terga I-III with pale markings; pronotal lateral angle not rugose 6

6 Occipital carina absent; female clypeal apical margin acutely angulate; male apical flagellomeres without tyloids; Alaska to Newfoundland, south to Arizona, North Carolina, Georgia.....***Dolichovespula arctica*** **(Rohwer)**

– Occipital carina present; female clypeal apical margin with obtuse to right angles; male apical flagellomeres with tyloids ..... **7**

7 Body, particularly face, with whitish markings, metasomal terga I-II often with lateral red spots (Fig. 29); Alaska, Maine and northern Canada ..... ..... ***Dolichovespula albida*** **(Sladen)**

– Body, particularly face, with yellow markings, usually without red metasomal spots; more southern distribution ..... **8**

8 Metasomal terga I and II broad yellow bands expanded medially into sharp, triangular projection (Fig. 32); genal band continuous, less commonly medially broken; widespread species ..... ***Dolichovespula arenaria*** **(Fabricius)**

– Metasomal terga I and II with narrow, parallel-sided yellow bands, sometimes slightly narrowed medially; genal band integrity variable ..... **9**

9 Malar space length one-fourth eye height; clypeal apex width 1.5–1.6× malar space length; male apical flagellomeres with two tyloids; Alaska to Newfoundland, south to Colorado, Georgia *Dolichovespula norvegicoides* (Sladen)

– Malar space length one-fifth eye height; clypeal apex width 1.9–2.0× malar space length; male apical flagellomeres with one or two tyloids; western North America, Alaska and Alberta south to Arizona .... ***Dolichovespula alpicola*** **Eck**

10 Female; six metasomal segments; 10 flagellomeres ..... **11**

– Male, seven metasomal segments; 11 flagellomeres ..... **23**

11 Scutum with two fully developed longitudinal yellow stripes (as in Fig. 11); metasomal sterna I-V with few if any black markings..... **12**

– Scutum without stripes, if stripes present only partly developed; metasomal sterna with extensive black markings..... **13**

12 Metasomal terga II-IV with small oval sublateral black spots (Fig. 46); supraantennal black mark as broad or broader than antennal socket (Fig. 24); primarily from California, with small populations in Arizona, Nevada, Oregon and Baja California, Mexico ..... ***Vespula sulphurea*** **(de Saussure)**

– Metasomal terga II-IV without small oval sublateral black spots (Fig. 45); supraantennal black mark narrower thanantennal socket (Fig. 25); mostly east of 100th meridian but extending through Texas to Guatemala ..... ..... ***Vespula squamosa* (Drury)**

13 Pale body markings whitish; metasomal tergum II pale apical band narrow and parallel-sided (as in Figs 38, 42) ..... **14**

– Body markings yellow; metasomal tergum II pale apical band usually broad and sinuous or emarginated medially (as in Figs 41, 43) ..... **15**

14 Metasomal terga I and II with reddish markings, tergum I extensively red, with posterior whitish band along apical margin, usually with partial transverse whitish band at apex of anterior face (Fig. 42); Alaska to Newfoundland, south to Vermont ..... ***Vespula intermedia* (du Buysson)**

– Metasomal terga I and II without reddish markings; tergum I black, with partial white band along posterior margin and often partial white band at apex of anterior face (Fig. 38); Canada and northern United States, south to Colorado and Georgia ..... ***Vespula consobrina* (de Saussure)**

15 Eye dorsally margined by continuous yellow band (Figs 10, 23), sometimes narrowly broken; metasomal tergum I with diamond-shaped medial black mark ..... ***Vespula pensylvanica* (de Saussure)**

– Eye not dorsally margined by yellow band on (as in Figs 15, 16), metasomal tergum I with or without diamond-shaped medial black mark..... **16**

16 Hindtibia with long black setae; clypeal apical angles acute in females (Fig. 20); northern North America, south to Arizona, New Jersey ..... ..... ***Vespula infernalis* (de Saussure) stat. n.**

– Hindtibia without long black setae; clypeal apical angles blunt in females (as in Fig. 16)..... **17**

17 Scape yellow ventrally ..... **18**

– Scape without yellow ventrally, although may be dark brown ventrally ..... **20**

18 Metasomal tergum II largely black, irregularly parallel-sided, with narrow apical yellow band and without sublateral yellow spot or spot faint (Fig. 47); northeastern North America south to Georgia and Alabama, west to Iowa.... ..... ***Vespula vidua* (de Saussure)**

– Metasomal tergum II black band apically lobate, with broad apical yellow band as broad or broader than apical bands on III-V, and usually with sublateral yellow spot (as in Figs 35, 37) ..... **19**

19 Metasomal tergum II black band angulate medially; gena with continuous yellow band in side view, sometimes interrupted by black spot or narrow medial interruption (Fig. 37) ..... ***Vespula atropilosa* (Sladen)**

– Metasomal tergum II black band broadly rounded medially, often having free lateral yellow spots; gena with yellow band broadly interrupted by black spot, rarely continuous (Fig. 35)..... ***Vespula acadica* (Sladen)**

20 Supraantennal black band as broad or broader than antennal socket; gena with yellow band broadly interrupted by black spot in side view..... ..... ***Vespula alascensis*** **(Packard)**

– Supraantennal black band much narrower than antennal socket; gena with yellow band uninterrupted or narrowly broken in side view.....**21**

21 Metasomal tergum I with diamond-shaped or somewhat broader medial black mark, attachment to anterior black band no narrower than one-third of width (Fig. 40)..... ***Vespula germanica*** **(Fabricius)**

– Metasomal tergum I with nearly free broadly diamond-shaped or triangular black mark or black mark broadly attached to anterior band.....**22**

22 Metasomal tergum I with anchor-shaped medial black mark, narrowly connected to anterior black band, if melanistic with at least pair of transverse yellow spots present (Fig. 43)..... ***Vespula maculifrons*** **(Buysson)**

– Metasomal tergum I with triangular medial black mark, broadly connected to anterior black band (Fig. 39)..... ***Vespula flavopilosa*** **Jacobson**

23 Paramere dorsomedial margin evenly convex, without well-developed acute tooth or angle (as in Fig. 78A); volsella without large, densely setose digitus (as in Fig. 78).....**24**

– Paramere dorsomedial margin with well-developed tooth or angle (as in Fig. 80A); volsella with large, densely setose digitus extending nearly as long as aedeagus, visible as dense brush of long setae at apex of genital capsule (as in Fig. 80).....**31**

24 Scutum with two longitudinal yellow stripes (as in Fig. 11) .....**25**

– Scutum without longitudinal yellow stripes .....**26**

25 Aedeagus elongate, strongly exserted beyond apex of paramere by one-half of paramere length or longer (as in Figs 71, 78) .... ***Vespula sulphurea*** **(Saussure)**

– Aedeagus short, broad, exserted beyond apex of paramere by one-third of paramere length or less (Figs 70, 77) ..... ***Vespula squamosa*** **(Drury)**

26 Body with pale markings whitish .....**27**

– Body with pale markings yellow.....**28**

27 Basal metasomal segments without red markings (Fig. 38)..... ..... ***Vespula consobrina*** **(de Saussure)**

– Basal metasomal segments with red markings (Fig. 42) ..... ..... ***Vespula intermedia*** **(du Buysson)**

28 Metasomal tergum I with diamond-shaped medial black mark, tergum II with broad irregularly lobate posterior yellow band (Fig. 37) ..... .....***Vespula atropilosa*** **(Sladen)**

– Metasomal terga I and II with narrow subparallel-sided posterior yellow band (as in Fig. 35).....**29**

29 Clypeus with large medial black spot or stripe (Fig. 14) ..... .....***Vespula acadica*** **(Sladen)**

– Clypeus without single medial black spot or black spot small irregular (as in Fig. 20).....**30**

30 Hindtibia without long black setae; clypeal apical angle obtusely angulate .... ..... ***Vespula vidua*** **(de Saussure)**

– Hindtibia with long black setae (even rubbed specimens have a few); clypeal apical angle blunt but well-developed (Fig. 20) ..... ..... ***Vespula infernalis*** **(de Saussure)**

31 Metasomal tergum I with diamond shaped medial black mark narrowly connected to black band (as in Figs 40, 44) ..... **32**

– Metasomal tergum I with parallel-sided black band, black band with triangular medial projection, broadly attached to rest of band (as in Figs 36, 39) ..... **34**

32 Aedeagus without lobe or process behind apex (Fig. 69, 80); eye usually margined by continuous yellow band (as in Fig. 10) or yellow band broken by narrow black line dorsally (may be more broadly interrupted in some males) ..... ***Vespula pensylvanica*** **(Saussure)**

– Aedeagus with short rounded (*germanica,* Fig. 67) or pointed (*maculifrons*, Fig. 68) process behind apex; eye with yellow marginal band always broadly broken dorsally ..... **3**

33 Metasomal tergum VII undulate, rounded dorsally in lateral view (Fig. 13); metasomal terga II-IV with free sublateral black spot or spot narrowly connected to black band (Fig. 40) ..... ***Vespula germanica*** **(Fabricius)**

– Metasomal tergum VII step-like in lateral view, angulate dorsally in lateral view (Fig. 12); metasomal terga II-IV without free or narrowly connected sublateral black spots (Fig. 43), if melanistic with at least pair of transverse yellow spots present ..... ***Vespula maculifrons*** **(du Buysson)**

34 Supraantennal black band much narrower than antennal socket at least medially; metasomal terga II-V with strongly trilobate black band (Fig. 39) ..... ..... ***Vespula flavopilosa*** **Jacobson**

– Supraantennal black band as wide or wider than antennal socket; metasomal terga II-V with black band parallel-sided or weakly lobate (Fig. 36) ..... ..... ***Vespula alascensis*** **(Packard)**

## Taxonomy, biology and distributions

### Genus *Dolichovespula* Rohwer

*Vespula* (*Dolichovespula*) Rohwer 1916:642. Type species: *Vespa maculata* Linnaeus 1763. Original designation.

*Pseudovespa* (*Pseudovespula*) Bischoff 1931:346. Type species: *Pseudovespa adulterina* Buysson (=*Vespa norwegica* var. *adulterina* du Buysson 1905). Original designation.

*Dolichovespula* (*Boreovespula*) Blüthgen 1943:149. Type species: V*espa norwegica* Fabricius (=*Vespa norwegica* Fabricius 1781). Original designation.

*Dolichovespula* (*Metavespula*) Blüthgen 1943:149. Type species: *Vespa silvestris* Scopoli [!] (=*Vespa sylvestris* Scopoli 1763). Original designation.

***Dolichovespula albida*** **(Sladen)**
http://species-id.net/wiki/Dolichovespula_albida
Figs 29, 48

*Vespa marginata* Kirby 1837:265, pl. VI, fig. 2. Syntype females; New York, latitude 65° (repository unknown). Nec *Vespa marginata* Gmelin 1790.
*Vespa albida* Sladen 1918:71. Lectotype male; Alaska (OTTAWA).

**Distribution.** This species occurs in the Hudsonian Zone of North America from Alaska to Maine.

**Biology.** *Dolichovespula albida* was split again from *D. norwegica* (Fabricius) by Carpenter et al. (2012). The nests are generally small and may be subterranean (Bequaert 1932), although Yamane et al. (1980) reported an aerial nest just above ground.

***Dolichovespula alpicola*** **Eck**
http://species-id.net/wiki/Dolichovespula_alpicola
Figs 30, 49, 54

*Dolichovespula alpicola* "Wagner" Eck 1984:40 (key), fig. 3L; 1987:191. Lectotype female; USA: Wyoming (DRESDEN).

**Distribution.** This is a northern boreal species found in western North America from Alaska to Alberta, and extending as far south as Arizona and New Mexico along the Rocky Mountains (R. Jacobson personal communication).

**Biology.** *Dolichovespula alpicola* is generally found in mixed hardwood-conifer forests in mountainous regions. There is little information on the nesting biology in this species. Eck (1984) attributed the species to Wagner in a key, thus validly publishing it. Eck (1987) later published a fuller description and designated a lectotype.

***Dolichovespula arctica*** **(Rohwer)**
http://species-id.net/wiki/Dolichovespula_arctica
Figs 31, 50, 55

*Vespa borealis* Lewis 1897:171 (key), 174 [misidentification]. Syntypes (PHILADELPHIA).
*Vespula arctica* Rohwer 1916:642 (key; in subgenus *Dolichovespula*). Replacement name for *Vespa borealis sensu* Lewis.

**Distribution.** It occurs as far south as California, Arizona and Georgia in North America. Pale markings can be yellow or whitish in *D. arctica*.

**Biology.** This species is an obligatory social parasite of *Dolichovespula arenaria* (Wheeler and Taylor 1921) and *D. alpicola* (Wagner 1978). The name is a replacement for a misidentification of *Vespa borealis* Kirby by Lewis (1897), and probably needs to be split from *D. adulterina* (du Buysson), a Palearctic species that has different host species (*D. saxonica* and *D. norwegica*; see Dvořák 2007).

***Dolichovespula arenaria* (Fabricius)**
http://species-id.net/wiki/Dolichovespula_arenaria
Figs 32, 51, 56

*Vespa arenaria* Fabricius 1775:365. Holotype female; "America arenosis" (LONDON).
*Vespa borealis* Kirby 1837:264. Holotype female; Canada (repository unknown).
*Vespa diabolica* de Saussure 1854:138. Syntype females; "L'Amerique du Nord, Philadelphia" (TURIN).
*Vespa fernaldi* Lewis 1897:173. Holotype female; "Colorado" (PHILADELPHIA).

**Distribution.** This species is abundant throughout boreal North America.

**Biology.** *Dolichovespula arenaria* feeds on live prey but will occasionally visit carrion. It builds aerial nests, like *D. maculata*, but its nests are usually built in more sheltered sites, such as within bushes, trees, on houses and outbuildings, and rarely even under rocks.

***Dolichovespula maculata* (Linnaeus)**
http://species-id.net/wiki/Dolichovespula_maculata
Figs 2, 6, 9, 33, 52, 57

*Vespa maculata* Linnaeus 1763:412. Lectotype female; "Pensylvania" (STOCKHOLM).
*Vespa maculata americana* Christ 1791:239. Type destroyed; "mitternachtlichen Amerika". Nec *Vespa americana* Fabricius 1775.

**Distribution.** The species occurs throughout North America.

**Biology.** This is the only *Dolichovespula* in North America with the anterior part of the metasoma completely black, and the pale markings are always whitish. It builds aerial nests, which are usually found in exposed places such as hanging from tree branches. These wasps usually feed on live prey, particularly spiders and flies.

***Dolichovespula norvegicoides* (Sladen)**
http://species-id.net/wiki/Dolichovespula_norvegicoides
Figs 34, 53, 58

*Vespa norvegicoides* Sladen 1918:71. Lectotype female; Amherst, Nova Scotia (OTTAWA).

**Distribution.** *D. norvegicoides* is relatively rarely collected, although it occurs widely throughout northern North America and further south along mountain ranges.

**Biology.** This species builds small, aerial nests.

## Genus *Vespa* Linnaeus

*Vespa* Linnaeus, 1758:343, 572. Type species: "*Vespa crabro* Fabricius" (=*Vespa crabro* Linnaeus 1758). Designated by Latreille 1810:438.
*Macrovespa* Dalla Torre 1904:64, group of genus *Vespa* Linnaeus. Type species: *Vespa crabro* Linnaeus 1758. Designated by Bequaert 1930: 64.
*Vespa* (*Nyctovespa*) van der Vecht 1959: 210. Type species: *Vespa binghami* du Buysson 1905. Original designation.

***Vespa affinis* (Linnaeus)**
http://species-id.net/wiki/Vespa_affinis
Figs 5, 26

*Apis affinis* Linnaeus 1764:417. Holotype female; "in Calidus regionibus" (UPPSALA).
*Vespa affinis* Fabricius 1787:287. Holotype; "in China" (COPENHAGEN). Nec *Vespa affinis* (Linnaeus) 1764.
*Vespa unifasciata* Olivier 1792:677. Type unknown; "Indes orientales". Nec *Vespa unifasciata* Gmelin 1790.
*Vespa alduini* Guérin-Méneville 1831:pl. 9 fig. 6; 1838: 264. Holotype; "l'île de Bourou, l'une des Moluques" (Indonesia) (GENOA).
*Vespa bimaculata* Guérin-Méneville: 264. Unnecessary replacement name for *Vespa alduini* Guérin-Méneville. Nec *Vespa bimaculata* Geoffroy 1785 and *Vespa bimaculata* Olivier, 1792.
*Vespa nigripennis* de Saussure: 1854:156. Holotype; "Les Philippines" (LONDON). Nec *Vespa nigripennis* Degeer 1773.
*Vespa cincta* var. *picea* du Buysson 1905 (1904):537. Lectotype female; New Guinea (GENOA).
*Vespa indosinensis* Pérez 1910:8. Lectotype female; Annam (PARIS).
*Vespa formosana* Sonan 1927:125. Syntype male, female; Taihoku (Taiwan) (TAICHUNG).

*Vespa affinis* var. *continentalis* Bequaert 1936:350. Holotype female; India: Mangalore (WASHINGTON).
*Vespa affinis* var. *hainanensis* Bequaert 1936:347. Holotype female; China: Hainan Island (CAMBRIDGE).
*Vespa affinis nigriventris* van der Vecht 1957:29. Holotype female; "Palawan" (Philippines) (GAINESVILLE).
*Vespa affinis rufonigrans* van der Vecht 1957:29. Holotype female; "Palu, Northwest Celebes" (Indonesia) (LIEDEN).
*Vespa affinis archboldi* van der Vecht 1957:32. Holotype female; "Hollandia" (New Guinea) (LIEDEN).
*Vespa affinis moluccana* van der Vecht 1957:32. Holotype female, "Saparua I. Near Amboina" (Indonesia) (LIEDEN).
*Vespa affinis alticincta* van der Vecht 1957:33. Holotype female; New Britain (LONDON).

**Distribution.** There is a single report of a colony of this Asian species in North America, from San Pedro, in Los Angeles Co., California in 2010 (LSK, personal observation). It is not clear if the species has become established in California. It has also been introduced into New Zealand. Its native range is from India to the Bismarck Islands.

**Biology.** In Asia, *Vespa affinis* builds large aerial nests of up to several thousand workers (Archer 1997). These wasps are predatory on other insects including honey bees near their hives.

***Vespa crabro* Linnaeus**
http://species-id.net/wiki/Vespa_crabro
Fig. 27

*Vespa crabro* Linnaeus 1758:572. Holotype female; "in Europae" (LINNAEAN SOCIETY).
*Vespa vexator* Harris 1776:128. Holotype female; "English" (destroyed).
*Vespa crabro major* Retzius 1783:63. Type unknown.
? *Vespa pratensis* Geoffroy (*in* Fourcroy) 1785:437. Type unknown; France.
*Vespa crabro germana* Christ 1791:215. Type unknown (destroyed).
*Vespa crabroniformis* Smith 1852:40. Syntype male, female; "north China" (LONDON).
*Vespa crabro* var. *borealis* Radoszkowski 1863:128. Syntype male, female; "Pargolova i Osinovoa Roshchi" (type lost?). Nec *Vespa borealis* Kirby 1837, *Vespa borealis* Zetterstedt 1840 and *Vespa borealis* Smith, 1843.
*Vespa crabro* var. *anglica* Gribodo 1892:242. Syntype females; "Inghilterra" (GENOA). Nec *Vespa anglica* Smith, 1843.
*Vespa oberthuri* du Buysson 1902:140. Lectotype female; "Chine: Se-tchouen, Siao-Lou" (China) (PARIS).
*Vespa flavofasciata* Cameron 1903:280. Holotype female; Japan: Nügata (Shinanogawa) (LONDON).

*Vespa crabro* var. *tartarea* du Buysson 1905:506. Holotype female; "Japon: Yokohama (BUDAPEST).

*Vespa crabro* var. *altaica* Pérez 1910:5. Holotype female: "Altai" (PARIS).

*Vespa crabro* var. *caspica* Pérez 1910:6. Holotype female; "Talysch et Lenkoran, région Caspienne" (Azerbaijan) (PARIS).

*Vespa crabro nigra* Birula 1925:55. Synypes; West Siberia (ST. PETERSBURG). Nec *Vespa nigra* Geoffroy 1785.

*Vespa crabro vulgata* Birula 1925:55. Syntypes ?; western Europe (ST. PETERSBURG).

*Vespa crabro meridionalis* Birula 1925:55. Syntypes ?; western Europe (ST. PETERSBURG).

*Vespa crabro chinensis* Birula 1925:55. Syntypes ?; middle and south China (ST. PETERSBURG). Nec *Vespa chinensis* Fabricius 1793.

*Vespa crabro* var. *birulai* Bequaert 1931:105. Replacement name for *Vespa crabro chinensis* Birula.

*Vespa crabro* var. *gribodoi* Bequaer, 1931:105. Replacement name for *Vespa crabro* var. *anglica* Gribodo.

**Distribution.** The central European color form of this Palearctic species was introduced into the New York area in the mid-1800's (de Saussure 1898). It now occurs throughout the eastern United States, east of the Mississippi River.

**Biology.** Nests are generally built in above-ground cavities, wall voids, hollow trees, and even in abandoned honey bee hives. Nests are large in size because of the size of the wasps but generally contain only a few thousand cells. These wasps feed on live insects, including honey bees near hives (Akre and Davis 1978) and have been recorded girdling saplings to feed on sap in the spring (Bromley 1931).

***Vespa simillima* (Smith)**
http://species-id.net/wiki/Vespa_simillima
Figs 3, 8, 28

*Vespa simillima* Smith 1868:280. Holotype female; Japan: Hakodadi (LONDON).

*Vespa mongolica* André 1884:lix. Syntype male, female; "Wladivostock, sur l'Amour, dans la Sibérie orientale" (western Russia) (PARIS).

*Vespa xanthoptera* Cameron 1903:278. Holotype male: Japan: Michzusawa (LONDON).

*Vespa micado* Cameron 1903:279. Holoytpe female; Japan: Nagasaki (LONDON).

*Vespa mongolica* var. *sexpunctata* Pérez 1905:79. Holotype female; Japan: Yokohama (PARIS).

*Vespa mongolica* var. *flavata* Pérez 1910:17. Holotype female; "Chine" (PARIS).

**Distribution.** This East Asian species was introduced into British Columbia, Canada but has apparently not become established. We have included it in this review because of the potential for a reintroduction.

**Biology.** Nests are built in a wide variety of situations including in bushes, underground cavities, hollow trees, under eaves, in attics, on rock walls, and in wall voids. As with the other *Vespa* species *affinis* is predatory on other insects, including honey bees.

## Genus *Vespula* Thomson

*Vespa* (*Vespula*) Thomson 1869:79 (8 species). Type species: *Vespa austriaca* Panzer 1799. Designated by Ashmead 1902:164.

*Vespa* (*Pseudovespa*) Schmiedeknecht 1881:314. Type species: *Vespa austriaca* Panzer 1799, by monotypy.

*Dolichovespula* (*Paravespula*) Blüthgen 1938:271. Type species: *Vespa vulgaris* Linnaeus 1758. Original designation.

*Paravespula* (*Allovespula)* Blüthgen 1943:149. Type species: *Paravespula rufa* (Linné) (=*Vespa rufa* Linnaeus 1758), by monotypy.

*Vespula* (*Rugovespula*) Archer 1982:261, 264. Type species: *Vespa koreensis* Radoszkowski, 1887. Original designation.

### *Vespula acadica* (Sladen)

http://species-id.net/wiki/Vespula_acadica
Figs 14, 35, 59, 72

*Vespa rufa* var. *americana* du Buysson 1905:592. Holotype male; Canada: Quebec (repository unknown). Nec *Vespa americana* Fabricius 1775, and *Vespa maculata americana* Christ 1791.

*Vespa acadica* Sladen 1918:72. Lectotype female; Canada: Ottawa (OTTAWA).

*Vespula rufa* var. *sladeni* Bequaert 1932:102. Holotype female; Washington State (CAMBRIDGE).

**Distribution.** This is primarily a boreal species, occurring across subArctic Canada and southern Alaska. Its range extends further south in the Rocky, Sierra, Cascade, Siskiyou and Appalachian mountains.

**Biology.** *Vespula acadica* feeds on live insects and builds small subterranean nests.

### *Vespula alascensis* (Packard)

http://species-id.net/wiki/Vespula_alascensis
Figs 15, 36, 65, 81

*Vespa alascensis* Packard 1870:27, pl. II fig. 10. Holotype female; "Lower Yukon" (Repository unknown).

*Vespa westwoodii* Shipp 1893:450. Holotype female; "N. Amer. Bor." (OXFORD).

**Distribution.** Widespread in North America

**Biology.** *Vespula alascensis* nests are usually built in subterranean cavities or in structures. The nests can be huge and may become perennial in warmer climates. This species feeds on live prey but will scavenge any source of protein or sugar. It has been introduced into Hawaii, but is not now established (Carpenter 2008, under *vulgaris*).

This North American species was usually known as *Vespula vulgaris* (Linnaeus), based on the similarity between the American and European populations. Carpenter and Glare (2010) discovered that the European and American populations are not conspecific based on features of the male genitalia and mitochondrial DNA evidence.

***Vespula atropilosa* (Sladen)**
http://species-id.net/wiki/Vespula_atropilosa
Figs 16, 37, 60, 73

*Vespa atropilosa* Sladen 1918:72. Lectotype female; Canada: Lethbridge (OTTAWA).

**Distribution.** *Vespula atropilosa* occurs in mountain regions from the Rocky Mountains west.

**Biology.** This species builds subterranean nests, preferring open areas, including pastures and golf courses. It is predatory on other insects.

***Vespula consobrina* (Saussure)**
http://species-id.net/wiki/Vespula_consobrina
Figs 17, 38, 61, 74

*Vespa consobrina* de Saussure 1854:141. Holotype female; "L'île de Terre-Neuve" (PARIS).
*Vespa scelesta* McFarland 1888:298. Lectotype female; "Montana" (PHILADELPHIA).

**Distribution.** *Vespula consobrina* occurs in the Canadian and Transition Zones of northern and central North America.

**Biology.** This predatory species preys on live insects and usually nests in cavities, using sites in logs, wall voids and rodent burrows.

***Vespula flavopilosa* Jacobson**
http://species-id.net/wiki/Vespula_flavopilosa
Figs 18, 39, 66, 82

*Vespula flavopilosa* Jacobson (in Jacobson et al.) 1978:303. Holotype female; Ithaca, New York (WASHINGTON).

**Distribution.** *Vespula flavopilosa* occurs in the eastern United States as far south as Georgia (R. Jacobson, personal communication).

**Biology.** It builds subterranean nests. This species feeds on live insects, as well as other sources of sugar and protein, and is a scavenger much like *Vespula germanica, V. pensylvanica* and *V. alascensis*.

***Vespula germanica* (Fabricius)**
http://species-id.net/wiki/Vespula_germanica
Figs 1a, b, 13, 19, 40, 67, 83

? *Vespa maculata* Scopoli 1763:312. Type destroyed; "Carnioliae" (Slovenia). Nec *Vespa maculata* Linnaeus 1763.
? *Vespa macularis* Olivier 1792:695. Unjustified emendation of *Vespa maculata* Scopoli.
*Vespa germanica* Fabricius 1793:256. Type unknown; "Kiliae" (Germany) (repository unknown).

**Distribution.** *Vespula germanica* has been unintentionally introduced into temperate regions worldwide. It apparently first appeared in Montreal in the 1960's and other parts of eastern North America in the 1970's, although there is a record of the species collected in Ithaca, New York in 1891 (Menke and Snelling 1975). The species reached California by 1989.

**Biology.** The nests are usually built in structures or less commonly in the ground. Nests can be huge and may become perennial in warmer climates. These wasps feed on live prey or scavenge any source of protein or sugar.

***Vespula infernalis* (de Saussure), stat. n.**
http://species-id.net/wiki/Vespula_infernalis
Figs 4, 7, 20, 41, 62, 75

*Vespa infernalis* de Saussure 1854:139. Holotype female; "L'Amérique du Nord, Philadelphie (TURIN?).
*Vespa tripunctata* Packard 1870:26, pl. II fig. 11. Holotype female: "Kutleet", USA (repository unknown). Nec *Vespa tripunctata* Fabricius 1787 and *Vespa tripunctata* Schenck 1861.

**Distribution.** The distribution of *Vespula austriaca* closely resembles that of *acadica*, occurring in subarctic Alaska and Canada, and southward in the western mountain ranges.

**Biology.** This is an obligatory social parasite of *Vespula acadica* (Reed et al. 1979). This species has been known as *Vespula austriaca*, a Palearctic species, since Bequaert (1916), but there are sculptural differences in queens between Palearctic and Nearctic specimens.

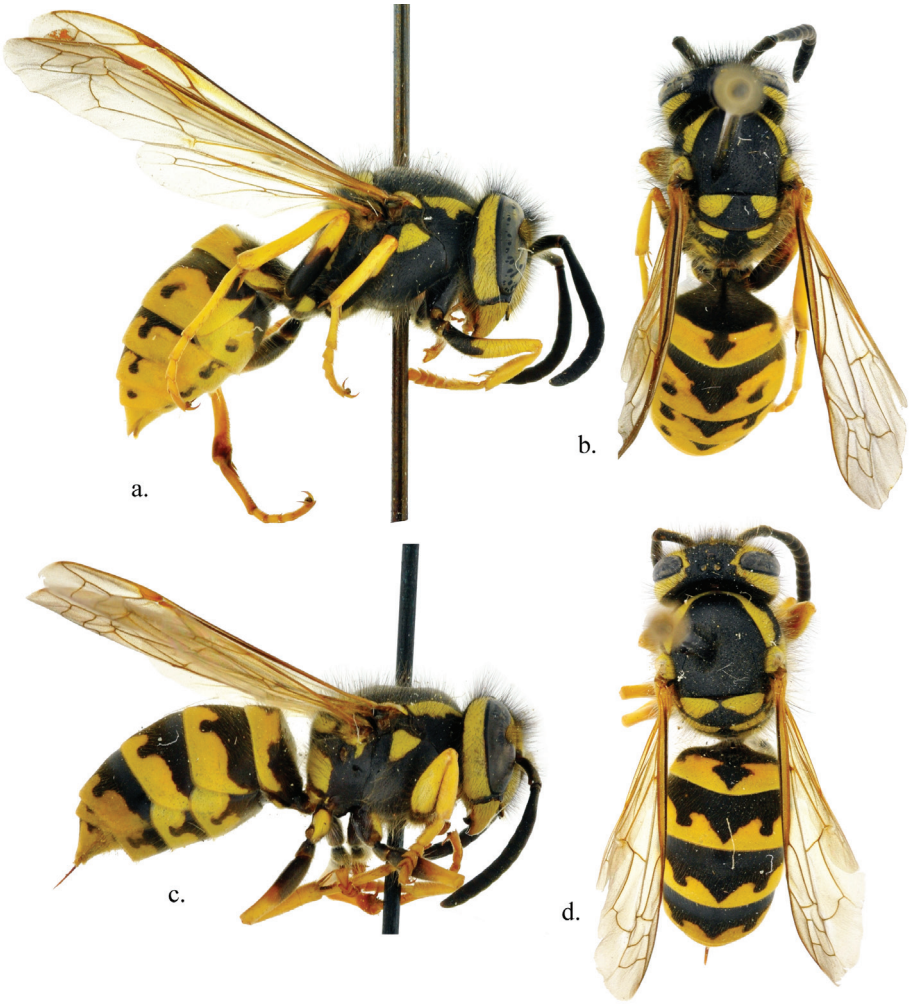


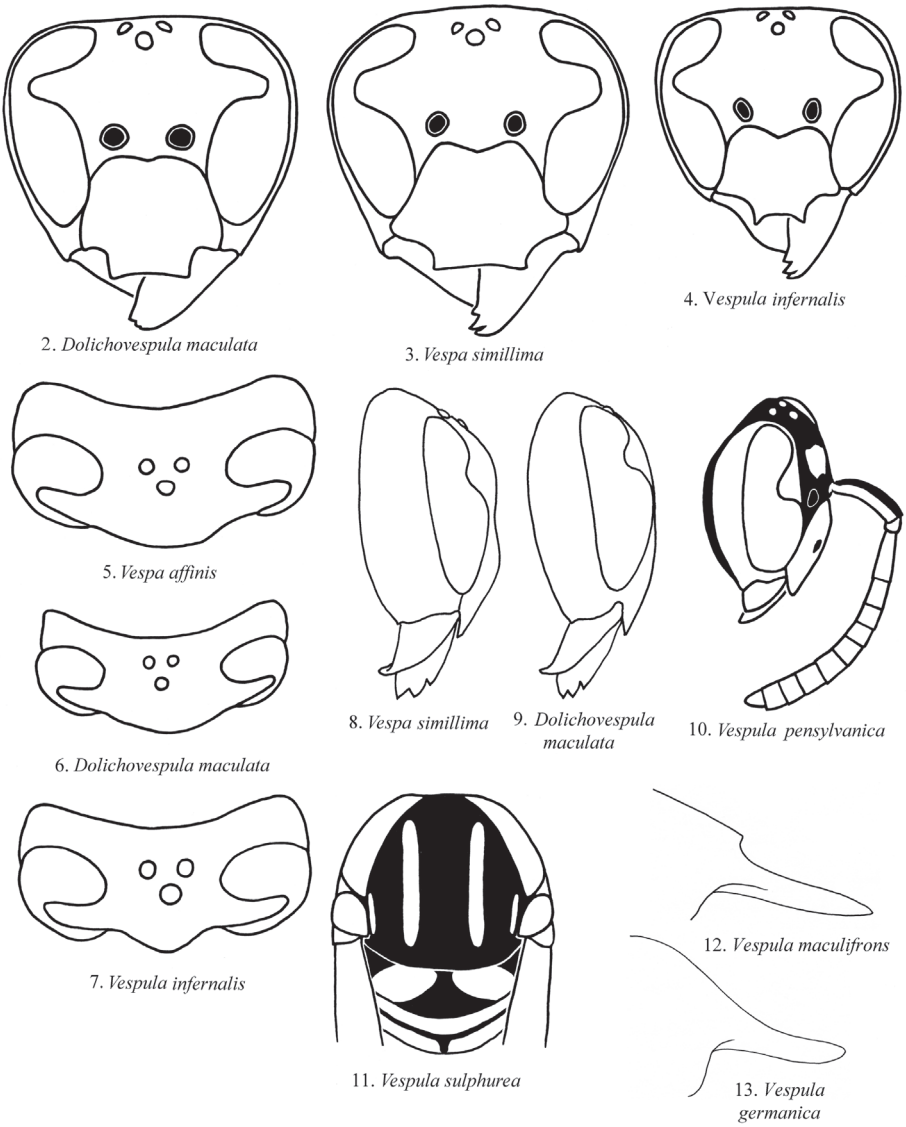

**Figure 1.** *Vespula pensylvanica* worker **a** side view **b** dorsal view; *Vespula germanica* worker **c** side view **d** dorsal view.

***Vespula intermedia* (du Buysson)**
http://species-id.net/wiki/Vespula_intermedia
Figs 21, 42, 63, 76

*Vespa rufa* var. *intermedia* du Buysson 1905:591. Syntype male, female; Manchuria, Hudson's Bay (PARIS, LONDON).

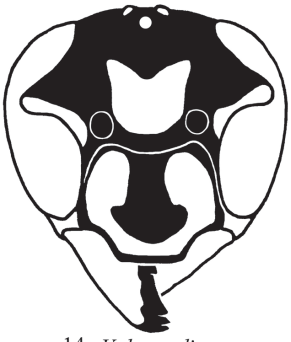
**Distribution.** These wasps occur in the far northern Nearctic Region.

**Biology.** The biology of North American *intermedia* has not been studied. *Vespula rufa* in the Palearctic usually nests below ground, in cavities or under eaves. They prey on live insects.

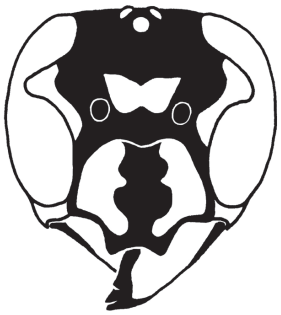



**Figures 2–13. 11–12** Front view of face **5–7** Dorsal view of head **8–10** Lateral view of head **11** Dorsal view of thorax **12, 13** Lateral view of male metasomal tergum VII.

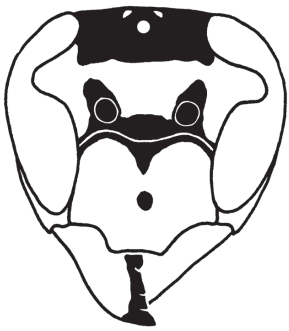
Although treated as a synonym of *Vespula rufa* (Linnaeus), which is thus a Holarctic species, the North American population is probably distinct and should be treated as a separate species, *V. intermedia* (du Buysson). It differs in coloration from *V. rufa*, with the pale markings being whitish and the metasomal terga I-II with reddish markings. The pale markings are either yellow in *V. rufa* (European specimens), or the terga lack reddish markings (Eastern Palearctic), or there are whitish spots in addition to reddish markings (Eastern Palearctic).



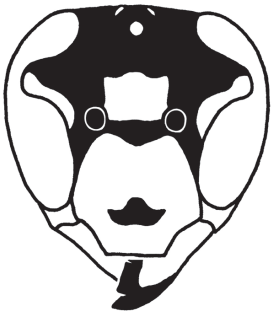
14. *Vpl. acadica*



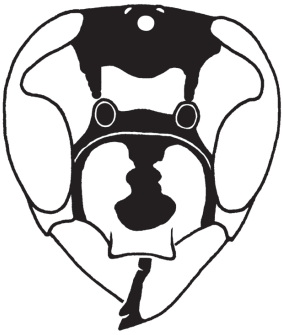
15. *Vpl. alascensis*



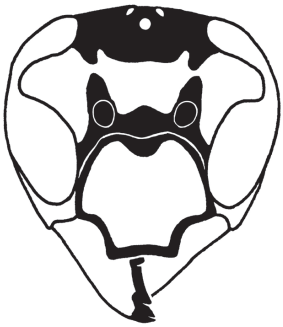
16. *Vpl. atropilosa*



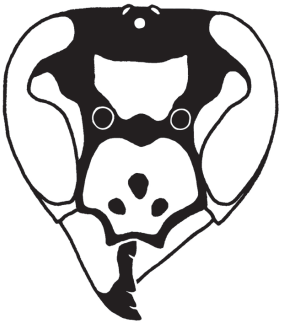
17. *Vpl. consobrina*



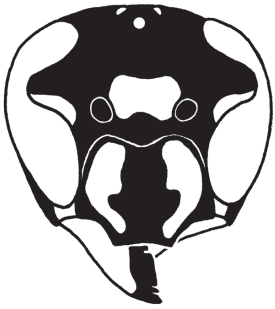
18. *Vpl. flavopilosa*



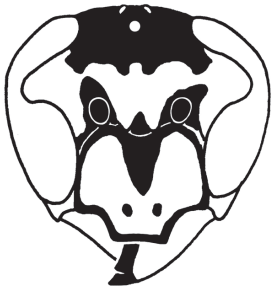
19. *Vpl. germanica*



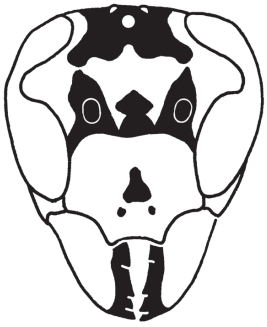
20. *Vpl. infernalis*



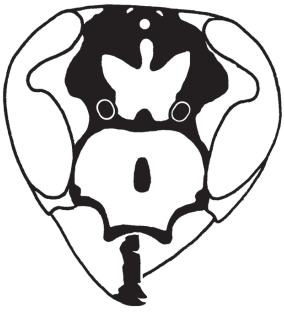
21. *Vpl. intermedia*



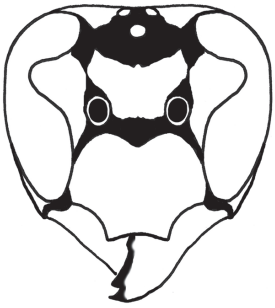
22. *Vpl. maculifrons*



23. *Vpl. pensylvanica*

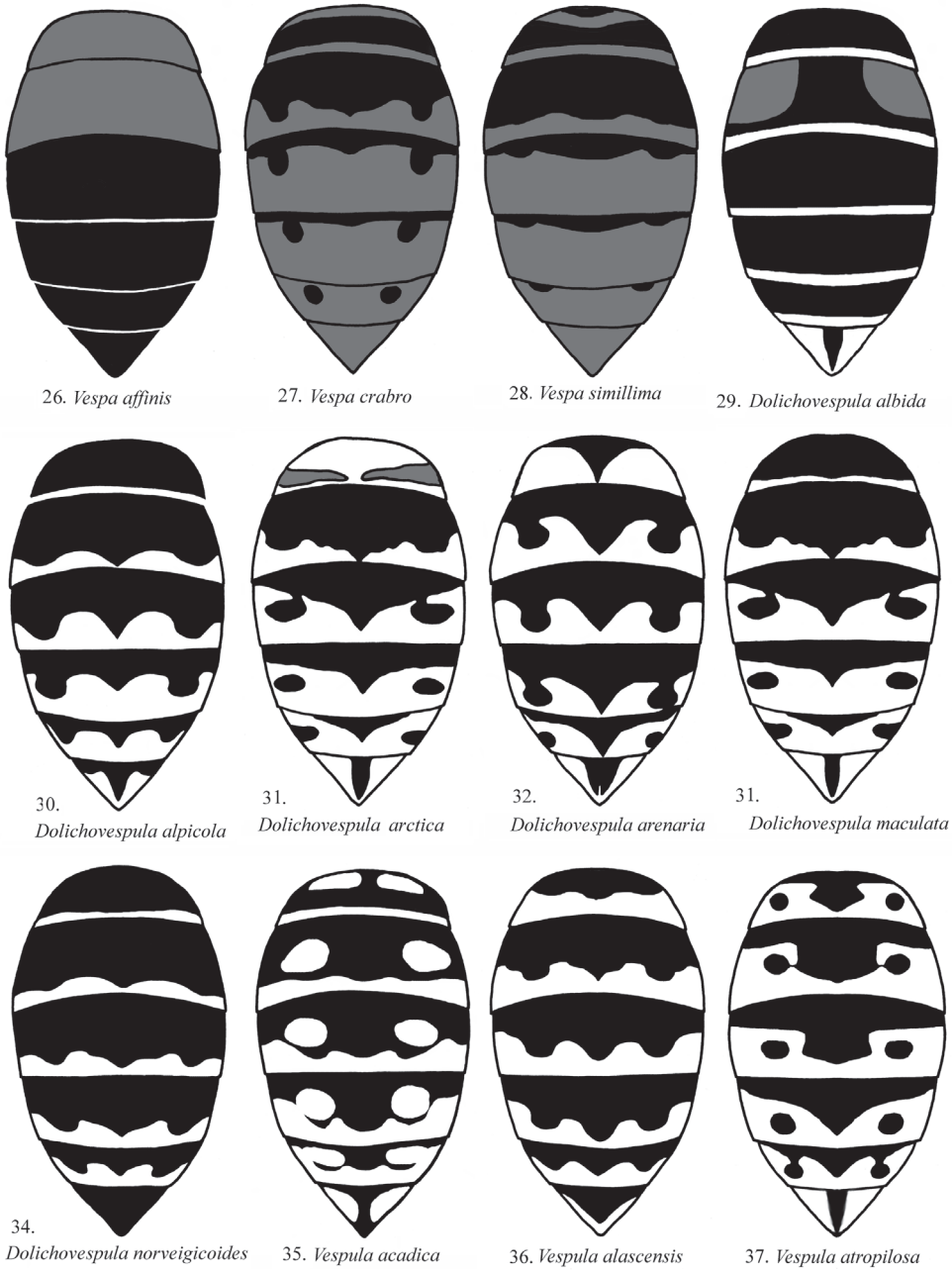


24. *Vpl. sulphurea*

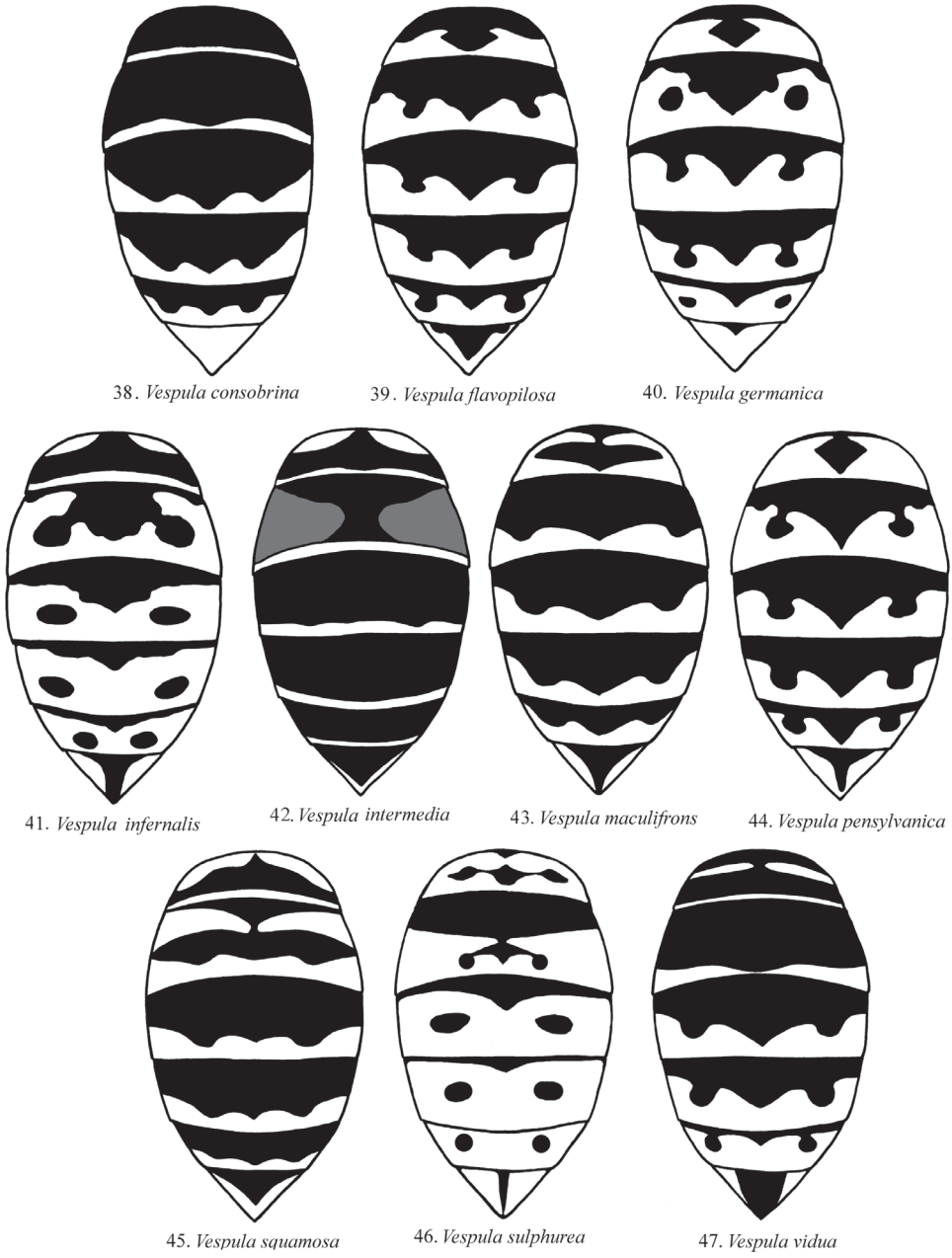


25. *Vpl. squamosa*

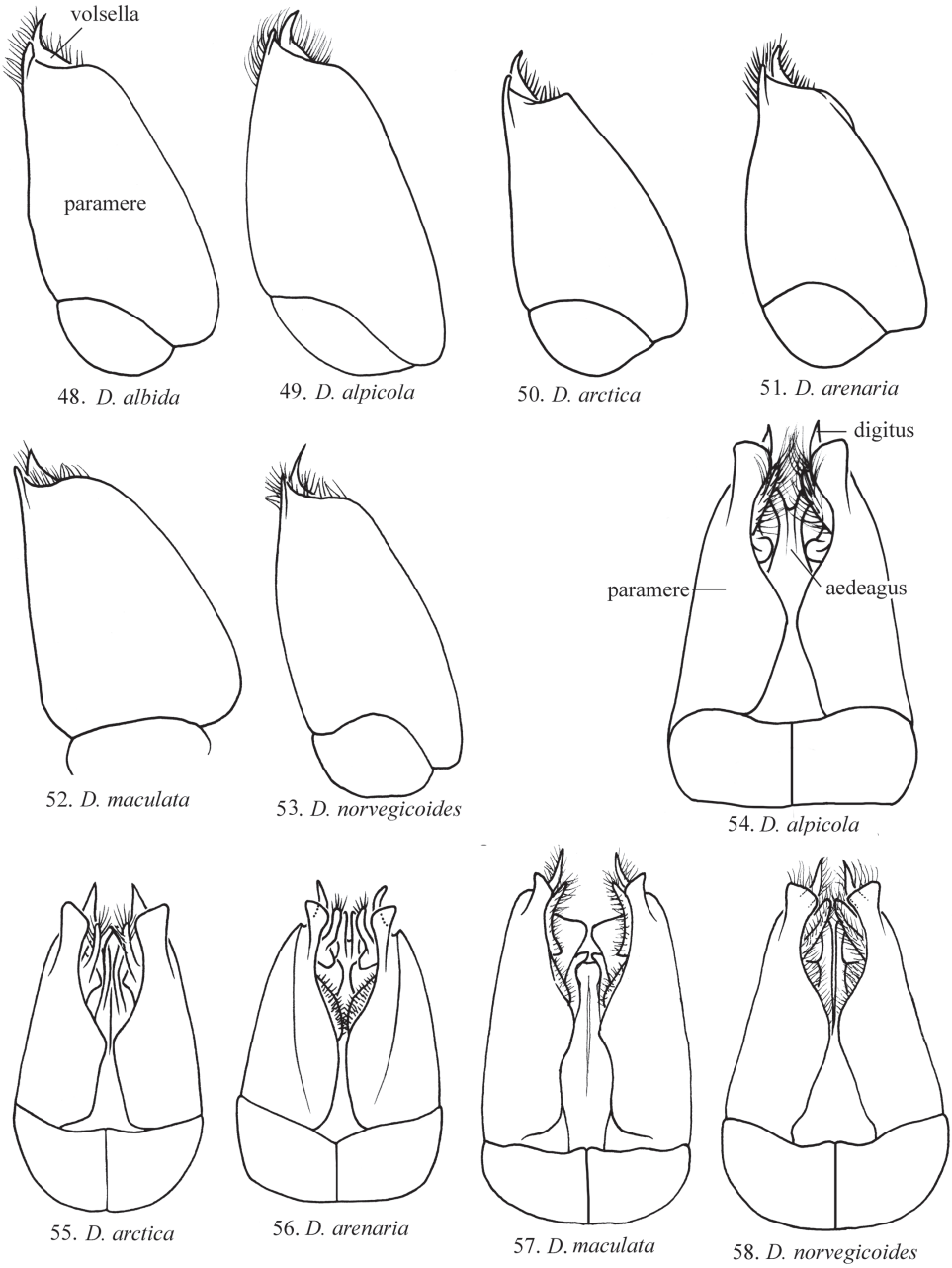
**Figures 14–25.** Front view of face, antennae removed. *Vpl.* = *Vespula*.



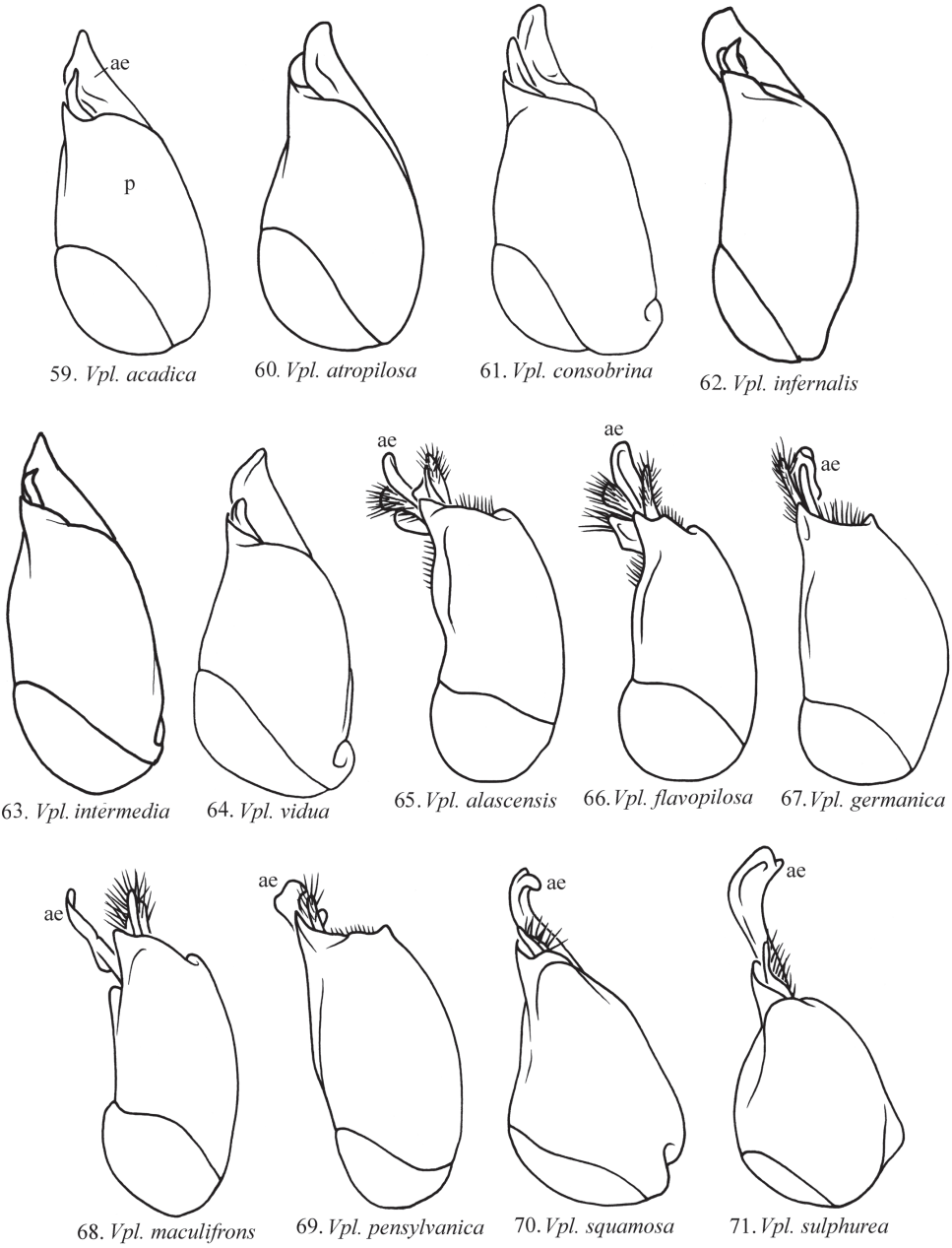

**Figures 26–37.** Dorsal view of worker metasoma.



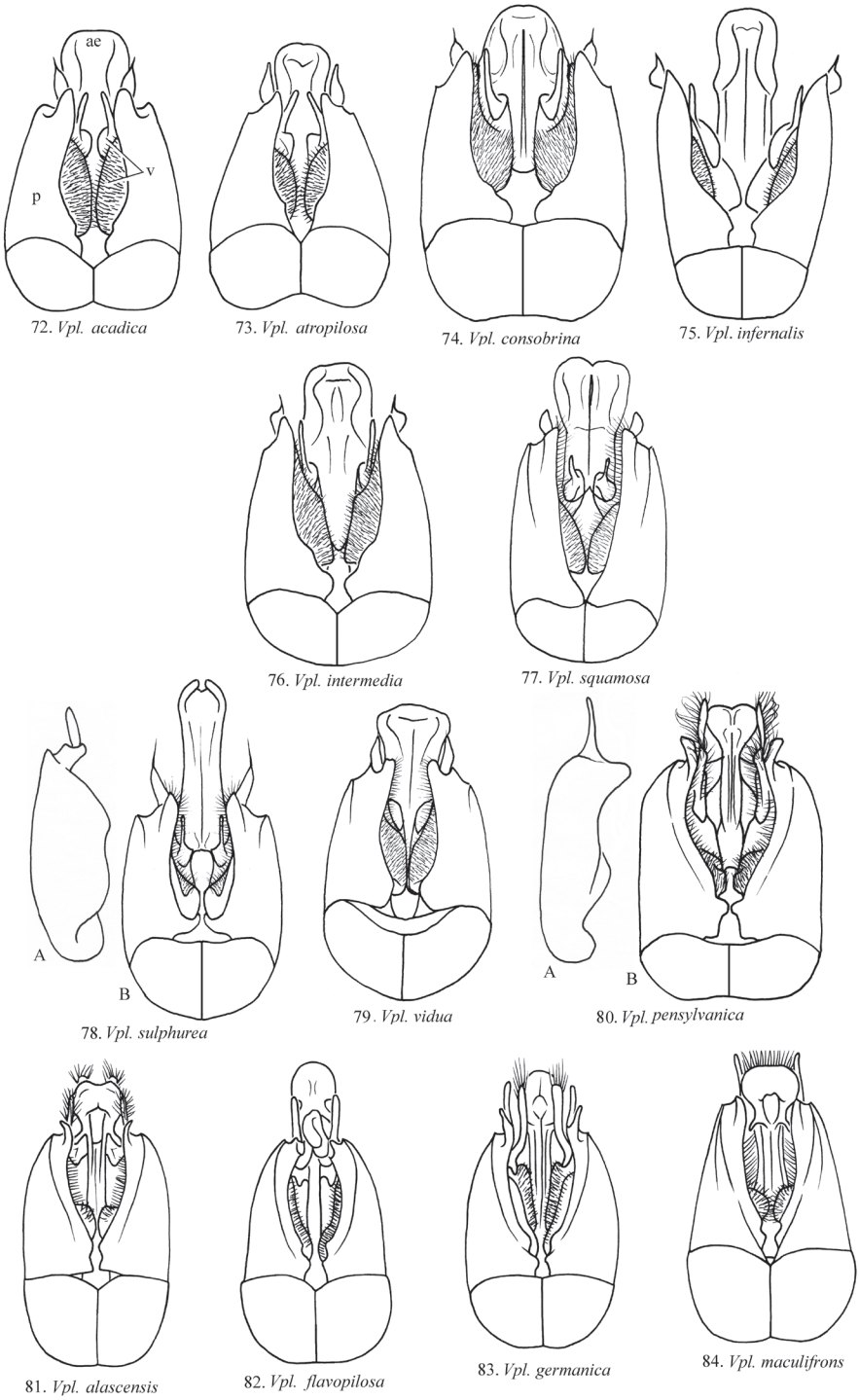

**Figures 38–47.** Dorsal view of worker metasoma.




**Figures 48–58.** Lateral view of genital capsule in *Dolichovespula* (*D.*) **54–58** Ventral view of genital capsule.




**Figures 59–71.** Lateral view of genital capsule in *Vespula* (*Vpl*). Abbreviations: **ae** = aedeagus **p** = paramere.




**Figures 72–84.** Ventral view of genital capsule in *Vespula* (*Vpl*). Abbreviations: **A.** = dorsal view of paramere **ae** = aedeagus **p** = paramere **v** = volsella **Vpl.** = *Vespula.*

***Vespula maculifrons* (du Buysson)**
http://species-id.net/wiki/Vespula_maculifrons
Figs 12, 22, 43, 68, 84

*Vespa maculifrons* "S." Harris (in Hitchcock) 1853:589. *Nomen nudum*.
*Vespa communis* de Saussure 1857:117. Syntype females; "America septentr." (GENEVA, PARIS). Nec *Vespa communis* von Schrank 1785.
*Vespa maculifrons* "H." du Buysson 1905 (1904):608, as a synonym of *Vespa communis* de Saussure 1857. Holotype female; Deleware: Wilmington" (LONDON). Available under Article 11.6.1 of the International Code of Zoological Nomenclature.
*Vespa communis* var. *flavida* Sladen 1918:71. Holotype female; Canada (repository unknown).

**Distribution.** This species is the most common *Vespula* occurring east of the 100th meridian.

**Biology.** It builds subterranean nests in a wide variety of situations, even in abandoned vehicles. These yellow jackets prey on live insects and are also scavengers of sources of protein and sugar.

***Vespula pensylvanica* (de Saussure)**
http://species-id.net/wiki/Vespula_pensylvanica
Figs 1c, d, 10, 23, 44, 69, 80

*Vespa pensylvanica* de Saussure 1857:116. Lectotype female; New Mexico (GENEVA).
*Vespa occidentalis* Cresson 1874:100. Lectotype female; Nevada (PHILADELPHIA) Nec *Vespa occidentalis* Olivier, 1792.

**Distribution.** This is the most abundant pest species of *Vespula* on the West Coast and much of the interior west of North America.

**Biology.** Nests are usually built in cavities, which may be in the ground or in structures, such as attics, wall voids and even basements. The nests can become huge and often become perennial in warmer climates. These wasps are general scavengers, and will feed on live prey or any other source of protein or sugar including garbage. It is adventive in Hawaii.

***Vespula squamosa* (Drury)**
http://species-id.net/wiki/Vespula_squamosa
Figs 25, 45, 70, 77

*Vespa squamosus* Drury 1773: Index to vol. I [pl. XLIII fig. 7 in Vol. 1]. Holotype female; New York (destroyed ?).

*Vespa lineata* Fabricius 1775:365. Type unknown; "in America".
*Sphex conchacea* Christ 1791:259, pl. 25 fig. 5. Type ?; "Neuiork" (destroyed).
*Vespa cuneata* Fabricius 1804:258. Type?; "Carolina" (COPENHAGEN).
*Vespa cruciata* Lepeletier 1836:514. Unjustified emendation of *Vespa cuneata* Fabricius 1804.
*Vespa bistriata* McFarland 1888:298. Holotype female; "North America" (PHILADELPHIA) Nec *Vespa bistriata* Fabricius 1804.
*Vespa macfarlandi* Lewis 1897:180. Replacement name for *Vespa bistriata* McFarland.
*Vespula squamosa* var. (or subsp.) *michoacana* Bequaert 1941:249. Holotype female; Mexico: Michoacan, Tancitaro (CAMBRIDGE).

**Distribution.** This is an eastern species, occurring east of the 100th meridian and south to Honduras.

**Biology.** It is a facultative social parasite of *Vespula maculifrons*. The two striped scutum is a distinctive feature of both *Vespula squamosa* and *Vespula sulphurea*. Queens of *squamosa* are quite different in color from workers and males, with their extensive orange-brown coloration, particularly on the metasoma.

***Vespula sulphurea* (de Saussure)**
http://species-id.net/wiki/Vespula_sulphurea
Figs 11, 24, 46, 71, 78

*Vespa sulphurea* de Saussure 1854:137. Holotype female; California (LONDON).

**Distribution.** *Vespula sulphurea* is abundant in mid elevation and wildland areas in western North America.

**Biology.** This is the yellowest of the North American species, with a two yellow-striped scutum much like that seen in *Vespula squamosa*, but *sulphurea* occurs west of the 100th meridian. They build small, subterranean nests, generally feed on live prey; in unusual circumstances they might scavenge food.

***Vespula vidua* (de Saussure)**
http://species-id.net/wiki/Vespula_vidua
Figs 47, 64, 79

*Vespa vidua* de Saussure 1854:136. Syntype females; "La Caroline" (PARIS).

**Distribution.** *Vespula vidua* occurs in the Transition and Upper Austral Zones of eastern North America.

**Biology.** Most nests are subterranean but *Vpl. vidua* will also build nests in hollow logs.

## Acknowledgments

JMC acknowledges the support of National Science Foundation Grant DEB-0843505. The manuscript was greatly improved by comments and suggestions from Michael Archer and Bob Jacobson.

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JHR 28: 67–84 (2012)
doi: 10.3897/JHR.28.2023
www.pensoft.net/journals/jhr

RESEARCH ARTICLE

JOURNAL OF Hymenoptera RESEARCH
A peer-reviewed open-access journal
The International Society of Hymenopterists

# Five new braconid species from Colombia (Hymenoptera, Braconidae)

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Academic editor: *Gavin Broad* | Received 7 September 2011 | Accepted 17 April 2012 | Published 24 August 2012

*urn:lsid:zoobank.org:pub:90F6E6B8-A903-44DB-AD0E-3D851F6454C9*

**Citation:** Papp J (2012) Five new braconid species from Colombia (Hymenoptera, Braconidae). Journal of Hymenoptera Research 28: 67–84. doi: 10.3897/JHR.28.2023

## Abstract

Descriptions are given of five new braconid species and one new genus from Colombia: *Aspilota stigmalis* **sp. n.**, *Synaldis cauca* **sp. n.**, *Telmogarbus* **gen. n.**, *Telmogarbus olivai* **sp. n.** (all Alysiinae); *Blacus (Tarpheion) latestigma* **sp. n.** (Blacinae) and *Pseudorhysipolis inaequalis* **sp. n.** (Rhysipolinae). Types are deposited in the A. Humboldt Institute, Villa de Leyva, Boyacá, Bogota (Colombia). Critical remarks on the taxonomic position of the genus *Synaldis* are included. With 57 line drawings.

## Keywords

New species, new genus, type, description, taxonomy, neotropics

## Introduction

In the Neotropical braconid material, sent by Dr. M. J. Sharkey (University of Kentucky) to me for identification, seven specimens were found which proved to represent five new species, one species also a new genus. The five species were collected in Colombia with Malaise traps. The new species are as follows (in brackets the respective subfamily name): *Aspilota stigmalis* sp. n. (Alysiinae: Alysiini), *Blacus (Tarpheion) latestigma* sp. n. (Blacinae), *Pseudorhysipolis inaequalis* sp. n. (Rhysipolinae), *Synaldis cauca*

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sp. n. (Alysiinae: Alysiini) and *Telmogarbus olivai* gen. et sp. n. (Alysiinae: Alysiini). The type specimens are deposited in the Insect Collection, Alexander Humboldt Institute, Villa de Leyva, Boyacá, Bogota, Colombia; one paratype is in the Hungarian Natural History Museum, Budapest, Hungary.

## Descriptions of the new taxa

In the descriptions abbreviations follow van Achterberg (1993: 4–5). Surface sculpture terminology follows Harris (1979).

### Subfamily Alysiinae, tribe Alysiini

***Aspilota stigmalis* sp. n.**
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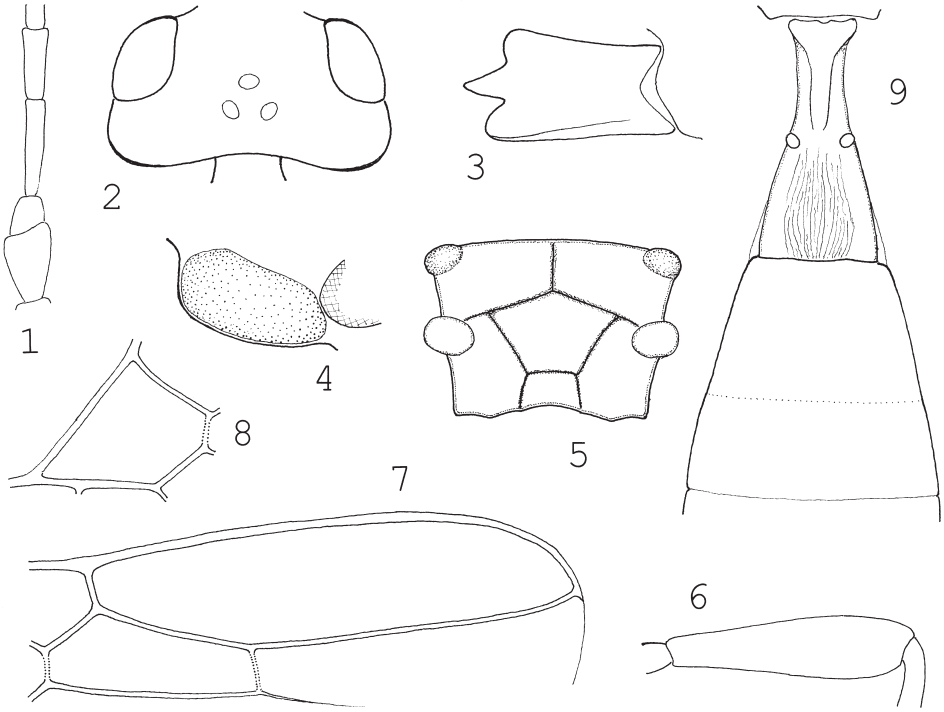
http://species-id.net/wiki/Aspilota_stigmalis
Figures 1–9

**Holotype ♀:** COLOMBIA, Magdalena PNN Sierra Nevada de Santa Marta Bella Vista, 10°48'N / 73°39'W, 1500 m, Malaise trap, 1–15 June 2001, leg. J. Cantillo. – Holotype is in good condition: (1) glued on a card point by the right mesopleuron, (2) left antenna missing ultimate or 19th antennomere (17th flagellomere), (3) right pair of wings less visible owing to mounting and to the apically creased fore wing.

**Etymology.** The species name *stigmalis* refers to the large pairs of spiracles on the propodeum and first tergite (Figs 5, 9).

**Description.** Body 3 mm long. Antenna as long as head, mesosoma and tergites 1–2 combined, with 19 antennomeres. Scape twice as long as broad apically and somewhat belly, first flagellomere 1.2 times as long as second, second flagellomere somewhat thicker than first, first flagellomere 3.7 times and second 2.5 times as long as broad (Fig. 1). Head in dorsal view transverse, almost 1.9 times as broad (between temples) as long (between compound eye and temple), temple slightly swollen, eye almost 1.3 times as long as temple (Fig. 2). Eye in lateral view 1.7 times as high as wide and just wider than gena, gena evenly broad beyond eye. Mandible along its lower margin 1.8 times as long as broad between upper and lower teeth, both teeth rounded (Fig. 3). Tentorial pit fairly large and extending to lower part of eye (Fig. 4). Head polished.

Mesosoma in lateral view stout, somewhat longer than high, polished. Notauli short, restricted to anterior declivous part of mesoscutum and finely crenulate. Pronope missing. Precoxal suture short, crenulate, medially on mesopleuron. Propodeum areolate, spiracles large, otherwise propodeum smooth and shiny, on its upper corner foveolate depressed (Fig. 5). Hind femur 3.8 times as long as broad distally (Fig. 6). Hind tibia slightly longer than hind tarsus.




**Figures 1–9.** *Aspilota stigmalis* sp. n.: **1** scape, pedicel and flagellomeres 1–2 **2** head in dorsal view **3** mandible **4** paraclypeal pit **5** propodeum **6** hind femur **7** distal part of right fore wing **8** first discal cell of fore wing **9** tergites 1–3.

Fore wing as long as body. Pterostigma linear (Fig. 7), *r* long, 3.5 times as long as width of pterostigma. Second submarginal cell long, *3–SR* 2.3 times as long as *2–SR*, *r–m* as long as *r*. First discal cell: *1–M* 1.9 times as long as *1–SR–M* (Fig. 8).

First tergite (Fig. 9) long, twice as long as posteriorly broad, spiracles large and at middle of tergite, pair of basal keels reaching spiracles, hind half of tergite striolate. Tergites 2–3 fully fused (i.e. border between tergites indistinct) and together with further tergites polished. Ovipositor sheath as long as mid tibia.

Scape and pedicel yellow, flagellum darkening brown. Head and mesosoma chestnut dark brown. Mouthparts whitish. First tergite brownish yellow, tergites 2–3 brownish, remaining tergites chestnut dark brown. Legs pale yellow. Tibiae apically and tarsi faintly light brownish. Wings hyaline, pterostigma brown, veins light brown.

**Male and host** unknown.

**Distribution.** Colombia.

**Diagnosis.** The new species, *Aspilota stigmalis*, is nearest to *A. phyllotomae* Fischer (Fischer 1970: 124) with their common features being the transverse head in dorsal view, first tergite 2.1 times as long as broad posteriorly, dentation of mandible and chestnut brown ground colour of body. The two species are distinguished by the following characters (*A. phyllotomae* is known only by its original description: Fischer 1970: 125):

1(2) Propodeum granulo-rugulose and not areolate, spiracles of propodeum and first tergite small, i.e. usual in size. Antenna with 14–15 antennomeres, flagellomeres 1–2 equal in length (each about three times as long as broad) and equally thick. Eye in dorsal view just shorter (cf. Abb. 33 in Fischer 1970: 33) to as long as temple. Fore wing: *r* slightly longer than width of pterostigma, *3–SR* 1.6 times as long as *2–SR*, *SR1* 2.7 times as long as *3–SR* (cf. Abb. 34 l.c.). Prosternum and tegula yellow. ♀ 1.3 mm. — U.S.A. (Maine, Michigan) ..... ***A. phyllotomae*** **Fischer, 1970**

2(1) Propodeum areolate, otherwise smooth and shiny, spiracles of propodeum and first tergite large (Figs 5, 9). Antenna with 19 antennomeres, first flagellomere 1.2 times as long as second flagellomere, second flagellomere somewhat thicker than first flagellomere (Fig. 1). Eye in dorsal view almost 1.3 times as long as temple (Fig. 2). Fore wing: *r* more than two times as long as width of pterostigma, *3–SR* 2.3 times as long as *2–SR*, *SR1* 2.25 times as long as *3–SR* (Fig. 7). Prosternum and tegula brown. ♀: 3 mm. – Colombia..... ..... ***A. stigmalis*** **sp. n.**

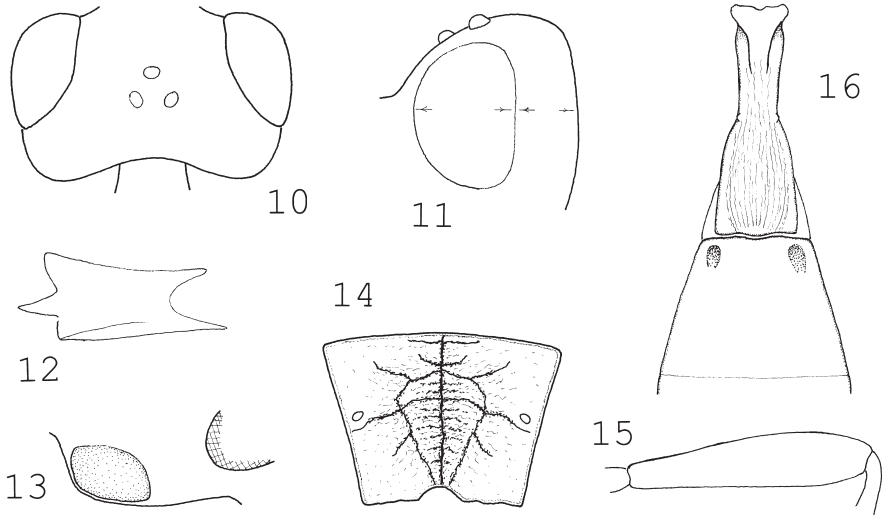
***Synaldis cauca*** **sp. n.**
urn:lsid:zoobank.org:act:78AEA130-5EF3-4FD2-A9BF-0415E0DCAFBC
http://species-id.net/wiki/Synaldis_cauca
Figures 10–16

**Holotype ♀:** COLOMBIA, Valle del Cauca, PNN Farallones de Cali, Anchicaya, 3°26'S / 76°48'W, 900 m, Malaise trap, 1 August – 10 October 2000, leg. S. Sarria. – Holotype is in good condition: (1) glued on a card point by its right mesopleuron, (2) right antenna broken, with 15 antennomeres, (3) right fore wing creased apico-posteriorly.

**Etymology.** The new species is named after the type locality, ”Cauca”.

**Description.** Body 2.6 mm long. Antenna as long as body and with 21 antennomeres. First flagellomere three times as long as broad apically, further flagellomeres gradually shortening and indistinctly attenuating so that penultimate flagellomere 2.5 times as long as broad. Head in dorsal view less transverse or subcubic (Fig. 10), 1.7 times as broad as long, eye almost 2.9 times as long as temple, temple rounded. Ocelli medium-sized, OOL almost three times as long as POL. Eye in lateral view nearly 1.5 times as high as wide and nearly 1.6 times as wide as temple, temple beyond eye evenly widened (Fig. 11, see arrows). Lower tooth of mandible somewhat small, mandible twice as long as broad between upper and lower teeth (Fig. 12). Paraclypeal pit short, i.e. distance between pit and eye as long as length of paraclypeal pit itself (Fig. 13). Maxillary palp one-sixth longer than height of head.

Mesosoma in lateral view stout, somewhat longer than high, polished. Mesoscutal dimple before prescutellar furrow. Precoxal suture medially on mesopleuron, crenulate. Propodeum with medio-longitudinal carina and with areolation (areola basalis, etc.,




**Figures 10–16.** *Synaldis cauca* sp. n.: **10** head in dorsal view **11** head in lateral view **12** mandible **13** paraclypeal pit **14** propodeum **15** hind femur **16** tergites 1–2.

Fig. 14). Hind femur 4.1 times as long as broad distally (Fig. 15). Hind tibia and tarsus equal in length. Hind basitarsus as long as tarsomeres 2–3 combined.

Fore wing: venation "*Synaldis*-form", i.e. *2–SR* missing hence first and second submarginal cells confluent; *r + 3–SR* as long as *SR1*, *CU1a* issuing from middle of outer side of subdiscal cell.

First tergite (Fig. 16) 2.8 times as long as broad posteriorly, moderately broadening posteriorly. Pair of keels merging into fine striation; spiracles close beyond middle of tergite. Tergites 2–3 fused and as long as first tergite, together with further tergites polished. Ovipositor sheath as long as mid tibia.

Scape and pedicel brownish yellow, flagellum darkening brown. Head, mesosoma and first tergite brownish black, rest of metasoma brown. Mandible and mouthparts yellow. Tegula brownish yellow. Legs yellow, hind tarsus greyish fumous. Wings hyaline, pterostigma and veins opaque brownish yellowish.

**Male and host** unknown.

**Distribution.** Colombia.

**Diagnosis.** The new species, *Synaldis cauca*, is near to *S. acutidens* Fischer as both have a mandible with three spiky teeth, *SR1* more than twice as long as *r + 3–SR* combined and dark bodies; the two species are distinguished as follows (*S. acutidens* is known by its original description: Fischer 1967: 434):

1(2) Head in dorsal view 1.5 times as broad as long; eye as long as temple. Propodeum polished and with medio-longitudinal carina, spiracles fairly large. Antenna with 16–18 antennomeres. Hind femur 3.5 times as long as broad

distally (Abb. 2 in Fischer 1967: 434). First tergite twice as long as broad posteriorly, widening more posteriorly. Lower tooth of mandible of usual size (Abb. 1 l.c in Fischer, 1967) . Head and mesosoma black, metasoma brown, first tergite yellow. ♀: 1.7 mm. – U.S.A. (Michigan, Wisconsin) ..... ..... ***Synaldis acutidens*** **Fischer, 1967**

2(1) Head in dorsal view 1.7 times as boad as long; eye almost 2.9 times as long as temple (Fig. 10). Propodeum with medio-longitudinal carina and with areolation, spiracles small (Fig. 14). Antenna with 21 antennomeres. Hind femur 4.1 times as long as broad distally (Fig. 15). First tergite 2.6 times as long as broad, widening less posteriorly (Fig. 16). Lower tooth of mandible somewhat small (Fig. 12). Head, mesosoma and first tergite brownish black, metasoma brown. ♀: 2.6 mm. – Colombia..... ***Synaldis cauca*** **sp. n.**

**Taxonomic remark.** The single distinctive generic feature of the genus *Synaldis* Foerster that differentiates it from *Aspilota* Foerster (the confluent first and second submarginal cells of the fore wing, or absence of vein *2–SR*) has been questioned since more than a century. Wharton (1980: 34) points out: "There are undoubtedly species of *Aspilota* in which only the *Synaldis*-type venation occurs. But the grouping of such species at a subgeneric level would be misleading, since it is based on a single character strongly subject to convergence." Fischer is the first specialist consistently maintaining *Synaldis* as a valid genus. To confirm and support his taxonomic standpoint he states (Fischer 1993: 453): "Da diese Gattungen [of the genus-group *Aspilota*] überwiegend diagnostischen Charakter haben und auch Übergänge aufweisen (und es übrigens auch keine objektiven Kriterien für das Aufstellen von Taxa der Gattungs-Gruppe gibt), erscheint mir das Beibehalten der verhältnismäßig leicht abgrenzbaren *Synaldis* Foerster gerechtfertigt und für die praktische Arbeit zweckmäßig." A second expert, Belokobylskij (2002), also considers *Synaldis* as a valid genus: in his key to the species of the Russian Far East the species are arranged under this genus. I am quite convinced that the species with *Synaldis*-form fore wing venation is evolving in our present epoch (in geochronological sense). In this conception the missing vein *2–SR* is an unambiguous character for the *Synaldis* species, consequently this feature is a "true generic" alar formation. The loss of vein *2–SR* is a convergent feature within the subfamily Alysiinae and also in the family Braconidae. The other convergent feature of *Synaldis* species (sensu Fischer) is the "long" versus "short" tentorial pit (occurring in several alysiine genera). The species with a "short" tentorial pit (i.e. pit not reaching compound eye) are in a small majority over the species with a "long" pit (i.e. pit reaching compound eye). I consider this feature also as an evolutionary process. There are evolving the *Synaldis* species with common generic feature: missing the vein *2–SR* (apomorphic) and forming the tentorial pit in two forms: in "short" and "long" pits. This taxonomic standpoint corresponds unambiguously with Fischer's one: *Synaldis* is a valid genus. However, several American (and also some European) specialists refute the validity of the genus *Synaldis*, emphasizing the complexity of these features and giving less evolution-

ary significance to the presence / absence of vein *2–SR*. Currently it seems difficult to decide whether the presence or absence of the "short" and "long" tentorial pit is plesiomorphic or apomorphic, respectively. In the case of vein *2–SR* it is generally considered that its presence is plesiomorphic and its absence is apomorphic. By the way, there are rarely occurring "*Synaldis*" specimens (one versus hundred to thousand specimens) which show transitional status: vein *2–SR* is (very) faintly present (considered as atavistic feature) — confirming the viewpoint that this venational mark is on the course to be stabilized. If we accept the hypothesis that the primary process within *Synaldis* species is the process of the loss of *2–SR* and the formation of the tentorial pit is the secondary process in the evolution of this genus then *Synaldis* is evidently tenable as a "good" genus.

The above short essay is but a viewpoint in the taxonomic treatment of the genus *Synaldis*. My conception is expounded in a traditional form – the morphological data matrix and molecular analysis will, presumably, unambiguously solve this taxonomic problem.

## ***Telmogarbus*** **gen. n.**

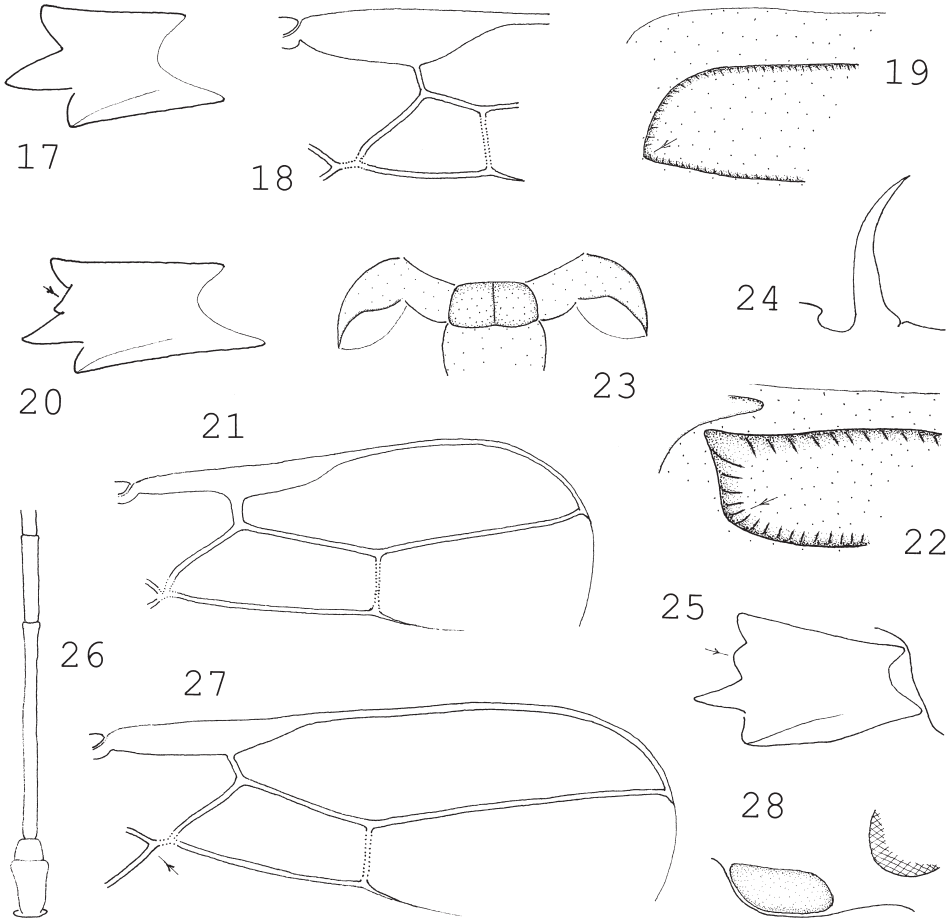
urn:lsid:zoobank.org:act:6F9EFAFB-3F27-4A38-BFE9-C84E3B673E0A
http://species-id.net/wiki/Telmogarbus
Figures 20–24, 33–40

**Type species:** *Telmogarbus olivai* gen. et sp. n. (monobasic and present designation).

**Etymology.** The new genus receives the fantasy name, *Telmogarbus*.

**Description.** Body gracile. Antenna filiform, flagellomeres very long. Head in dorsal view transverse, eye distinctly longer than temple (Fig. 36). Mandible with four teeth, fourth tooth between first and second teeth (Fig. 20, see arrow). Maxillary palp very long, about twice as long as height of head. Face and clypeus much wider than high. Paraclypeal pit short, i.e. not reaching compound eye (Fig. 35). Ocelli medium-sized, elliptic. Pronope small, distinct. Notauli evenly deep, meeting behind, finely crenulate; mesoscutal dimple missing. Prescutellar furrow wide, with a few crenulae. Axille with pair of lamelliform excrescences (Fig. 23). Metanotum medially with thin, long spine curving posteriorly (Fig. 24). Propodeum polished, carinate (Fig. 38). Precoxal suture distinct, crenulate. Epicnemial carina present. Legs long and thin. Fore wing as long as body. Pterostigma widening medially, second submarginal cell long: *3–SR* clearly longer than *2–SR*, *m–cu* interstitial (Fig. 21). First tergite petiolate, beyond first tergite metasoma narrow, tergites polished, tergites 2–3 fused (Fig. 33). Hypopygium small, ovipositor sheath short. Ground colour of body yellow to (light) brown. Wings hyaline.

**Diagnosis.** The new genus is near to the Palaearctic genus *Kritscherysia* Fischer (Fischer 1993: 484), to the Neotropic *Gnathopleura* Fischer (Fischer 1975: 128) and to the Palaearctic / Oriental / Nearctic genus *Cratospila* Foerster. The generic differentation of the four genera is presented below.




**Figures 17–28. 17–19** *Cratospila circe* (Haliday): **17** mandible **18** pterostigma and first submarginal cell of right fore wing **19** mesoscutum in lateral view (its declivous lateral part). **20–24** *Telmogarbus olivai* gen. et sp. n.: **20** mandible **21** distal part of right fore wing **22** mesoscutum in lateral view (its declivous lateral part) **23** axilla with pair of excrescenses **24** metanotal spine in lateral view. **25–28** *Kritscherysia longimembrum* Fischer: **25** mandible **26** scape, pedicel and flagellomeres 1–2 **27** distal part of right fore wing **28** paraclypeal pit.

1.) Distinction between *Kritscherysia* and *Telmogarbus*: Common features of the two genera are the pair of more or less lamelliform excrescenses laterally from the prescutellar furrow (or on axillae) (Fig. 23; Abb. 54 in Fischer 1993: 485), long second submarginal cell (Fig. 21; Abb. 51 l.c.), long flagellomeres (Figs 26, 34) and ground colour of body yellow to light brown. The two genera are distinguished as follows.

1(2) Metanotum without spine. Mandible with convexity between teeth 1 and 2 ("Interkalarwölbung" Fischer 1993: 484; Fig. 25, see arrow). First flagellomere 2.5 times as long as second flagellomere (Fig. 26). Fore wing: *r* issuing distally from pterostigma, *n. rec.* antefurcal (Fig. 27, see arrow). Paraclypeal

pit long, its length greater than distance between pit and compound eye (Fig. 28). Two species in the Ethiopian Region ..... ***Kritscherysia*** **Fischer, 1993**

2(1) Metanotum with spine (Fig. 24). Mandible with a fourth tooth between teeth 1 and 2 (Fig. 20, see arrow). Flagellomeres 1 and 2 equal in length (Fig. 34). Fore wing: *r* issuing from middle of pterostigma (Fig. 21), *n. rec.* interstitial (Fig. 40, see vertical arrow). Paraclypeal pit short, its length as long as distance between pit and compound eye (Fig. 35). One species in the Neotropical Region ..... ***Telmogarbus*** **gen. n.**

2.) Distinction between *Gnathopleura* and *Telmogarbus*: The new genus runs to *Gnathopleura* Fischer in Wharton's (1997: 88–98) identification key to the alysiine genera of the Neotropical Region, their common feature is the fourth tooth between teeth 1 and 2 (Figs 20, 29, see arrows); the distinction between them is presented here.

1(2) Mandible strong and broad, 1.2–1.4 times as long as broad between upper and lower teeth (Fig. 29). First tergite as long as to 1.2 times as long as broad posteriorly, strongly widening posteriorly (Fig. 30). Flagellomeres thick, first flagellomere 2 to 3 times as long as broad, second flagellomere variably longer / as long as / shorter than first flagellomere (Fig. 31). Fore wing: *3–SR* at most as long as *2–SR* or shorter, i.e. second submarginal cell short (Fig. 32). Wings dark, infumate. – Twelve described species in the Neotropical Region (Yu et al. 2005) ..... ***Gnathopleura*** **Fischer, 1975**

2(1) Mandible usual in size, 1.8 times as long as broad between upper and lower teeth (Fig. 20). First tergite 1.8 times as long as broad posteriorly, subparallel-sided (Fig. 33). Flagellum thin, first flagellomere 10 times as long as broad, second flagellomere as long as first flagellomere (Fig. 34). Fore wing: *3–SR* 1.5 times as long as *2–SR*, i.e. second submarginal cell long (Fig. 21). Wings hyaline. – One species in the Neotropical Region ..... ***Telmogarbus*** **gen. n.**

3.) Distinction between *Cratospila* and *Telmogarbus*: disregarding the number of mandibular teeth, the new genus will run to *Cratospila* Foerster (Wharton 1997: 88–98) by virtue of their delicate body shape, very long flagellomeres and long first tergite; the two genera differ from each other by the features in the key below.

1(2) Mandible with three teeth (Fig. 17). Fore wing: *3–SR* shorter than (or at most as long as) *2–SR*, i.e. second submarginal cell short; pterostigma with *r* issuing distal to its middle (Fig. 18; Fig. 83 in Wharton 1997: 109). Notauli not turning into crenulate lateral margin of mesoscutum (Fig. 19, see arrow). Axilla without excrescense; metanotum without spine. Fourteen species in Old and New World ..... ***Cratospila*** **Foerster, 1862**

2(1) Mandible with four teeth, fourth tooth between first and second teeth (Fig. 20, see arrow). Fore wing: *3–SR* 1.5 times as long as *2–SR*, i.e. second sub-

marginal cell long; pterostigma with *r* issuing from its middle (Fig. 21). Notauli turning into crenulate lateral margin of mesoscutum (Fig. 22, see arrow). Axilla with lamelliform excrescense (Fig. 23); metanotum with spine (Fig. 24). One species in the Neotropical region ..... ***Telmogarbus* gen. n.**

**Taxonomic remark.** The three genera related to the new genus *Telmogarbus* are known to me by the following material: 1.) *Cratospila* by females and males of *C. circe* Haliday; 2.) *Gnathopleura* by a few Neotopical species; 3.) *Kritscherysia* by two male paratypes of *K. longimembrum* Fischer and the original description.

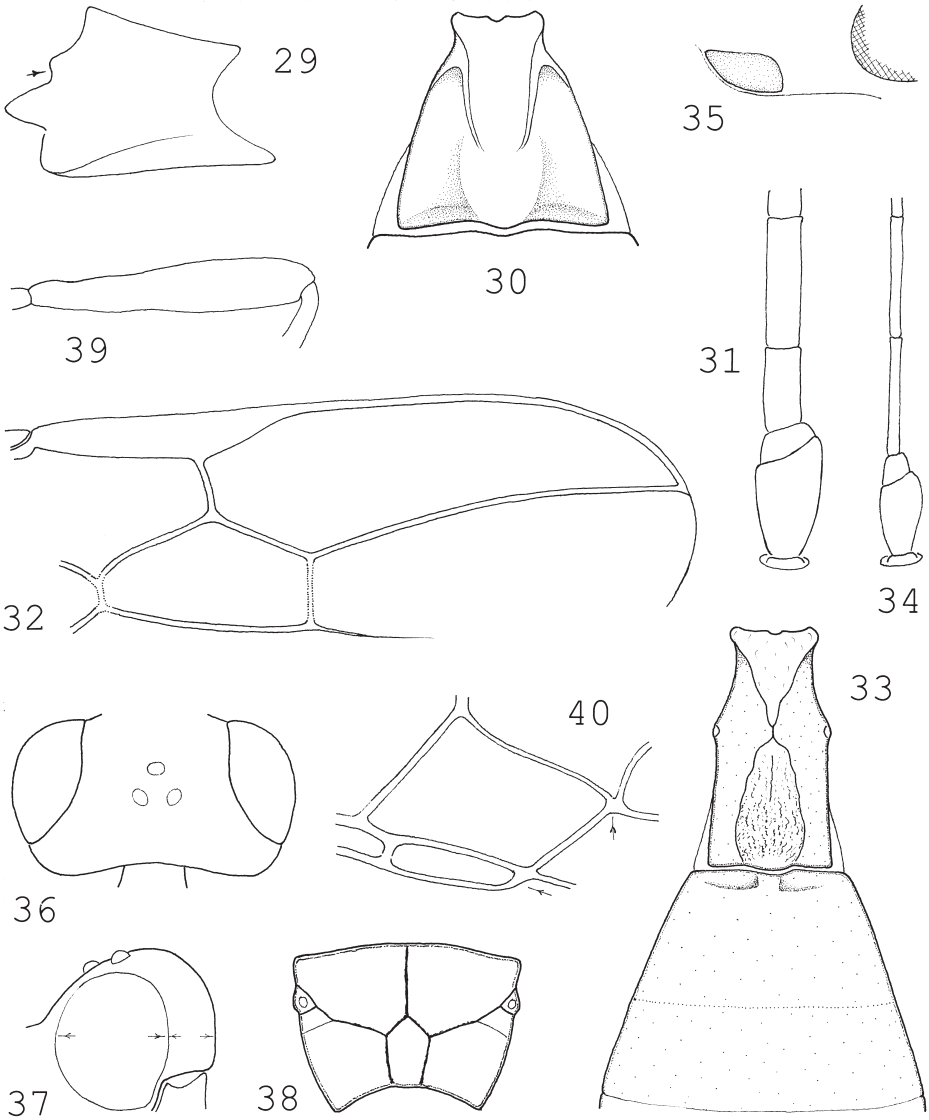
***Telmogarbus olivai* sp. n.**
urn:lsid:zoobank.org:act:198BCB2B-3030-4C87-B2D3-D944CFA2E478
http://species-id.net/wiki/Telmogarbus_olivai
Figures 20–24, 33–40

**Holotype ♀ and one paratype ♂:** COLOMBIA, Nariño R. N., La Planada Parcela Olga, 1°15'N / 78°15'W, Malaise trap, holotype: 16 June – 2 July 2000 and paratype: 16 March – 2 April 2001, leg. G. Oliva. Holotype is in fairly good condition: (1) glued on a card point by lower part of mesopleuron,;(2) right flagellum broken, antenna with 19 antennomeres; (3) missing: right middle leg, right fore leg (except coxa) and tarsomeres 2–4 of left hind leg; (4) left fore wing apically missing beyond pterostigma. Paratype is also in fairly good condition: (1) glued on card point by meso- and metapleura; (2) left flagellum apically broken, antenna with 22 antennomeres; (3) missing tarsi of right fore and hind legs.

**Etymology.** The new species is dedicated to its collector, Mr. G. Oliva.

**Description.** *Female:* Body 3.6 mm long. Antenna long, twice as long as body, with 33 antennomeres. Flagellomeres very long, flagellomeres 1–2 equal in length and ten times as long as broad apically (Fig. 34), subsequent flagellomeres slightly shortening so that penultimate flagellomere four times as long as broad. Head in dorsal view transverse (Fig. 36), 1.8 times as broad as long, eye 4.5 times as long as temple, temple rounded, occiput weakly excavate. OOL somewhat more than twice as long as POL. Eye in lateral view 1.25 times as high as wide and 2.4 times as wide as temple, temple beyond eye evenly wide (Fig. 37). Mandible 1.8 times as long below as broad between upper and lower teeth, fourth tooth between upper and middle teeth, every tooth pointed (Fig. 20). Paraclypeal pit as long as distance between pit and compound eye (Fig. 35). Segments of maxillary palp long, palp about 1.5 times as long as height of head. Head polished.

Mesosoma in lateral view stout, 1.2 times as long as high, polished. Pronope present. Crenulate notauli turning down to crenulated margin of mesoscutum, i.e. notauli not extending onto declivous anterior part of mesoscutum (Fig. 22, see arrow). Notauli meeting posteriorly (before prescutellar furrow) and here dimple missing. Prescutellar furrow subcrenulate, laterally from furrow (or on axillae) with pair of lamelliform excrescenses (Fig. 23). Metanotum medially with fairly long and somewhat posteriorly




**Figures 29–40. 29–32** *Gnathopleura cariosa* Marsh: **29** mandible **30** first tergite **31** scape, pedicel and flagellomeres 1–2 **32** distal part of right fore wing. **33–40** *Telmogarbus olivai* gen. et sp. n.: **33** tergites 1–3 **34** scape, pedicel and flagellomeres 1–2 **35** paraclypeal pit **36** head in dorsal view **37** head in lateral view **38** propodeum **39** hind femur **40** first discal and first subdiscal cells.

curved spine (Fig. 24). Propodeum areolate, areolae polished, spiracles before middle of propodeum, carination strong (Fig. 38). Precoxal suture distinct, restricted to middle of mesopleuron, crenulate, hind margin of mesopleuron almost smooth to subcrenulate; epicnemial carina present. Legs long. Hind femur 5.5 times as long as broad distally (Fig. 39). Hind tibia almost 1.3 times as long as hind tarsus.

Pterostigma (Fig. 21) 6.6 times as long as wide and *r* issuing from its middle, *r* short, shorter than width of pterostigma. Second submarginal cell long, *3–SR* 1.6 times as long as *2–SR*, *n. rec.* interstitial, *SR1* 1.6 times as long as *3–SR* and reaching tip of wing. First subdiscal cell narrowing distally and closed (Fig. 40, see horizontal arrow), *CU1a* interstitial (Fig. 40, see vertical arrow).

First tergite (Fig. 33) 1.8 times as long as broad behind, weakly broadening posteriorly, spiracles before middle of tergite; pair of basal keels meeting at spiracle and posteriorly diverging, reaching hind end of tergite. Hind half of tergite medially between keels longitudinally substriate, otherwise polished. Tergites 2–3 fused and as long as first tergite, together with further tergites polished (Fig. 33). Ovipositor sheath as long as first tergite or hind basitarsus + half of second tarsomere.

Ground colour of body yellow to brownish yellow. Scape and pedicel brownish yellow. Flagellum brown to dark brown, flagellomeres 19–25 white. Head brownish yellow, vertex brown. Mandible, mouthparts, palps pale yellow. Prothorax browish yellow, mesoscutum, scutellum and mesosternum brown. Mesopleuron and propodeum blackish brown. Tergites brown, sternites yellow. Legs yellow, coxae and trochanters lemon yellow. Wings hyaline, pterostigma and veins yellowish.

**Description.** *Male paratype.* Similar to female holotype. Body 3.5 mm long. Antenna with 31 antennomeres. Head in dorsal view 1.8 times as broad as long. Pterostigma wide, 5.7 times as long as wide. Dark colour somewhat more extensive.

**Host.** Unknown.

**Distribution.** Colombia.

## Subfamily Blacinae

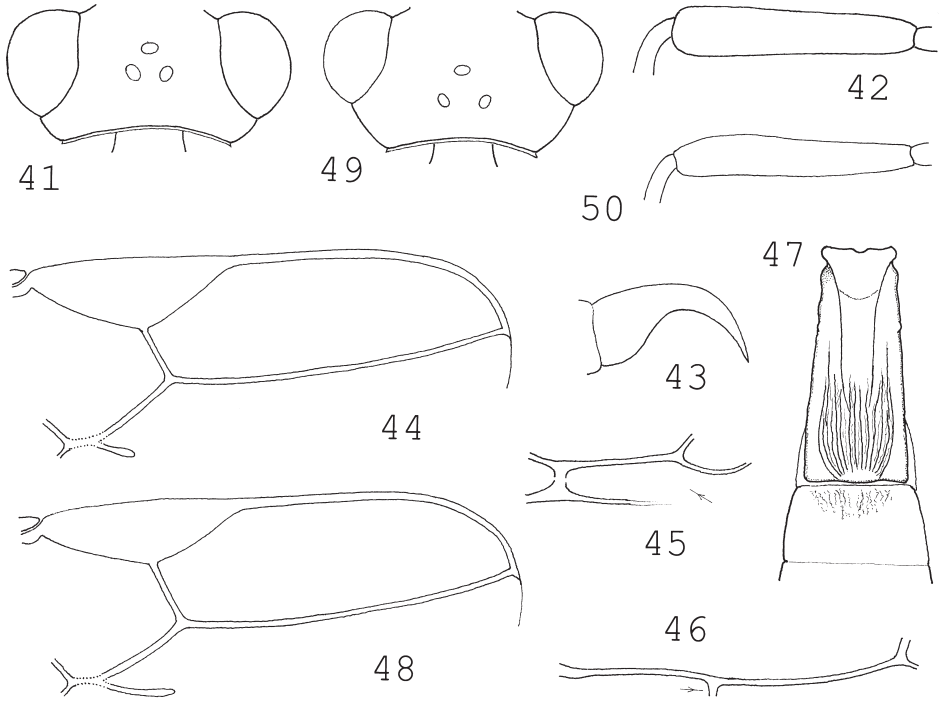
### *Blacus* (*Tarpheion*) *latestigma* sp. n.

urn:lsid:zoobank.org:act:AF970EB5-9078-4098-AE34-B6B8D1B0AD93
http://species-id.net/wiki/Blacus_latestigma
Figures 41–50

**Holotype ♀:** COLOMBIA, Amazonas, PNN Amacayacu San Martin, 150 m, 3°23'S / 70°6'W, Malaise trap, leg. B. Amado. Holotype is in good condition: (1) glued on a card point by the right metapleuron, (2) right femur + tibia in glue, hardely visible, (3) left hind leg on the right side owing to the mounting.

**Etymology.** The name *latestigma* refers to the wide pterostigma.

**Description.** Body 2.5 mm long. Antenna somewhat longer than body and with 25 antennomeres. First flagellomere six times as long as broad apically and 1.5 times as long as second flagellomere, subsequent flagellomeres shortening so that penultimate flagellomere twice as long as broad. Head in dorsal view (Fig. 41) distinctly twice as broad as long, eye almost four times as long as temple, temple receding. Occiput carinate. Ocelli elliptic, OOL twice as long as POL. Malar suture present. Maxillary palp somewhat longer than height of head. Eye in lateral view 1.3 times as high as wide. Head polished.




**Figures 41–50. 41–47** *Blacus (Tarpheion) latestigma* sp. n.: **41** head in dorsal view **42** hind femur **43** claw **44** distal part of right fore wing **45** first subdiscal cell **46** hind wing: *M+CU + 1–M+cu–a* **47** tergites 1–2. **48–50** *Blacus (Tarpheion) erugatus* van Achterberg: **48** distal part of right fore wing **49** head in dorsal view **50** hind femur.

Mesosoma in lateral view 1.4 times as long as high. Notauli distinct, smooth. Precoxal suture short with weak crenulae. Lateral carina of scutellum missing. Propodeum rugose (like Fig. 101 in van Achterberg 1976: 64). Hind femur five times as long as broad distally (Fig. 11). Claw simple, basal lobe distinct (Fig. 43).

Fore wing almost as long as body. Pterostigma wide (Fig. 44), 2.6 times as long as wide, *r* issuing somewhat distal to middle, *r* 0.8 times as long as width of pterostigma. *2–SR* nearly 1.6 times as long as *r*, *3–SR + SR1* slightly bent and reaching tip of wing, 2–M short. First subdiscal cell open distally (Fig. 45, see arrow). Hind wing: *cu–a* slightly proximal to middle of vein *M+CU + 1–M* (Fig. 46, see arrow).

First tergite long and hardly broadening posteriorly (Fig. 47), 2.2 times as long as broad posteriorly, pair of keels distinct, finely striate. Second tergite almost 1.9 times as broad posteriorly as long, anteriorly strio-rugulose. Further tergites polished. Hypopygium fairly large, ovipositor sheath downcurved, somewhat longer than hind tibia.

Scape, pedicel and flagellomeres 1–2 straw yellow, rest of flagellum brown. Head brownish yellow, occiput brown, mouthparts whitish. Mesosoma blackish brown, tegula brown. Legs yellow, coxae and trochanters straw yellow. First tergite blackish

brown, further tergites brown, anterior sternites whitish. Wings hyaline, pterostigma brown, parastigma whitish, veins opaque brown.

**Male and host** unknown.

**Distribution.** Colombia.

**Diagnosis.** The new species, *Blacus (Tarpheion) latestigma*, runs to *B. (T.) erugatus* van Achterberg with the help of van Achterberg's keys (1976: 186, 1988: 140–141); the two species differ from each other by a few features.

1(2) Fore wing: pterostigma narrower, 3–3.3(3.6) times as long as wide, *r* as long as width of pterostigma, *2–M* long (Fig. 48). Eye in dorsal view 2.3 times as long as temple, temple slightly less receding, head in dorsal view slightly less transverse: 1.9 times as broad as long (Fig. 49). Hind femur 5.5–6.2 times as long broad distally (Fig. 50). First tergite more broadening posteriorly (Fig. 101 in van Achterberg 1976: 264). Antenna with 20–23 antennomeres. Ground colour of mesosoma reddish brown, head brown, face brownish yellow. ♀♂: 1.9 mm. – Brazil, Costa Rica, Ecuador ..... ..... ***Blacus (Tarpheion) erugatus* van Achterberg, 1976**

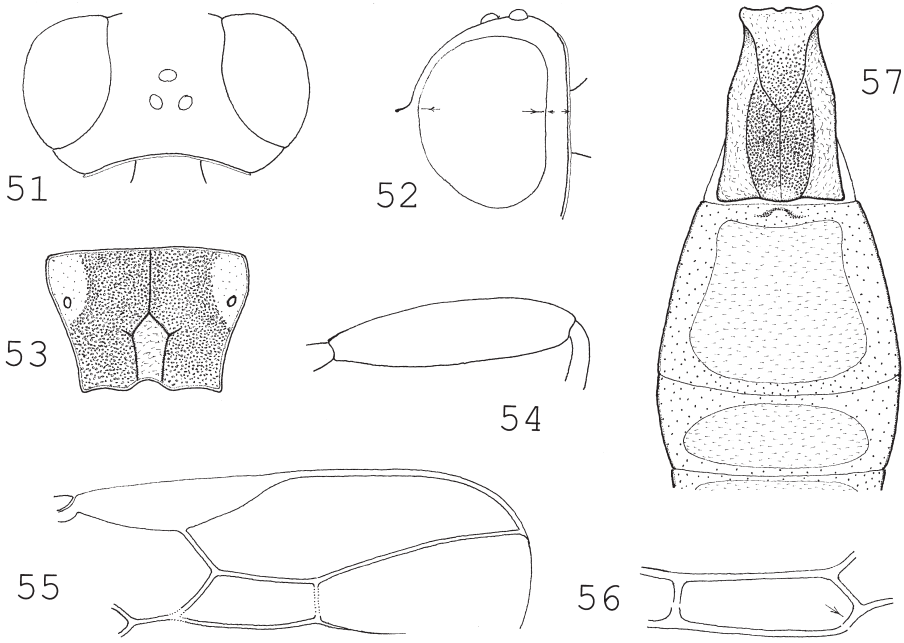
2(1) Fore wing: pterostigma wide, 2.6 times as long as wide, *r* 0.8 times as long as width of pterostigma, *2–M* short (Fig. 44). Eye in dorsal view 3.8 times as long as temple, temple slightly more receding, head in dorsal view clearly transverse, twice as broad as long (Fig. 41). Hind femur five times as long as broad distally (Fig. 42). First tergite hardly broadening posteriorly (Fig. 46). Antenna with 25 antennomeres. Ground colour of mesosoma blackish brown, head brownish yellow, occiput brown. ♀: 2.5 mm. – Colombia..... .....***Blacus (Tarpheion) latestigma* sp. n.**

**Taxonomic remark.** *Blacus (Tarpheion) erugatus* is known to the author by a pair of female specimens, their data: (a) Costa Rica, Puntar, Golfo Dulce, 24 km W Piedras-Blancas, 200 m, June–August 1989, leg. Hanson; (b) Costa Rica, Carthago Pr., La Cangreja, 1950 m, October 1991, leg. Hanson. Both females identified by S.R. Shaw in 1999 and in the Hungarian Natural History Museum (Budapest) by exchange of material. The species is new to the fauna of Costa Rica.

## Subfamily Rhysipolinae

***Pseudorhysipolis inaequalis* sp. n.**
urn:lsid:zoobank.org:act:8076B0BB-A892-4EF2-B203-345925A26426
http://species-id.net/wiki/Pseudorhysipolis_inaequalis
Figures 51–57

**Holotype ♀ and one paratype ♀:** COLOMBIA, Amazonas, PNN Amacayacu Mata-Mata, Malaise trap, 150 m, 2–15 October 2001, leg. D. Chota. M 2239. Holotype is




**Figures 51–57.** *Pseudorhysipolis inaequalis* sp. n.: **51** head in dorsal view **52** head in lateral view **53** propodeum **54** hind femur **55** distal part of right fore wing **56** first discal cell **57** tergites 1–3.

in good condition: (1) glued on a card point by its right meso- and metapleura, (2) left antenna broken, flagellum with 20 flagellomeres. Paratype is in fairly good condition: (1) glued on a card point by its right mesopleuron, (2) both antennae broken, right antenna with 16 and left antenna with 13 antennomeres, (3) right fore wing somewhat creased distally. Holotype in Boyacá, Colombia; one female paratype in Museum Budapest, Hym. Typ. No. 12021.

**Etymology.** The species name *inaequalis* refers to the unequal lengths of *3–SR* and *2–M* of the fore wing (Fig. 55).

**Description.** Body 3.3 mm long. Antenna (right one) somewhat longer than body and with 30 antennomeres. First flagellomere a little longer than second, first flagellomere 3.5 times as long as broad apically, subsequent flagellomeres shortening and attenuating so that penultimate flagellomere 3.6 times as long as broad. Head in dorsal view transverse (Fig. 51), almost 1.7 times as broad as long, eye fairly large: 7.5 times as long as temple, temple receding. Ocelli small, elliptic, OOL twice as long as POL. Eye in lateral view 1.3 times as high as wide and 5.4 times as wide as temple, beyond eye evenly wide (Fig. 52). Horizontal diameter of oral opening twice as long as shortest distance between opening and eye. Maxillary palp as long as height of head. Occipital carina completely removed from hypostomal carina. Face and gena smooth and shiny, vertex subgranulose, subshiny to matt.

Mesosoma in lateral view nearly twice as long as high. Mesoscutum, scutellum and propodeum granulose, otherwise mesosoma smooth and shiny. Pronope absent.

Notauli complete, deep, smooth. Prescutellar furrow crenulate. Precoxal suture weakly distinct, smooth. Propodeum granulose, with a medio-longitudinal carina dividing posteriorly, polished anterior to and around spiracles (Fig. 53). Hind femur 3.8 times as long as broad medially (Fig. 54). Inner apex of hind tibia with comb-like dense bristles (cf. Fig. 15 in Scatolini et al. 2002: 126). Pair of spines of hind tibia shorter than half length of basitarsus.

Fore wing as long as body. Pterostigma (Fig. 55) four times as long as wide and *r* issuing from its middle, somewhat longer than width of pterostigma (12:10). Second submarginal cell long, *3–SR* twice as long as *2–SR*; *SR1* faintly bent, slightly more than twice as long as *3–SR* and reaching tip of wing. Vein *r*, *2–SR* and *m–cu* equal in length. First subdiscal cell long, distally closed (Fig. 56, see arrow).

First tergite (Fig. 57) 1.5 times as long as broad posteriorly, weakly broadening posteriorly, dorsope distinct, pair of basal keels ending before middle of tergite, domed median part of tergite granulose. Second tergite quadrate, a little broader behind than long medially; tergites 2–4 largely weakly sclerotized or membranous (Fig. 57). Ovipositor sheath long, as long as mid tibia.

Scape and pedicel ochre, flagellum brown. Ground colour of head and mesosoma ochre; scutellum, propodeum and tergites brown. Mouthparts yellow, palps straw yellow. First tergite dark brown. Legs yellow, coxae and trochanters 1–2 straw yellow. Wings hyaline, pterostigma brownish, basally and apically yellow, veins yellowish to brownish.

**Paratype ♀.** Similar to the female holotype. Body 3.3 mm long. Head somewhat dark ochre.

**Male and host** unknown.

**Distribution.** Colombia.

**Diagnosis.** The new species, *Pseudorhysipolis inaequalis*, runs to *P. notaulicus* van Achterberg & Penteado-Dias in Scatolini et al.'s key (2002: 111–113) and belongs to the subgenus *Pararhysipolis;* the two species differ from each other by the features in the key (*P. notaulicus* is known to me by its original description: Scatolini et al. 2002: 111–113):

1(2) Fore wing: *3–SR* and *2–M* equal in length, i.e. second submarginal cell rectangular (Fig. 12 in Scatolini et al. 2002: 126). Eye in dorsal view 4.4 times as long as temple. First tergite 1.1 times as long as broad behind (on Fig. l.c. 1.25 times longer). Hind femur 4.4 times as long as broad. Pterostigma rather dark brown, mesoscutum black. ♀: 3.3 mm. – Brazil ..... ..... ***Pseudorhysipolis notaulicus*** **van Achterberg & Penteado-Dias, 2002**

2(1) Fore wing: *3–SR* 0.6 times as long as *2–M*, i.e. second submarginal cell usual in form (Fig. 55). Eye in dorsal view 7.5 times as long as temple (Fig. 51). First tergite 1.5 times as long as broad posteriorly (Fig. 57). Hind femur 3.8 times as long as broad (Fig. 54). Pterostigma basally yellow, mesoscutum ochre. ♀: 3.3 mm. – Colombia..... ***Pseudorhysipolis inaequalis*** **sp. n.**

## Acknowledgements

I am much indebted to the curators for their kindness to promote my taxonomic work by loaning type and other braconid material: Dr M. Fischer (Wien), Dr M. J. Sharkey (Lexington) and Dr S. R. Shaw (Laramie). Also my sincere thank should go to Dr. G. Broad (London) as peer referee considerably improved the content as well as the linguistic style of my paper.

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JHR 28: 85–121 (2012)
doi: 10.3897/JHR.28.3484
www.pensoft.net/journals/jhr

RESEARCH ARTICLE

JOURNAL OF Hymenoptera RESEARCH
A peer-reviewed open-access journal
The International Society of Hymenopterists

# *Colastomion* Baker (Braconidae, Rogadinae): nine new species from Papua New Guinea reared from Crambidae

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| *urn:lsid:zoobank.org:author:31771CB4-A88A-4BF6-ACF0-28F9564D2692*
¶ *urn:lsid:zoobank.org:author:3AC486D1-9045-44FB-9FE4-FF71A0C2909C*

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Academic editor: *Gavin Broad* | Received 7 July 2012 | Accepted 13 August 2012 | Published 24 August 2012

*urn:lsid:zoobank.org:pub:1352252C-D511-44A1-A2D0-B74E00C7D616*

**Citation:** Quicke DLJ, Smith MA, Miller SE, Hrcek J, Butcher B (2012) *Colastomion* Baker (Braconidae, Rogadinae): nine new species from Papua New Guinea reared from Crambidae. Journal of Hymenoptera Research 28: 85–121. doi: 10.3897/JHR.28.3484

## Abstract

Nine new species of *Colastomion* Baker are described, illustrated and keyed based on series of specimens reared from caterpillars of crambid moths from lowland Papua New Guinea plus one additional field collected specimen, viz. *C. cheesmanae* Quicke **sp. n.**, *C. crambidiphagus* Quicke **sp. n.**, *C. gregarius* Quicke **sp. n.**, *C. maclayi* Quicke sp. n., *C. madangensis* Quicke **sp. n.**, *C. masalaii* Quicke **sp. n.**, *C. parotiphagus* Quicke **sp. n.**, *C. pukpuk* Quicke **sp. n.** and *C. wanang* Quicke **sp. n.** Most species are morphologically easily distinguished but DNA barcoding additionally reveals a pair of exceedingly similar species (*C. pukpuk* **sp. n.** and *C. maclayi* **sp. n.**) that might otherwise have gone unrecognised. The new species each appear to be relatively specialised on their host species and all parasitize only caterpillars of Lepidoptera: Crambidae: Spilomelinae.

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**Keywords**
cytochrome oxidase I, DNA barcoding, Lepidoptera, hosts, Rogadini, Crambidae

## Introduction

*Colastomion* Baker (1917) is a relatively uncommon genus of rogadine parasitic wasp that occurs throughout the southern East Palaearctic, S. E. Asia and Africa. It belongs to a group of genera which additionally includes the tropical Old World genera *Cystomastacoides* van Achterberg, *Macrostomion* Szépligeti, *Megarhogas* Szépligeti and *Myocron* van Achterberg (1991) all of which share a more or less deep and ventrally strongly curved hypopyium with a strongly down-curved ovipositor (also present in various other SE Asian genera). Until recently nothing was known about its biology though *Macrostomion* has been reared from various Sphingidae caterpillars within which it is gregarious with 20–50 individuals typically emerging from a single mummified host larva (Shaw 2002, Maeto and Arakaki 2005).

To date, only six species of *Colastomion* have been described, viz. *C. abdominale* Baker (1917) from the Philippines, *C. bicoloricorne* (Granger 1949) from Madagascar, *C. concolor* (Szépligeti 1911) originally described from Tanzania and subsequently reported from Democratic Republic of Congo, Madagascar, Malawi and Togo (Yu et al. 2005), *C. formosanum* Watanabe (1932) originally described from Taiwan, but recently recorded from Japan (Tenma 2002), *C. nigricorne* (Granger 1949) and *C. tristis* (Granger 1949) both from Madagascar.

Here we describe nine new species of *Colastomion*, eight of which are based on reared specimens from caterpillars feeding on various trees and shrubs in lowland Papua New Guinea. These were obtained during an extensive caterpillar collecting and rearing programme which has additionally yielded a number of other interesting rogadine parasitoids including the recently described, highly distinctive genus *Vojtechirogas* Quicke & van Achterberg (Quicke et al. 2012).

The host records for some of the species include a degree of fuzziness because identifications are based on caterpillar morphology. The actual parasitized caterpillars of course never produce an adult moth, and so there is always some degree of uncertainty with host records acquired by rearing. Because in the course of the New Guinea rearing programme there were several hundred thousand caterpillars reared, we are able to quantify the inevitable uncertainty. For any reared specimen we present only host records which are at least 95% sure, i.e. at least 95% of the tens or hundreds of moth adults reared from the same combination of caterpillar morphotype and host plant as the parasitoid agree with the reported host identification. Two rearing records for *C. masalaii* sp. n. and *C. parotiphagus* sp. n. were confirmed by sequencing host remnants (Hrcek et al. 2011).

The systematics of several of the moth taxa involved here, all of which belong to the crambid subfamily Spilomelinae, is also far from complete and there is no meaningful phylogeny as yet. Thus some genera may well be poly- or paraphyletic assemblages, and in these cases we have sometimes been able to assign hosts to species groups, that in the future may shift into other generic combinations.

## Terminology

Terminology follows van Achterberg (1979, 1988). Measurements of the height and horizontal length of the eye are approximations because the very bulbous face and very large eyes make it difficult to measure consistently; in our attempts to do so, the head was orientated so that the face (defined as running from the anterior edge of the toruli to the dorsal margin of the clypeus) was horizontal or perpendicular to the measurement axis.

Abbreviations: NHM (The Natural History Museum, London); USNM (United States National Museum, Washington D.C.). Note, some paratypes will be repatriated to PNG when analysis is complete.

## Methodology

Phylogenetic inference and bar-coding discrimination of species were based upon maximum likelihood (ML) analysis of approximately 657 base pairs of the 5' end of the mitochondrial cytochrome oxidase I gene, using the programme *RAxML* (Stamatakis 2006) with the *GTRGAMMA* model and using a sequence from the related genus *Myocron* van Achterberg as outgroup. DNA sequencing was performed at the Biodiversity Institute of Ontario, University of Guelph, using their standard methods (Hrcek et al. 2011).

Most specimens were imaged using Cell^D® imaging facility. *C. gregarious* sp. n. and *C. cheesmanae* sp. n. were imaged using a Canon EOS 7D camera, Adobe Lightroom software and edited using Adobe Photoshop CS4.

## Results

DNA barcodes were generated from all but one of the species described below, the exception being a nearly 80 year old specimen found in the NHM collection. Fig. 1 shows a ML tree from these, with eight clearly separated molecular species, and intraspecific variation was limited to two individuals of *C. masalaii* sp. n. (vouchers USNM ENT 00503254 and 00643295) differing from the remainder at a single base position.

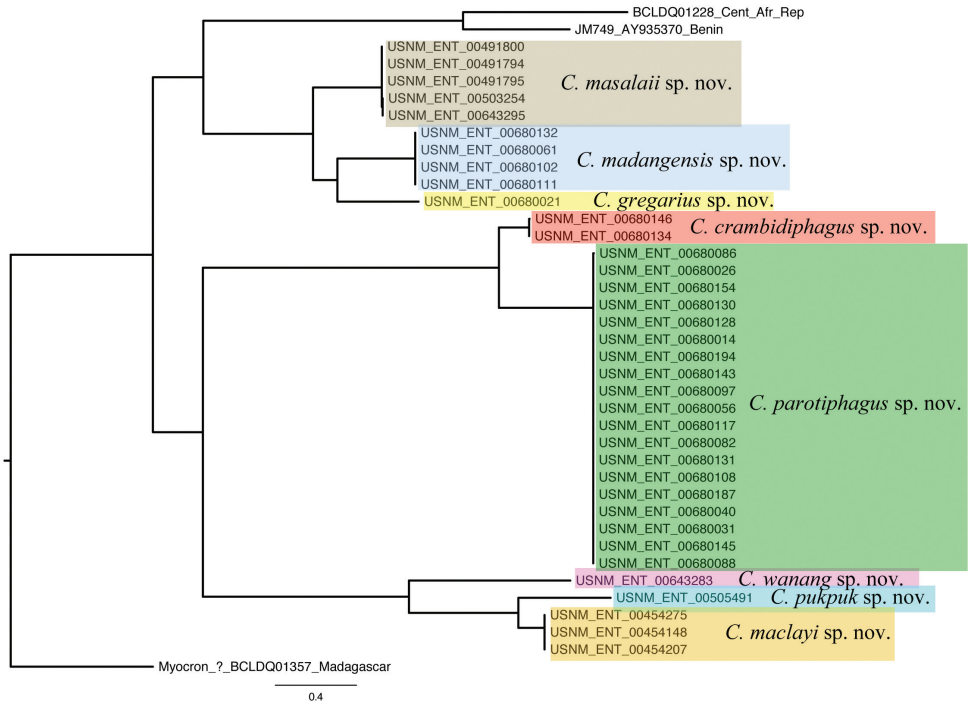



**Figure 1.** Maximum likelihood tree (using GTR+G parameter model) of the reared and barcoded species of *Colastomion* (final Gamma –based likelihood -2578.386754).

## Systematics

### Key to species

1 Fore wing vein cu-a antefurcal (Figs 5, 15, 21); propodeum with short mid-longitudinal carina anteriorly, giving rise to a midlongitudinal depression with transverse crenulae or transverse rugosity (Fig. 7); antenna with fewer than 42 [31–39] flagellomeres (Fig. 2); hind wing vein M+CU shorter [0.6–0.9 ×] than 1-M; largely yellow or yellow brown, metasoma the same colour as mesosoma ..... **2**

– Fore wing vein cu-a postfurcal; propodeum with a complete midlongitudinal carina or if incomplete, replaced by rugosity on posterior half; antenna with more than 43 [45–57]; flagellomeres; hind wing vein M+CU longer [1.1–2.5 ×] than 1-M; colour variable, sometimes metasoma black and cream contrasting with yellow-brown mesosoma ..... **4**

2 Antenna with fewer than 35 [32] flagellomeres (Fig. 2); 3rd segment of female maxillary palp distinctly swollen, approximately 4.5 × longer than maximally

wide; pterostigma entirely pale yellow (Fig. 2); mesosoma brown yellow dorsally with posterior of pronotum, mesopleuron, mesosternum and metapleuron whitish (Fig. 4) ..... ***C. gregarius* sp. n.**

– Antenna with more than 35 [37–40] flagellomeres; 3rd segment of female maxillary palp slender, approximately 7 × longer than maximally wide; pterostigma either bicolorous (Fig. 21) or entirely dark grey (Fig. 15); mesosoma unicolorous, either entirely pale yellow or brown yellow (Fig. 13) ..... **3**

3 Pterostigma largely dark brown; antenna largely dark brown (Fig. 15); fore wing vein cu-a strongly inclivous (Fig. 15) ..... ***C. masalaii* sp. n.**

– Pterostigma bicolorous, cream on basal 0.3 and on anterior margin, remainder brown (Fig. 21); antenna cream coloured; fore wing vein cu-a vertical (Fig. 21) ..... ***C. madangensis* sp. n.**

4 Metasoma almost entirely brown-yellow, sometimes with basal grooves of tergites brown medially (Figs 29, 30); 5th segment of female maxillary palp less than 0.6 [0.5 ×] 6th segment (Fig. 32) ..... **5**

– Metasomal tergites 3–4 largely black (Figs 39, 47, 51, 52); 5th segment of female maxillary palp more than 0.6 [0.7–0.9 ×] 6th segment (Fig. 54) ..... **6**

5 Flagellum entirely yellow; metasomal tergites 3–5 pale yellow with distinctly brown yellow mark narrowly mediobasally, tergite 6 somewhat more extensively brown yellow medially (Fig. 29) ..... ***C. crambidiphagus* sp. n.**

– Flagellum black on basal half becoming paler, sometimes yellow, from about middle to shortly before tip, contrasting strongly with pale yellow scapus and pedicellus (Fig. 31); metasomal tergites more or less evenly coloured pale yellow (Fig. 30) ..... ***C. parotiphagus* sp. n.**

6 Fore wing vein M+CU thickened up to near its middle and sharply narrowing and curved beyond this (Figs 41, 42) ..... ***C. wanang* sp. n.**

– Fore wing vein M+CU more or less evenly thick and straight or only weakly curved (Figs46, 50, 52) ..... **7**

7 Anterior of propodeum strongly sculptured, rugose (Fig. 47, see also Fig. 38); 2nd subdiscal cell rather widened distally, maximum length of cell membrane < 3.5 [3.1] × maximum width (see Fig. 41) ..... ***C. cheesmanae* sp. n.**

– Anterior of propodeum on either side of midlongitudinal carina largely smooth with punctures or at most with narrow crenulated groove next to carina (Figs 49, 54); 2nd subdiscal cell long and narrow, maximum length of cell membrane < 3.7 [4.0] × maximum width (Fig. 50) ..... **8**

8 1st tergite in lateral profile distinctly deeper near midlength (Fig. 55) ..... ..... ***C. pukpuk* sp. n.**

– 1st tergite in lateral profile deepest on anterior third and behind this flat or weakly depressed (Fig. 56) ..... ***C. maclayi* sp. n.**

## Descriptions of new species

### *Colastomion gregarius* Quicke, sp. n.

urn:lsid:zoobank.org:act:6C64E6C5-8CB9-48B3-9A92-1475E7779B24
http://species-id.net/wiki/Colastomion_gregarius
Figs 2–8

**Material examined.** Holotype female, Papua New Guinea, Madang Province, Wanang, 24-May-07, 145°10.910'E, 5°13.853'S, 100m, ex caterpillar on *Ficus variegata* Blume (Moraceae) (voucher USNM ENT 00680021; BOLD ASQSP084-08; Genbank JF963128) [furthest specimen from pin on topmost card] (USNM)

Paratypes. 4 males and 3 females, 1 unknown (missing metasoma), rest of reared series from the same parasitized host, mounted on total of 3 cards and on same pin as holotype. (USNM).

**Morphology.** Length of body 4.0–4.8 mm, of fore wing 3.0–3.6 mm and of antenna 5.1–5.2 mm.

*Head*. Antenna with 31–32 flagellomeres. Terminal flagellomere acuminate. Median flagellomeres approximately 2 × longer than wide. 3$^{rd}$ segment of maxillary palp of female weakly swollen, approximately 4.5 longer than maximally wide. 5$^{th}$ segment approximately same length as 6$^{th}$. Base of mandible well removed from eye, closest point approximately 1.3 distance from middle of anterior tentorial pit and eye. Distance between anterior tentorial pits approximately 2.7 × shortest distance between pit and eye. Width of face: width of head across eyes: height of eye = 1.0 : 2.25 : 1.3. Face rather shiny, with fine transverse striation laterally above level of clypeus. Shortest distance between posterior ocelli: transverse diameter of posterior ocellus: shortest distance between posterior ocellus and eye = 1.0: 1.2 : 1.4. Occipital carina broadly obliterated or extremely weak mediodorsally

*Mesosoma*. Notauli narrow, moderately impressed, crenulated. Mesoscutum longitudinally striate-rugulose at confluence of notauli. Mesopleuron largely smooth and shiny. Precoxal sulcus deeply impressed and strongly crenulate. Propodeum with very short midlongitudinal carina anteriorly that splits giving rise to pair of weak carinae bordering a widening midlongitudinal depression with moderately well developed transverse striation. Propodeum with distinct mediolateral projections.

*Fore wing*. Vein 1-CU1 antefurcal. Vein 2-CU1 6.0 × longer than 1-CU1. Vein 1-M weakly curved. Lengths of veins SR1: 3-SR: r = 6.0: 2.7 : 1.0. Vein 2-SR 1.0 × 2-SR+M.

*Hind wing*. Vein M+CU 0.9 × length of 1-M. Vein 2-SC+R thickened and distinctly inclivous. Vein SR moderately strongly curved on basal half, almost reaching wing margin approximately half distance to wing tip, then running more or less parallel to wing margin.

*Metasoma*. 1$^{st}$ metasomal tergite 1.7 × longer than posteriorly wide. 2nd metasomal tergite 1.6 × wider than long, with wide midbasal triangular area giving rise

**Figures 2–5.** *Colastomion gregarius* sp. n. light photomicrographs. **2** Habitus, lateral view **3** face **4** head and mesosoma, lateral view **5** basal venation of fore wing.

to weak midlongitudinal carina; rather weakly irregularly longitudinally striate with approximately 7 striate lateral to midlongitudinal carina. 3rd metasomal tergite 1.9 × wider than long; weakly irregularly longitudinally rugulose-striate basally and medially. $4^{th}$ - $6^{th}$ tergite s smooth.

**Coloration.** Body, legs, wing venation and antennae largely pale ochreous yellow with malar region, posteroventral part of pronotum, propleuron, mesopleuron and mesosternum, metapleuron, sides of tergites 2–6 and fore and mid coxa, trochanter and trochantellus whitish; terminal 6 or 7 flagellomeres dark grey-black.

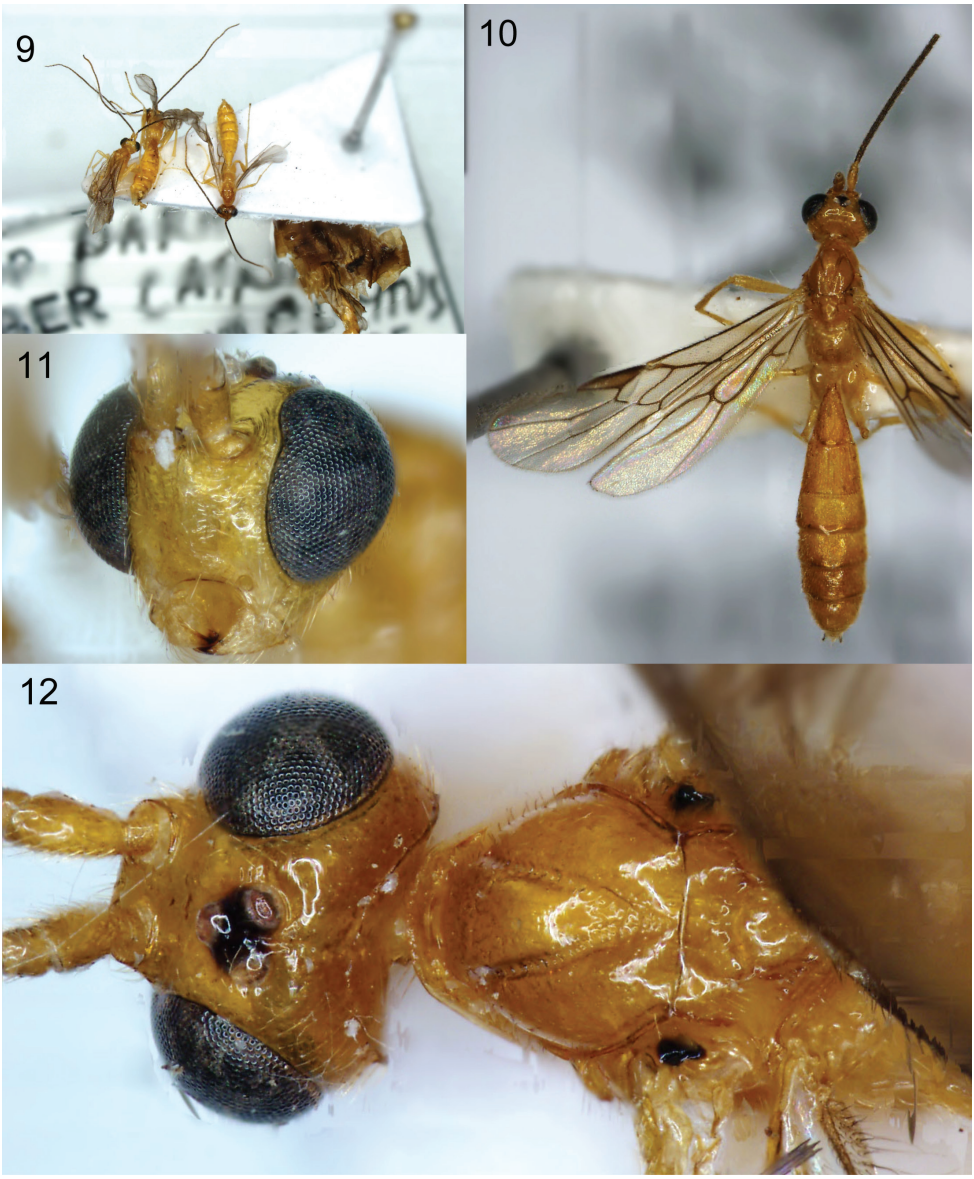
**Biology.** Gregarious parasitoid of *Glyphodes* near *stolalis.*

**Etymology.** Based on gregarious biology.

**Figures 6–8.** *Colastomion gregarius* sp. n. light photomicrographs. **6** Head and anterior mesosoma, dorsal view **7** propodeum **8** metasoma.

***Colastomion masalaii* Quicke, sp. n.**
urn:lsid:zoobank.org:act:0C6B94FD-975C-435A-A554-171939C4D138
http://species-id.net/wiki/Colastomion_masalaii
Figs 9–16

**Material examined.** Holotype female, East Sepik Province, Wamangu, 143°39.125'E, 03° 47.228'S, 100m, 30-Mar-05, ex caterpillar on *Ficus bernaysii* King (Moraceae),. (voucher USNM ENT 00503254; BOLD ASQSP055-08; Genbank JF271305) [fur-




**Figures 9–12.** *Colastomion masalaii* sp. n. holotype and paratypes, Cell^D® light photomicrographs. **9** Brood including holotype (furthest individual from pin on card) and two female paratypes **10** habitus, dorsal view **11** face, oblique view **12** head and mesosoma, dorsal view.

thest individual from pin on card]. Host remnants were sequenced (BOLD ASPN766-09, Genbank JF271356) and the sequence identified as *Glyphodes margaritaria.*

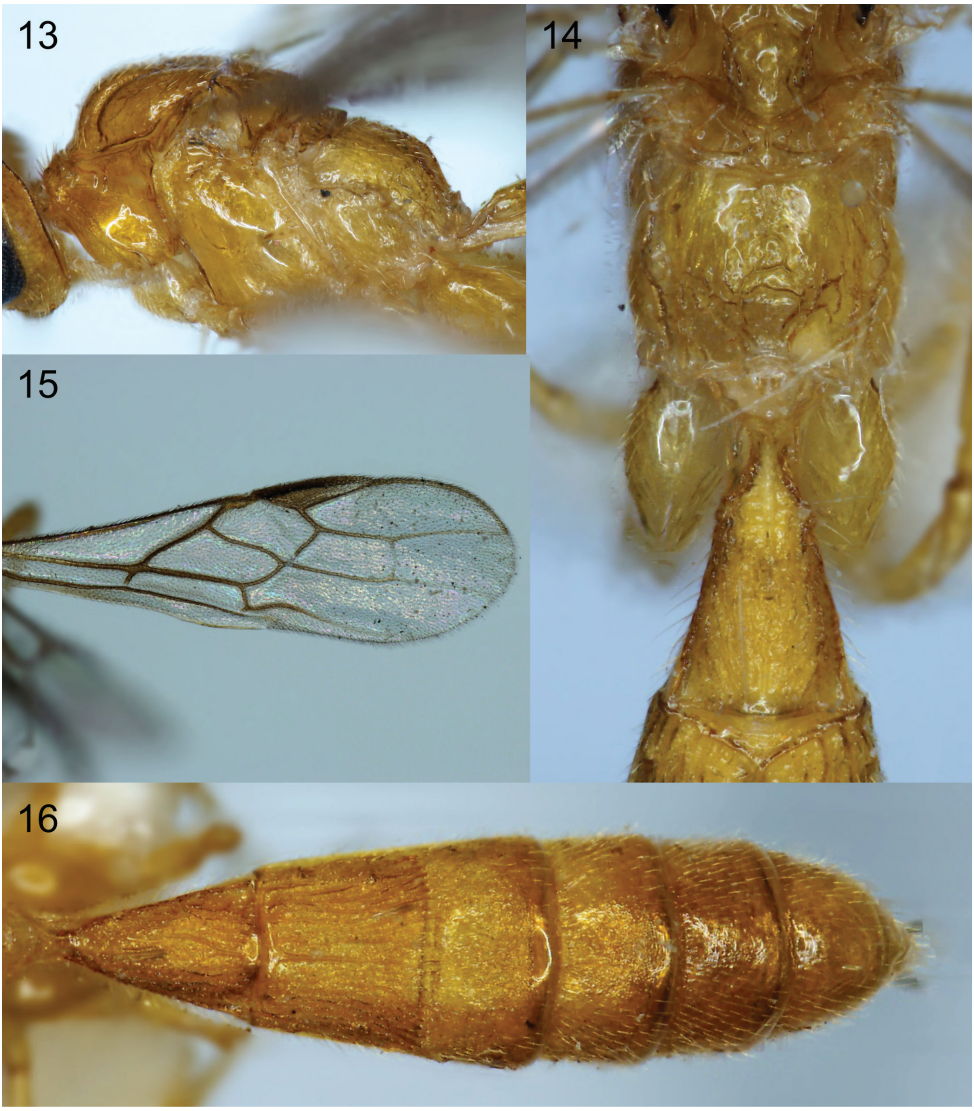
Paratypes. 2 additional females on same card and from same brood as holotype; see Table 1 for all data on 30 additional rearings totalling 33 paratypes. Specimens USNM ENT 00491800, USNM ENT 00491811 and USNM ENT 00648414 are deposited in the BMNH.

**Table 1.** Collection data, sex, host and host plant associations of paratypes of *Colastomion masalaii* sp. n.

| USNM ENT voucher number | BOLD process ID | Genbank accession number | No. and sex | Province | Locality[a] | Latitude and longitude | Collection date | Host identification | Host plant |
|---|---|---|---|---|---|---|---|---|---|
| 00209066 | - | - | 4F | Madang | Baitabag | 145°47'E, 5°08'S | 20-Nov-02 | Crambidae | *Ficus molior* F. Meull. ex Benth. (Moraceae) |
| 00211702 | - | - | 1F | East Sepik | Elem | 143°55'E, 4°49'S | 16-Apr-03 | Crambidae | *Ficus conocephalifolia* Ridley (Moraceae) |
| 00491773 | - | - | 1M | Sandaun | Utai | 141°35.153'E, 3°23.043'S | 28-Jul-04 | Crambidae | — ditto — |
| 00491774 | - | - | 1F | Sandaun | Utai | 141°35.153'E, 3°23.043'S | 28-Jul-04 | Crambidae | — ditto — |
| 00491775 | - | - | 1F | Sandaun | Utai | 141°35.153'E, 3°23.043'S | 28-Jul-04 | Crambidae | — ditto — |
| 00491776 | - | - | 1F | Sandaun | Utai | 141°35.153'E, 3°23.043'S | 28-Jul-04 | Crambidae | — ditto — |
| 00491790 | - | - | 1F | Sandaun | Utai | 141°35.153'E, 3°23.043'S | 28-Jul-04 | Crambidae | — ditto — |
| 00491794 | ASQSP126-08 | JF271307 | 1F | Sandaun | Utai | 141°35.153'E, 3°23.043'S | 28-Jul-04 | Crambidae | — ditto — |
| 00491795 | ASQSP125-08 | JF271308 | 1M | Sandaun | Utai | 141°35.153'E, 3°23.043'S | 28-Jul-04 | Crambidae | — ditto — |
| 00491799 | - | - | 1F | Sandaun | Utai | 141°35.153'E, 3°23.043'S | 28-Jul-04 | Crambidae | — ditto — |
| 00491800 | ASQSP128-08 | JF271306 | 1F | Sandaun | Utai | 141°35.153'E, 3°23.043'S | 28-Jul-04 | Crambidae | — ditto — |
| 00491801 | - | - | 1F | Sandaun | Utai | 141°35.153'E, 3°23.043'S | 30-Jul-04 | *Talanga sexpunctalis* complex | — ditto — |
| 00491807 | - | - | 1F | Sandaun | Utai | 141°35.153'E, 3°23.043'S | 28-Jul-04 | no host information | — ditto — |
| 00491808 | - | - | 1F | Sandaun | Utai | 141°35.153'E, 3°23.043'S | 28-Jul-04 | Crambidae | — ditto — |
| 00491809 | - | - | 1F | Sandaun | Utai | 141°35.153'E, 3°23.043'S | 28-Jul-04 | Crambidae | — ditto — |
| 00491810 | - | - | 1F | Sandaun | Utai | 141°35.153'E, 3°23.043'S | 28-Jul-04 | Crambidae | — ditto — |
| 00491811 | - | - | 1F | Sandaun | Utai | 141°35.153'E, 3°23.043'S | 28-Jul-04 | Crambidae | — ditto — |
| 00506254 | - | - | 4F | Madang | Ohu | 145°41'E, 5°14'S | 12-Jul-04 | *Glyphodes margaritaria* (Cramer) | *Ficus dammaropsis* Diels |
| 00643279 | - | - | 1F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 26-Apr-05 | Crambidae | *Ficus conocephalifolia* Ridley |
| 00643281 | - | - | 1F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 26-Apr-05 | Crambidae | — ditto — |
| 00643282 | - | - | 1F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 26-Apr-05 | Crambidae | — ditto — |

| USNM ENT voucher number | BOLD process ID | Genbank accession number | No. and sex | Province | Locality[a] | Latitude and longitude | Collection date | Host identification | Host plant |
|---|---|---|---|---|---|---|---|---|---|
| 00643285 | - | - | 1F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 26-Apr-05 | Crambidae | — ditto — |
| 00643293 | - | - | 1F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 26-Apr-05 | Crambidae | — ditto — |
| 00643294 | - | - | 1F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 26-Apr-05 | Crambidae | — ditto — |
| 00643295 | ASQSP059-08 | JF271309 | 1M | Madang | Wanang | 145°10.910'E, 5°13.853'S | 26-Apr-05 | Crambidae | — ditto — |
| 00643298 | - | - | 1F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 26-Apr-05 | Crambidae | — ditto — |
| 00643299 | - | - | 1F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 26-Apr-05 | Crambidae | — ditto — |
| 00648414 | - | - | 1F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 26-Apr-05 | Crambidae | — ditto — |
| 00648415 | - | - | 1F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 26-Apr-05 | Crambidae | — ditto — |
| 00648419 | - | - | 1F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 26-Apr-05 | Crambidae | — ditto — |

[a] Ohu is 200 m above mean sea level, other localities are 100 m above mean sea level




**Figures 13–16.** *Colastomion masalaii* sp. n. Cell^D® light photomicrographs. **13** Mesosoma, lateral view **14** propodeum and 1st tergite **15** fore wing **16** metasoma.

**Morphology.** Length of body 5.5–6.5 mm, of fore wing 48–5.0 mm and of antenna 7.0 mm.

*Head*. Antenna with 35–37 flagellomeres. Terminal flagellomere pointed, not or hardly acuminate. Median flagellomeres 1.8 × longer laterally than wide. 3rd segment of maxillary palp of female not swollen, approximately 7 × longer than maximally wide. 5th segment approximately 0.7 length of 6th. Base of mandible well separated from eye, closest point approximately 1.2 distance from middle of anterior tentorial pit and eye. Distance between anterior tentorial pits approximately 3.0 × shortest distance between pit

and eye. Width of face: width of head across eyes: height of eye = 1.0 : 2.3 : 1.3. Face with distinct transverse striation laterally. Frons with distinct pattern of elongate pits forming chevrons on either side of midlongitudinal sulcus. Shortest distance between posterior ocelli: transverse diameter of posterior ocellus: shortest distance between posterior ocellus and eye = 1.0: 1.6: 2.0. Occipital carina complete but irregular and weak mediodorsally

*Mesosoma*. Notauli more or less impressed along whole length, and crenulated, converging medioposteriorly and mesoscutum with some irregular rugosity at their confluence. Mesopleuron smooth and shiny. Precoxal sulcus strongly impressed, rather narrow, foveate. Propodeum with short midlongitudinal carina anteriorly that splits giving rise to a widening midlongitudinal depression with moderately well developed transverse striation. Propodeum with distinct mediolateral projections.

*Fore wing*. Vein 1-CU1 antefurcal. Vein 2-CU1 9 × longer than 1-CU1. Lengths of veins SR1: 3-SR: r = 5.5: 3.5: 1.0. Vein 2-SR 2.4 × 2-SR+M.

*Hind wing*. Vein M+CU 0.7 × length of 1-M.

*Metasoma*. 1st metasomal tergite 1.6–1.9 × longer than posteriorly wide. 2nd metasomal tergite 1.25 × wider than long, with well developed midbasal triangular area giving rise to weak midlongitudinal carina; irregularly longitudinally striate with approximately 15 striae lateral to midlongitudinal carina. 3rd metasomal tergite 1.9 × wider than long; longitudinally striate without distinct midlongitudinal carina. 4th - 6th tergites almost smooth.

*Coloration*. Body largely pale brown yellow; scapus and pedicellus yellow, flagellum largely black becoming more rufous distally; legs entirely pale brown yellow. Wing membrane hyaline, venation largely brown, pterostigma dark brown.

*Etymology*. Named after the local forest spirits called 'masalai' in Melanesian Pidgin.

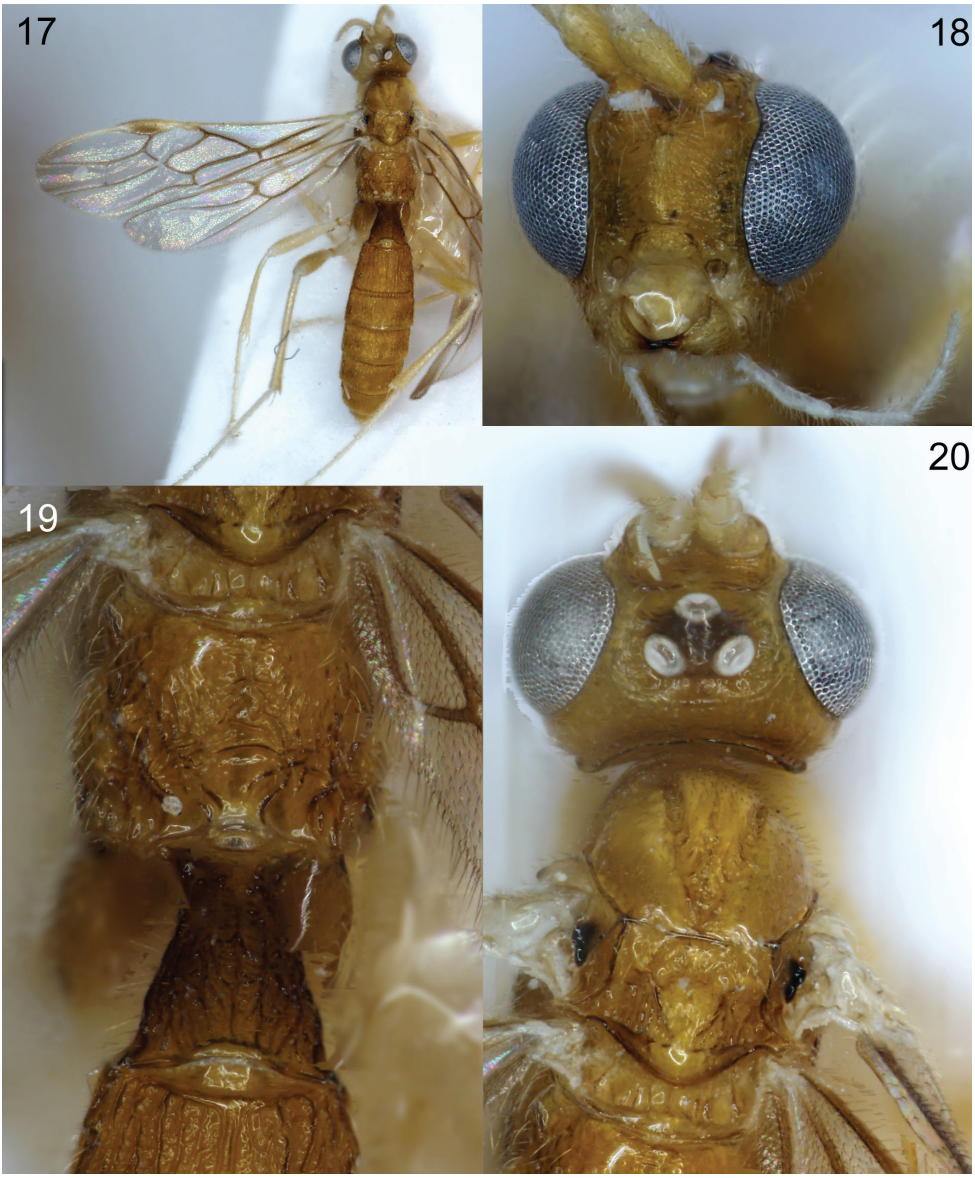
*Biology*. Solitary and gregarious (3 or 4 individuals per brood) endoparasitoids of *Talanga sexpunctalis* complex and *Glyphodes margaritaria* (Cramer) (both Crambidae) feeding on *Ficus* spp (Moraceae). *T. sexpunctalis* is usually considered a widespread species but appears to be a complex of species, including several in New Guinea (Craft et al. 2010: S2). *G. margaritaria* is a widespread species (Craft et al. 2010: 5043 and S2).

### ***Colastomion madangensis*** **Quicke, sp. n.**

urn:lsid:zoobank.org:act:F30DD23D-34AE-4663-AC71-0A520491E039
http://species-id.net/wiki/Colastomion_madangensis
Figures 17–22

**Material examined.** Holotype female, Papua New Guinea, Madang Province, Wanang, 24-May-07, 145°10.910'E, 5°13.853'S, 100m, ex caterpillar on *Ficus variegata* Blume (Moraceae) (vouchers USNM ENT 00680132; BOLD ASQSP177-08; Genbank JX034716) [individual furthest from pin on upper card] [host *Glyphodes* near *stolalis*].

Paratypes: 5 females, 2 males, from same brood as holotype, mounted on 3 cards on same pin; 6 females, 3 males mounted on 2 cards on same pin, Madang Province, Wanang, 10-May-06, 145°10.910'E, 5°13.853'S, 100m, ex caterpillar on *Ficus variegata* Blume, (voucher USNM ENT 00680061; BOLD ASQSP081-08; Genbank JF271301); 9 fe-




**Figures 17–20.** *Colastomion madangesis* sp. n. holotype, Cell^D® light photomicrographs. **17** Habitus, dorsal view **18** face, showing slender 3rd segment of maxillary palp **19** propodeum **20** head and anterior mesosoma, dorsal view.

males, 3 males, mounted on three cards on same pin, Madang Province, Wanang, 24-May-07, 145°10.910'E, 5°13.853'S, 100m, ex caterpillar on *Ficus variegata* Blume, Moraceae, (voucher USNM ENT 00680102; BOLD ASQSP083-08; Genbank JX034721) [host *Glyphodes* near *stolalis*]; 10 individals, Madang Province, Wanang, 10-May-06, 145°10.910'E, 5°13.853'S, 100m, ex caterpillar on *Ficus variegata* Blume, Moraceae, (voucher USNM ENT 00680111; BOLD ASQSP139-08; Genbank JX034722).

**Figures 21–22.** *Colastomion madangesis* sp. n. holotype, Cell^D® light photomicrographs. **21** Wings **22** metasoma.

**Morphology.** Length of body 4.3–5.5 mm, of fore wing 3.0–4.1 mm and of antenna 4.5–5.0 mm.

*Head*. Antenna with 35–39 flagellomeres. Terminal flagellomere acuminate. Median flagellomeres 2.3 × longer than wide. 3rd segment of maxillary palp of female slender, approximately 7 longer than maximally wide. 5th segment slender and approximately same length of 6th. Base of mandible well separated from eye, closest point approximately 1.1 distance from middle of anterior tentorial pit and eye. Distance be-

tween anterior tentorial pits approximately 5.2 × shortest distance between pit and eye. Width of face: width of head across eyes: height of eye = 1.0 : 2.25 : 1.36. Face laterally with well developed transverse rugosity. Shortest distance between posterior ocelli: transverse diameter of posterior ocellus: shortest distance between posterior ocellus and eye = 1.0: 1.0 : 1.0. Occipital carina complete but distinctly weak mediodorsally

*Mesosoma*. Notauli more or less strongly impressed and crenulated. Mesoscutum rugulose at confluence of notauli. Mesopleuron largely smooth and shiny. Precoxal sulcus strongly impressed, weakly sinuate, strongly finely crenulated. Propodeum with short midlongitudinal carina anteriorly that splits giving rise to a widening midlongitudinal depression with moderately well developed transverse striation.

*Fore wing*. Vein 1-CU1 antefurcal. Vein 2-CU1 7 × longer than 1-CU1. Vein 1-M weakly curved. Lengths of veins SR1: 3-SR: r = 4.5:2.7:1.0. Vein 2-SR 2.8 × 2-SR+M.

*Hind wing*. Vein M+CU 0.6 × length of 1-M. Vein 2-SC+R thickened, distinctly inclivous. Vein SR weakly curved on basal half, getting closest to wing margin approximately 0.6 distance to wing tip, then running more or less parallel to wing margin.

*Metasoma*. 1$^{st}$ metasomal tergite 1.4 × longer than posteriorly wide. 2nd metasomal tergite 1.35 × wider than medially long, with well developed midbasal triangular area giving rise to complete midlongitudinal carina; irregularly longitudinally striate with approximately 8 striate lateral to midlongitudinal carina. 3rd metasomal tergite 1.9 × wider than long; longitudinally striate, without distinct midlongitudinal carina. 4$^{th}$ tergite distinctly irregularly longitudinally striate, 5$^{th}$ tergite more weakly striate and largely only on basal 0.5; 6$^{th}$ tergite smooth.

*Coloration*. Body largely brown yellow, metasoma somewhat more reddish; antennae largely cream white, darkening to blackish near tip; fore legs entirely, mid- and hind legs from apex of coxa white. Wing membrane hyaline, venation largely brown, pterostigma largely brown, paler at base.

*Etymology*. Named in reference to the province where specimens were reared.

*Biology*. Gregarious parasitoid of *Glyphodes* near *stolalis* Guenee 1854, caterpillars: the broods reared comprised members of both sexes. *Glyphodes* near *stolalis* is a member of a species complex needing revision (Munroe 1996: 280), complicated by the type of *stolalis* being lost (Viette 1987) (Hrcek et al. 2011: supplement).

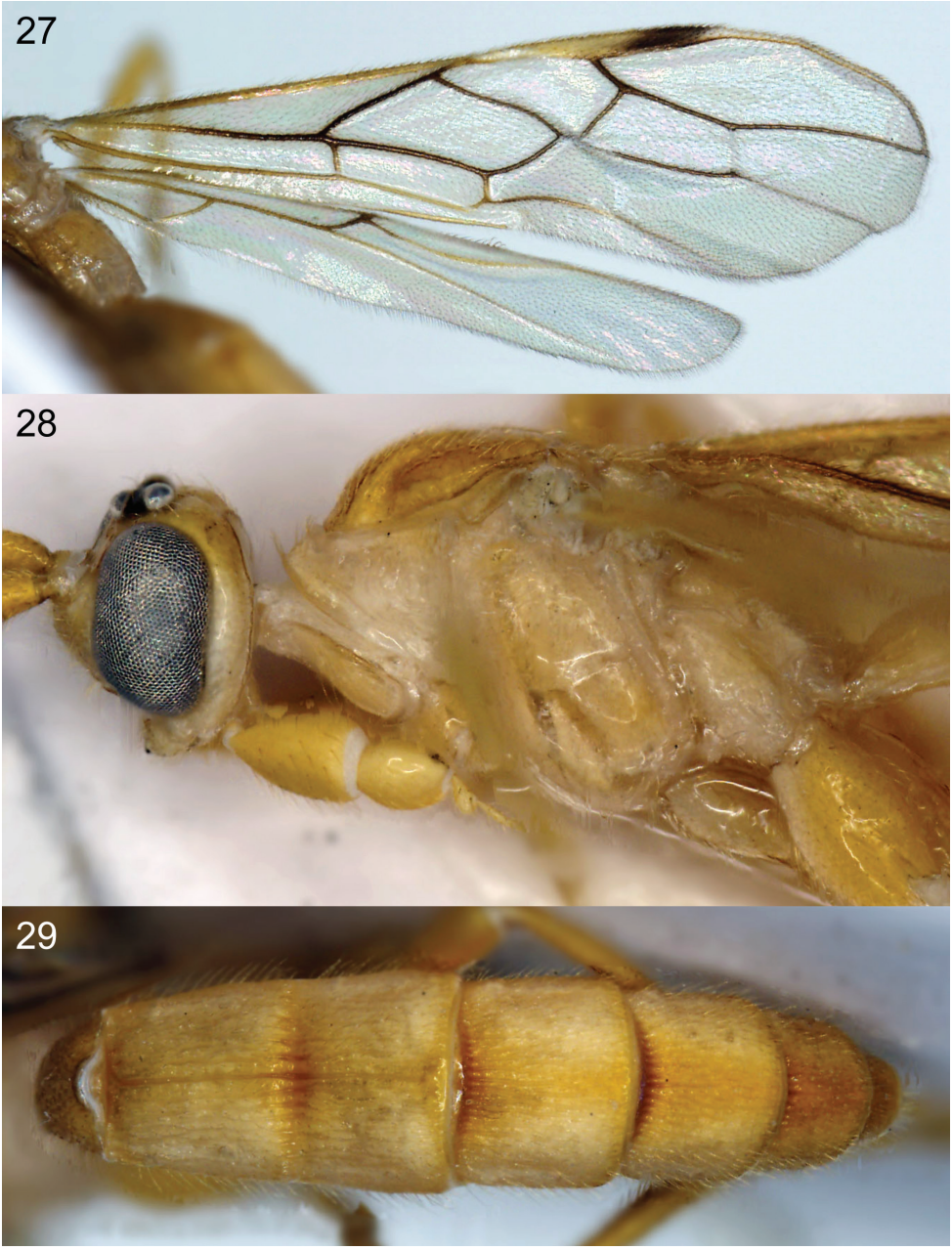
### ***Colastomion crambidiphagus*** **Quicke, sp. n.**

urn:lsid:zoobank.org:act:ACC78520-7B06-49C3-83D1-2701CC861913
http://species-id.net/wiki/Colastomion_crambidiphagus
Figs 23–29

**Material examined.** Holotype male, Papua New Guinea, Madang Province, Wanang, 12-Apr-07, 145°10.910'E, 5°13.853'S, 100m, WP-5E-2952, ex caterpillar on *Merremia peltata* (L.) Merr. (Convolvulaceae) (voucher USNM ENT 00680146; BOLD ASQSP086-08; Genbank JX034720).

**Figures 23–26.** *Colastomion crambidiphagus* sp. n. holotype, Cell^D® light photomicrographs. **23** Habitus, lateral view **24** face **25** head and anterior mesosoma, dorsal view **26** propodeum.

Paratypes: 1 female, Papua New Guinea, Madang Province, Wanang, 16-Feb-2007, 145°10.910'E, 5°13.853'S, 100m, ex caterpillar feeding on *Merremia peltata* (L.) Merr. (Convolvulaceae) (voucher USNM ENT 00680134; BOLD ASQSP135-08; Genbank JF963127); 1 female, Papua New Guinea, Madang Province, Wanang, 20-Jun-06, 145°10.910'E, 5°13.853'S, 100m, ex caterpillar feeding on *Merremia peltata* (L.) Merr. (Convolvulaceae) (voucher USNM ENT 00680173, no sequence data).




**Figures 27–29.** *Colastomion crambidiphagus* sp. n. holotype, Cell^D® light photomicrographs. **27** Wings **28** head and mesosoma, lateral view **29** metasoma.

**Morphology.** Length of body 6.0–8.5 mm, of fore wing 5.0–6.5 mm and of antenna 8.0–8.5 mm.

*Head*. Antenna with 45 flagellomeres. Terminal flagellomere strongly acuminate. Median flagellomeres approximately 2.5 × longer than wide. 3rd segment of maxillary palp of female swollen, approximately 4.0 longer than maximally wide. 5th segment reduced, approximately 0.5 length of 6th. Base of mandible separated from eye by approximately same distance as from middle of anterior tentorial pit and eye. Distance between anterior tentorial pits approximately 4.0 × shortest distance between pit and eye. Width of face: width of head across eyes: height of eye = 1.0 : 2.5 : 1.6. Face weakly transversely to obliquely striate dorsolaterally. Shortest distance between posterior ocelli: transverse diameter of posterior ocellus: shortest distance between posterior ocellus and eye = 1.0: 2.0 : 1.2. Occipital carina narrowly obliterated medially

*Mesosoma*. Notauli moderately deep, narrow and crenulated, uniting shortly before posterior of mesoscutum. Mesoscutum with distinct narrow midlongitudinal groove posteriorly. Propodeum with midlongitudinal carina at least on anterior 0.5, posteriorly either complete with strong transverse rugae lateral to it, or replaced by transverse rugosity.

*Fore wing*. Vein 1-CU1 postfurcal. Vein 2-CU1 18–19 × longer than 1-CU1. Lengths of veins SR1: 3-SR: r = 4.5 : 2.7 : 1.0. Vein 2-SR 2.1 × 2-SR+M.

*Hind wing*. Vein M+CU 1.1 × length of 1-M. Vein 1-SC+R slightly thickened, almost transverse. Vein SR strongly curved on basal half, almost reaching wing margin approximately half distance to wing tip, then running more or less parallel to wing margin.

*Metasoma*. 1st metasomal tergite 2.0 × longer than posteriorly wide. 2nd metasomal tergite 1.1 × longer than maximally wide, with well developed midbasal triangular area giving rise to complete midlongitudinal carina; irregularly longitudinally striate with approximately 6 striate lateral to midlongitudinal carina. 3rd metasomal tergite 1.1 × longer than maximally wide; longitudinally striate. 4th and 5th tergites longitudinally striate. 6th tergite smooth.

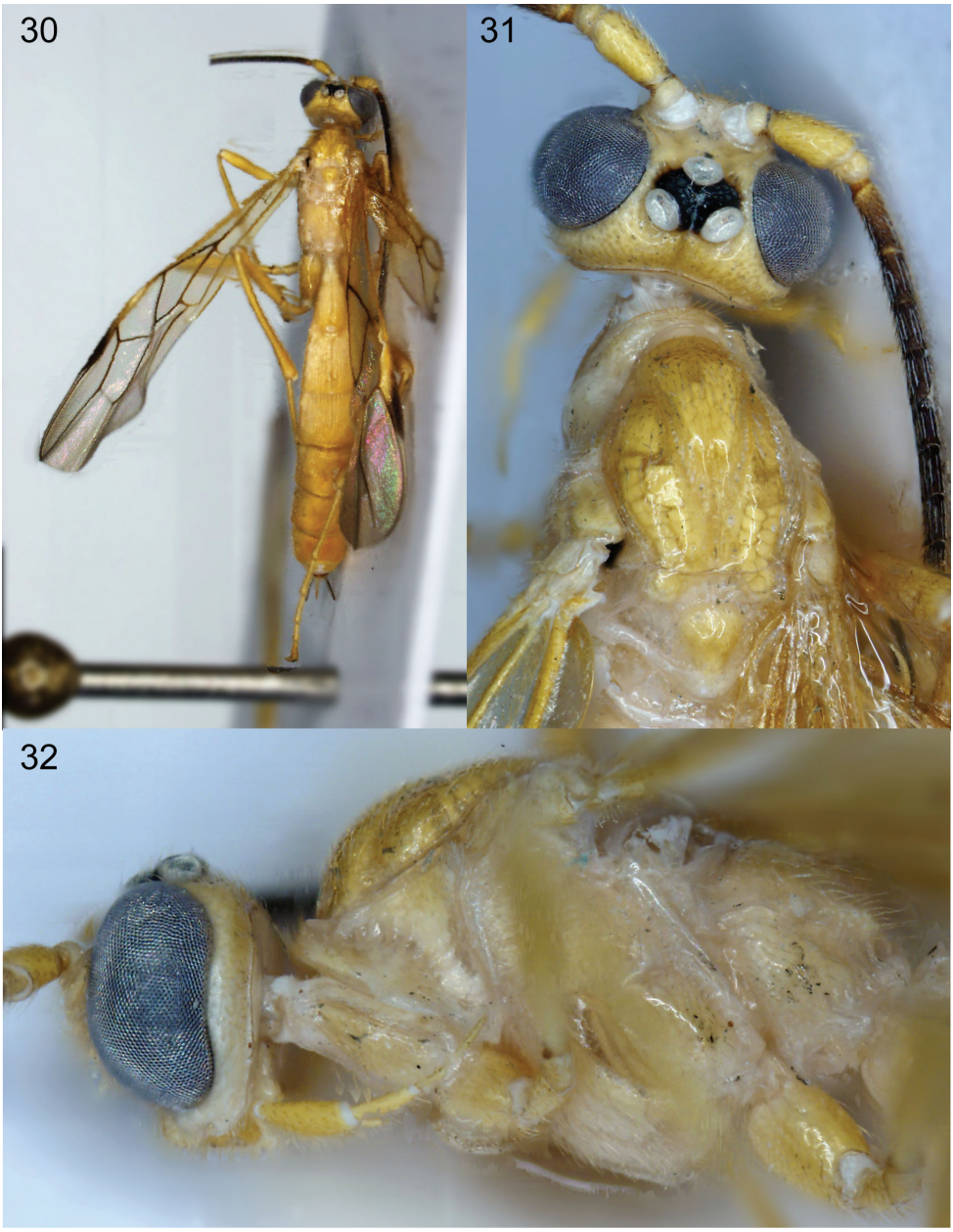
**Coloration.** Body.

**Etymology.** Named because of its parasitism of Crambidae.

**Biology.** Solitary endoparasitoids of Crambidae feeding on *Merremia peltata* (L.) Merr. (Convolvulaceae). The holotype was reared from *Hydriris guadealis* Rothschild. Paratype USNM ENT 00680134 was reared from *Tabidia insanalis* Snellen, and paratype USNM ENT 00680173 was reared from.a further unidentified crambid.

***Colastomion parotiphagus* Quicke, sp. n.**
urn:lsid:zoobank.org:act:BE5DD9B9-5DB2-4C52-A95C-ED2FE0E76FD0
http://species-id.net/wiki/Colastomion_parotiphagus
Figs 30–32

**Material examined.** Holotype male, Papua New Guinea, Madang Province, Wanang, 30-May-07, 145°10.910'E, 5°13.853'S, 100m, WS-2D-0932, ex caterpillar on *Sarcocephalus coadunatus* (Sm.) Druce (Rubiaceae), CATX043 (voucher USNM ENT




**Figures 30–32.** *Colastomion parotiphagus* sp. n. holotype, Cell^D® light photomicrographs. **30** Habitus, dorsal view **31** head and anterior mesosoma, dorsal view **32** head and mesosoma, lateral view.

00680014; BOLD ASQSP026-08; Genbank JX034709) [Host – *Parotis tricoloralis* (Pagenstecher)].

For details of 34 paratypes see Table 2.

For details of 34 paratypes see Table 2. Specimens USNM ENT 00680067, USNM ENT 00680154 and USNM ENT 00690187 are deposited in the BMNH.

**Morphology.** Length of body 6.2–9.5 mm, of fore wing 5.8–7.5 mm and of antenna 7.5–9.5 mm.

*Head*. Antenna with 50 flagellomeres. Terminal flagellomere acuminate. Median flagellomeres 2 × longer than wide. 3rd segment of maxillary palp of female distinctly swollen, approximately 3.5 × longer than maximally wide. 5th segment reduced and approximately half length of 6th. Base of mandible very close to eye, closest point approximately 0.2 distance from middle of anterior tentorial pit and eye. Distance between anterior tentorial pits approximately 5 × shortest distance between pit and eye. Width of face: width of head across eyes: height of eye = 1.0 : 2.5 : 1.6. Face transversely striate except for smooth triangular area above clypeus extending nearly to antennal sockets. Frons largely smooth but with well developed ridge running parallel to eye margin and reaching stemmaticum. Shortest distance between posterior ocelli: transverse diameter of posterior ocellus: shortest distance between posterior ocellus and eye = 1.5: 2.5:1.0. Occipital carina complete, well developed dorsally.

*Mesosoma*. Notauli deep, complete, finely punctate anteriorly becoming obliquely crenulated posteriorly, uniting to form groove before posterior margin of mesoscutum. Mesoscutum with an elongate groove between notauli anterior to the point of their fusion. Propodeum with complete midlongitudinal carina. Mesopleuron largely smooth. Precoxal sulcus narrow and deep on posterior half of mesopleuron, finely crenulated. Propodeum with complete midlongitudinal carina.

*Fore wing*. Vein 1-CU1 postfurcal. Vein 2-CU1 6.4 × longer than 1-CU1. Lengths of veins SR1: 3-SR: r = 4.0: 1.6 :1.0. Vein 2-SR 2.0 × 2-SR+M.

*Hind wing*. Vein M+CU 1.75 × length of 1-M. Vein 2-SC+R weakly thickened, distinctly reclivous. Vein SR strongly curved on basal half, almost reaching wing margin approximately half distance to wing tip, then distinctly diverging again towards wing tip.

*Metasoma*. 1st metasomal tergite 2.2 × longer than posteriorly wide. 2nd metasomal tergite as long as maximally wide, with well developed midbasal triangular area giving rise to complete midlongitudinal carina; irregularly longitudinally striate with approximately 8 striate lateral to midlongitudinal carina. 3rd metasomal tergite 1.4 × wider than long; longitudinally striate and with midlongitudinal carina more or less differentiated. 4th and 5th tergites longitudinally striate. 6th tergite smooth (faintly aciculate).

**Coloration.** Head and body ochreous yellow, stemmaticum black, hypopygium usually brown. Scapus and pedicellus bright yellow, contrasting with flagellum which is usually largely black but with variable paler brown-yellow to yellow zone from approximately middle to near the apex. Wing membrane yellowish on basal half, pale grey distally; pterostigma bicolorous, dark brown distally but with large yellow zone basally and posterobasally.

**Etymology.** Named after the known host genus.

**Biology.** Solitary larval endoparasitoids of *Parotis tricoloralis* (Pagenstecher) (Crambidae), *Parotis hilaralis* (Walker) (Crambidae) and *Haritalodes adjunctalis* Leraut (Crambidae).

**Table 2.** Collection data, sex, host and host plant associations of paratypes of *Colastomion parotiphagus* sp. n.

| USNM ENT voucher number | BOLD process ID | Genbank accession number | Sex | Province | Locality[a] | Latitude and longitude | Collection date | Host identification | Host plant |
|---|---|---|---|---|---|---|---|---|---|
| 00206476 | - | - | F | Madang | Baitabag | 145°47'E, 5°08'S | 04-Jun-02 | *Haritalodes adjunctalis* Leraut | *Hibiscus tiliaceus* L. (Malvaceae) |
| 00680001 | - | - | M | Madang | Wanang | 145°10.910'E, 5°13.853'S | 30-May-07 | *Parotis tricoloralis* (Pag.) | *Sarcocephalus coadunatus* (Sm.) Druce (Rubiaceae) |
| 00680023 | - | - | F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 23-May-07 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680026 | ASQSP094-08 | JX034711 | M | Madang | Wanang | 145°10.910'E, 5°13.853'S | 30-May-07 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680031 | ASQSP090-08 | JX034723 | M | Madang | Wanang | 145°10.910'E, 5°13.853'S | 30-May-07 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680035 | - | - | F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 24-Feb-06 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680040 | ASQSP137-08 | JX034713 | M | Madang | Wanang | 145°10.910'E, 5°13.853'S | 30-May-07 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680056 | ASQSP018-08 | JF271317 | M | Madang | Wanang | 145°10.910'E, 5°13.853'S | 23-May-07 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680057 | - | - | F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 30-May-07 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680060 | - | - | M | Madang | Wanang | 145°10.910'E, 5°13.853'S | 30-May-07 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680067 | - | - | M | Madang | Wanang | 145°10.910'E, 5°13.853'S | 23-Feb-06 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680075 | - | - | F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 12-May-06 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680082 | ASQSP091-0 | JX034710 | M | Madang | Wanang | 145°10.910'E, 5°13.853'S | 30-May-07 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680085 | - | - | ? | Madang | Wanang | 145°10.910'E, 5°13.853'S | 30-May-07 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680086 | ASQSP089-08 | JX034714 | F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 30-May-07 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680088 | ASQSP092-08 | JX034718 | F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 30-May-07 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680093 | - | - | M | Madang | Wanang | 145°10.910'E, 5°13.853'S | 30-May-07 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680097 | ASQSP020-08 | JF271315 | F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 30-May-07 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680103 | - | - | M | Madang | Wanang | 145°10.910'E, 5°13.853'S | 30-May-07 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680106 | - | - | | Madang | Wanang | 145°10.910'E, 5°13.853'S | 30-May-07 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680108 | ASQSP136-08 | JX034717 | M | Madang | Wanang | 145°10.910'E, 5°13.853'S | 13-May-06 | most likely *Parotis* | — ditto — |
| 00680117 | ASQSP082-08 | JF963129 | F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 30-May-07 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680124 | - | - | M | Madang | Wanang | 145°10.910'E, 5°13.853'S | 12-May-06 | *Parotis tricoloralis* (Pag.) | — ditto — |

| USNM ENT voucher number | BOLD process ID | Genbank accession number | Sex | Province | Locality[a] | Latitude and longitude | Collection date | Host identification | Host plant |
|---|---|---|---|---|---|---|---|---|---|
| 00680128 | ASQSP025-08 | JF271314 | ? | Madang | Wanang | 145°10.910'E, 5°13.853'S | 23-May-07 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680130 | ASQSP027-08 | JX034715 | F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 21-Jun-07 | no host information | *Actinodaphne nitida* Teschn. (Lauraceae) |
| 00680131 | ASQSP138-08 | JF271318 | F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 30-May-07 | *Parotis tricoloralis* (Pag.) | *Sarcocephalus coadunatus* (Sm.) Druce (Rubiaceae) |
| 00680142 | - | - | ? | Madang | Wanang | 145°10.910'E, 5°13.853'S | 31-May-07 | No host information | *Trema orientalis* (L.) Blume (Ulmaceae) |
| 00680143 | ASQSP019-08 | JF271316 | M | Madang | Wanang | 145°10.910'E, 5°13.853'S | 30-May-07 | *Parotis tricoloralis* (Pag.) | *Sarcocephalus coadunatus* (Sm.) Druce (Rubiaceae) |
| 00680145 | ASQSP032-08 | JX034708 | M | Madang | Wanang | 145°10.910'E, 5°13.853'S | 30-May-07 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680148 | - | - | M | Madang | Wanang | 145°10.910'E, 5°13.853'S | 30-May-07 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680154 | ASQSP093-08 | JX034712 | F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 12-May-06 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680176 | - | - | ? | Madang | Wanang | 145°10.910'E, 5°13.853'S | 7-Mar-07 | most likely *Parotis* | — ditto — |
| 00680187 | ASQSP130-08 | JX034719 | M | Madang | Wanang | 145°10.910'E, 5°13.853'S | 18-Apr-06 | *Parotis tricoloralis* (Pag.) | — ditto — |
| 00680194 | ASQSP181-08 | JF271319 | F | Madang | Wanang | 145°10.910'E, 5°13.853'S | 13-May-06 | *Parotis hilaralis* (Walker) (host sequence: ASPN768-09; Genbank JF271498) | — ditto — |

[a] Both localities are 100m above mean sea level

***Colastomion wanang* Quicke, sp. n.**
urn:lsid:zoobank.org:act:EDAACAC2-0645-45D7-860F-2C959EFE4D0F
http://species-id.net/wiki/Colastomion_wanang
Figs 33–41

**Material examined.** Holotype female, Papua New Guinea, Madang Province, Wanang, 29-Apr-05, 145°10.910'E, 5°13.853'S, 100m, SSW, ex caterpillar on *Syzigium longipes* (Warb.) Merrill & Perry (Myrtaceae), Mark (voucher USNM ENT 00643283; BOLD ASQSP063-08; Genbank JF271302). [see *Notes* on possible conspecifics excluded from type series].

**Morphology.** Length of body 12 mm, of fore wing 8.8 mm.

*Head*. Antenna with 56–57 flagellomeres. Terminal flagellomere acuminate. Median flagellomeres approximately 2 × longer than wide. 3rd segment of maxillary palp of female weakly swollen, approximately 6 longer than maximally wide. 5th segment approximately 0.8 length of 6th. Base of mandible very close to eye, closest point approximately same as distance from middle of anterior tentorial pit and eye. Distance between anterior tentorial pits approximately 10 × shortest distance between pit and eye. Width of face: width of head across eyes: height of eye = 1.0 : 3.3 : 2.0. Face with coarse transverse striae ventrolaterally, becoming finer and reaching near to midline dorsally. Frons with rather well developed ridge paralleling margin of eye; generally with weak sublongitudinal sculpture Shortest distance between posterior ocelli: transverse diameter of posterior ocellus: shortest distance between posterior ocellus and eye = 1.0: 3.5: 1.7. Occiput with deep crescent-shaped depressions behind posterior ocelli; with only weak midlongitudinal groove. Occipital carina complete and strongly lamelliform.

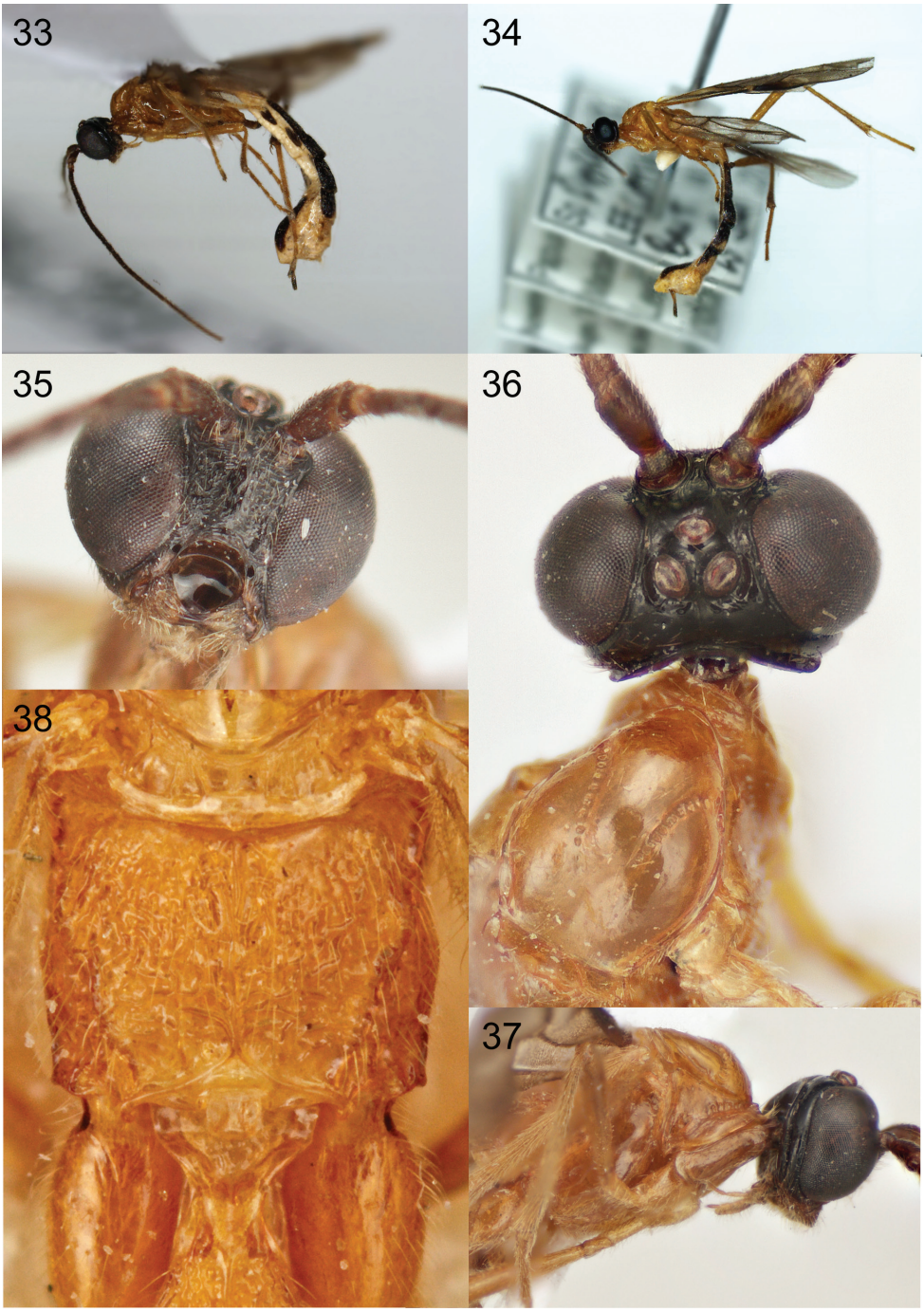
*Mesosoma*. Notauli weakly impressed anteriorly, dorsally crenulated to foveate as impressions get weaker. Mesoscutum smooth where notauli converge. Mesopleuron smooth and shiny. Precoxal sulcus strongly impressed, rather narrow, smooth. Propodeum with complete midlongitudinal carina.

*Fore wing*. Vein 1-CU1 postfurcal. Vein 2-CU1 5.8 × longer than 1-CU1. Vein 1-M weakly curved near base. Lengths of veins SR1: 3-SR: r = 3.5:2.7:1.0. Vein 2-SR 4 × 2-SR+M.

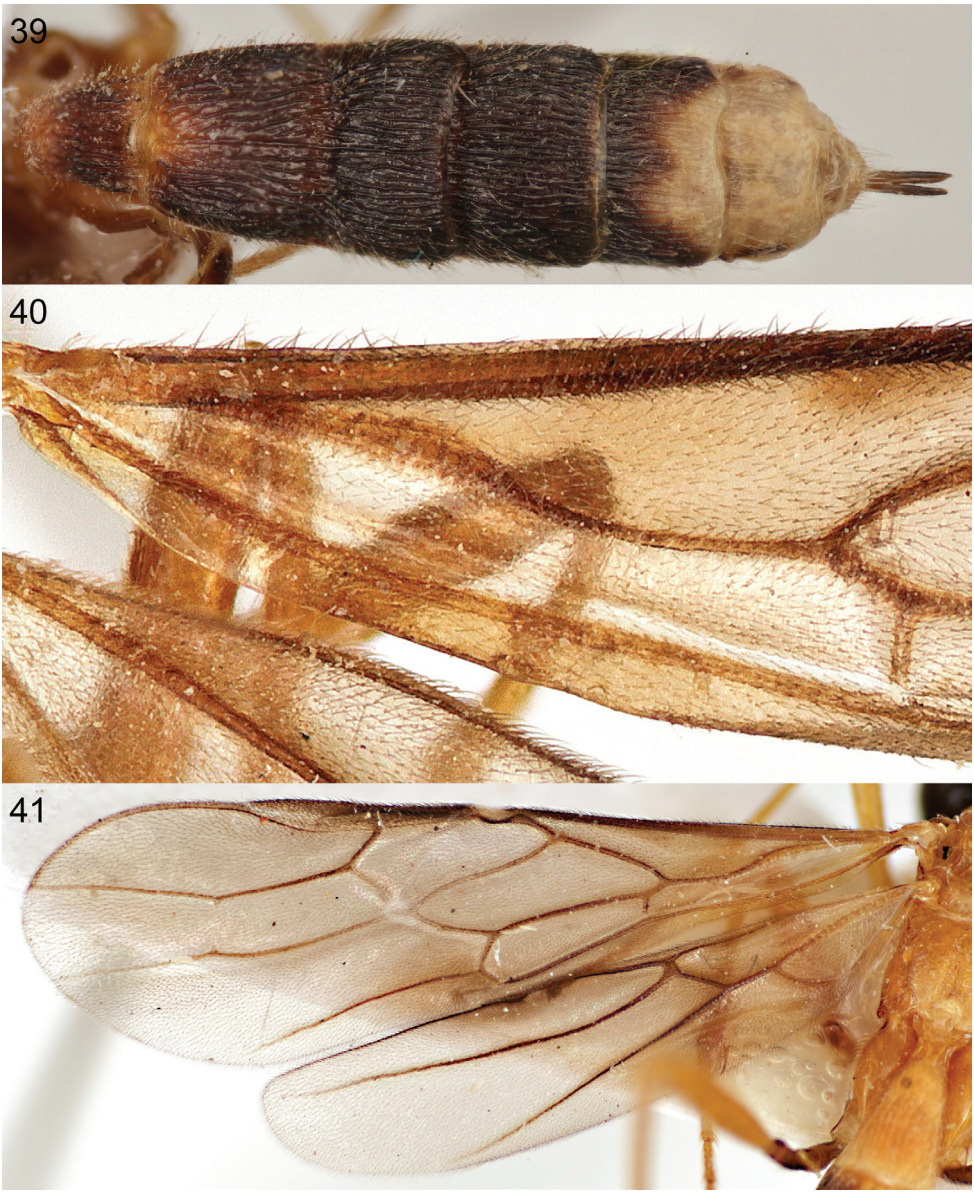
*Hind wing*. Vein M+CU 2.5 × length of 1-M. Vein 2-SC+R very thick, short transverse. Vein SR gently curving basally and gradually getting closer to anterior margin towards wing tip.

*Metasoma*. 1st metasomal tergite 2.0 × longer than posteriorly wide. 2nd metasomal tergite 1.1 × wider than long, with well developed midbasal triangular area giving rise to complete midlongitudinal carina; irregularly longitudinally striate with approximately 7 striate lateral to midlongitudinal carina. 3rd metasomal tergite 1.3 × longer than maximally wide; longitudinally striate. 4th and 5th tergites entirely coarsely longitudinally striate. 6th tergite faintly aciculate.

**Coloration.** Head, hind trochanter and trochantellus and metasomal tergites 1–4 (largely) black, tergite 5 black basally and laterally, hind tibia dark brown to black,




**Figures 33–38.** *Colastomion wanang* sp. n. **33, 34** Holotype female and putatively conspecific individual (USNM ENT 00206919) habitus respectively. **35** face of holotype **36** head and anterior mesosoma of holotype, dorsal view **37** head and anterior mesosoma of holotype, lateral view **38** propodeum of putatively conspecific individual (USNM ENT 00452009).




**Figures 39–41.** *Colastomion wanang* sp. n. **39** Metasomal tergites of holotype **40** base of fore wing of holotype showing distinctive thickening and sudden curving of vein M+CU **41** wings of putatively conspecific individual (USNM ENT 00452009).

mesosoma and rest of legs orange red, metasomal tergites 5 medioposteriorly and tergite 6 largely cream white. Wings largely pale brown with dark brown venation, pterostigma entirely dark brown.

**Etymology.** Named after collection locality as a noun in apposition.

**Biology.** Host unknown for holotype.

**Notes.** Four specimens with host data from a different locality and host tree but lacking barcoding data probably belong to this species but are excluded for the above reason from the type series. We can find no convincing morphological difference between them and the holotype of *C. wanang* sp. n. though they do have the 1st metasomal tergite largely orange. Their collection data are:

Papua New Guinea, Madang Province, Baitabag, 23-Jul-02, 145°47'E, 5°08'S, 100m, Ulai ex caterpillar on *Leea indica* Merrill (Vitaceae) (voucher USNM ENT 00206919); 1 male, Madang, Baitabag, 23-Jan-04, 145°47'E, 5°08'S, 100m, ex caterpillar on *Leea indica* Merrill (Vitaceae) (voucher USNM ENT 00452009); 1 male, Madang Province, Mis, 1-Aug-02, 145°47'E, 5°11'S, 50m, ex caterpillar on *Leea indica* Merrill, Vitaceae, David (voucher USNM ENT 00206716)**;** 1 female [metasoma missing but palps not swollen], Madang Province, Mis, 23-Jul-02, 145°47'E, 5°11'S, 50m (voucher USNM ENT 00206736). These four specimens were solitary larval endoparasitoids of one or both of two similar species which are superficially similar to "*Syllepte*" *crotonalis* Walker (CRAM078, Genbank GU695707 and CRAM092, Genbank GU695702). The genus *Syllepte* has accumulated many unrelated brown moths, and needs revision, so the correct generic name is also unclear.

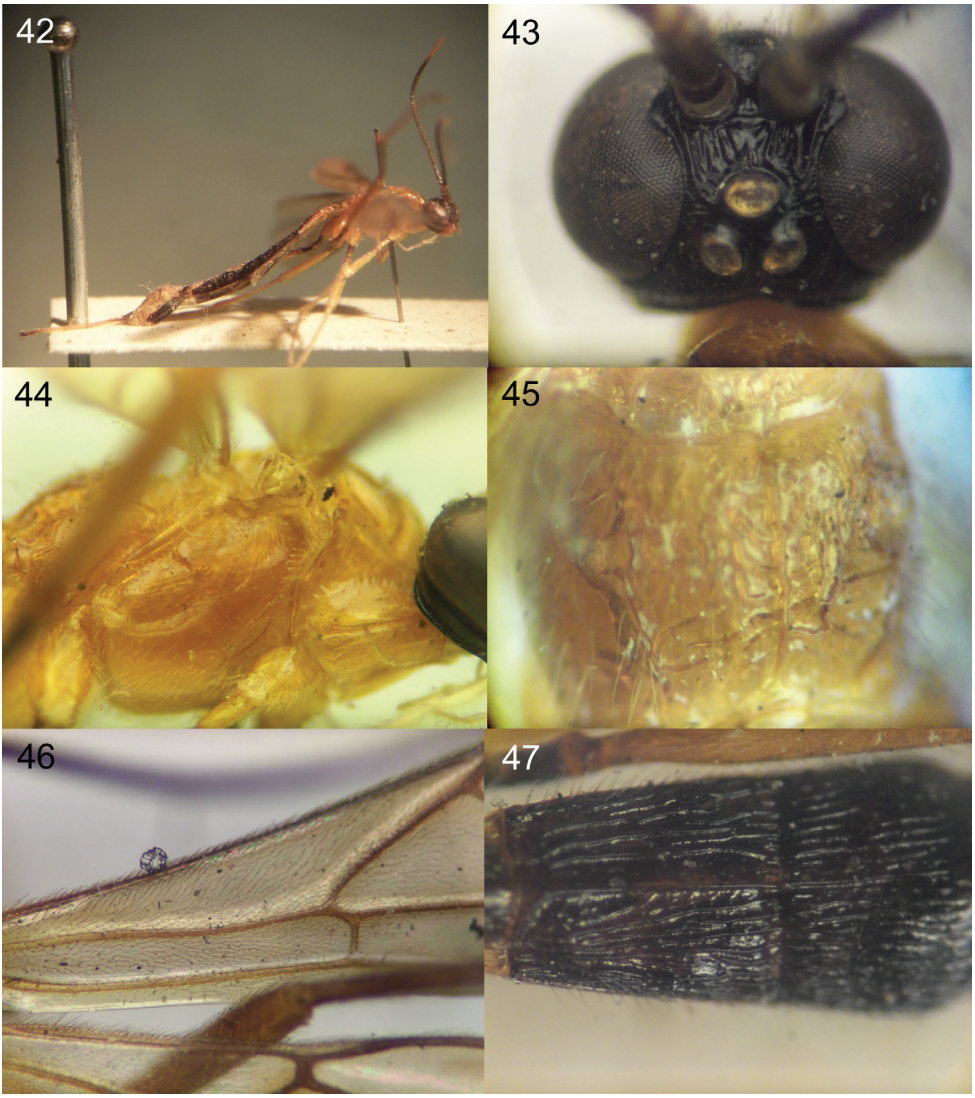
***Colastomion cheesmanae*** **Quicke, sp. n.**
urn:lsid:zoobank.org:act:757380FD-963E-4583-A8AC-44FD96ABCB19
http://species-id.net/wiki/Colastomion_cheesmanae
Figs 42–47

**Material examined.** Holotype female, Papua New Guinea, Oro Province, Kokoda, iv.1933, 1200ft [= 365 m], L. E. Cheesman (NHM).

**Morphology.** Length of body 11 mm, of fore wing 8.5 mm and of antenna 9.2 mm.

*Head*. Antenna with 55 flagellomeres. Terminal flagellomere acuminate. Median flagellomeres approximately 2 × longer than wide. 3rd segment of maxillary palp of female rather slender, approximately 5 longer than maximally wide. 5th segment 1.5 × length of 6th. Base of mandible well very close to eye, closest point approximately same distance as from middle of anterior tentorial pit and eye. Distance between anterior tentorial pits approximately 6 × shortest distance between pit and eye. Width of face: width of head across eyes: height of eye = 1.0 : 3.1 : 2.2. Face rather shiny, with quite strong diagonal striation laterally above level of clypeus. Shortest distance between posterior ocelli: transverse diameter of posterior ocellus: shortest distance between posterior ocellus and eye = 1.0: 2.5 : 1.4. Occipital carina complete mediodorsally

*Mesosoma*. Notauli narrow, weakly impressed, finely crenulated anteriorly becoming more foveate posteriorly. Mesoscutum smooth and broadly depressed at confluence of notauli. Mesopleuron largely smooth and shiny. Precoxal sulcus deeply, narrow, weakly crenulate. Propodeum with complete midlongitudinal carina and largely rugose with only narrow smooth and punctate area submedially anteriorly. Propodeum evenly rounded, without mediolateral projections.




**Figures 42–47.** *Colastomion cheesmanae* sp. n. light photomicrographs of holotype **42** Habitus, lateral view **43** head dorsal view **44** mesosoma, lateral view **45** propodeum **46** basal half of fore wing **47** metasomal tergites **2** and 3.

*Fore wing*. Vein M+CU distinctly though weakly curved on distal half, but not thickened medially. Vein 1-CU1 postfurcal. Vein 2-CU1 8.5 × longer than 1-CU1. Vein 1-M moderately strongly curved posteriorly. Vein 1-SR+M strongly bisinuate. Lengths of veins SR1: 3-SR: r = 5.0: 4.3: 1.0. Vein 2-SR 3.5 × 2-SR+M.

*Hind wing*. Vein M+CU 1.75 × length of 1-M. Vein 2-SC+R strongly thickened, vertical. Vein SR gently curving basally and gradually getting closer to anterior margin towards wing tip.

*Metasoma*. 1st metasomal tergite 2.1 × longer than posteriorly wide. 2nd metasomal tergite 1.1 × wider than long, with wide midbasal triangular area giving rise to weak midlongitudinal carina; rather weakly irregularly longitudinally striate with approximately 9 striate lateral to midlongitudinal carina. 3rd metasomal tergite 1.2 × wider than long; longitudinally striate. 4th and basal 0.6 of 5th tergites coarsely longitudinally striate, posterior of tergite 5 and all of tergite 6 smooth.

**Coloration.** Head, hind trochanter and trochantellus and metasomal tergite 1 posteriorly, 2–4 entirely, anterior half of tergite 5, and extreme base of tergite 6 black, hind tibia dark brown, mesosoma and rest of legs orange red, metasomal tergites 5 posteriorly and 6 largely cream-white. Antenna largely black with a distinct brown-yellow zone occupying flagellomeres 22–34. Wing membrane largely pale brown, venation largely (except more basal veins, dark brown; pterostigma dark brown.

**Biology.** Unknown.

**Etymology.** Named in honour of Miss L. E. Cheesman who collected much interesting material in New Guinea in expeditions in the 1930s (see Kimmins 1962).

**Notes.** Very similar to *C. wanang* sp. n. except lacks the thickened and strongly curved fore wing vein M+CU.

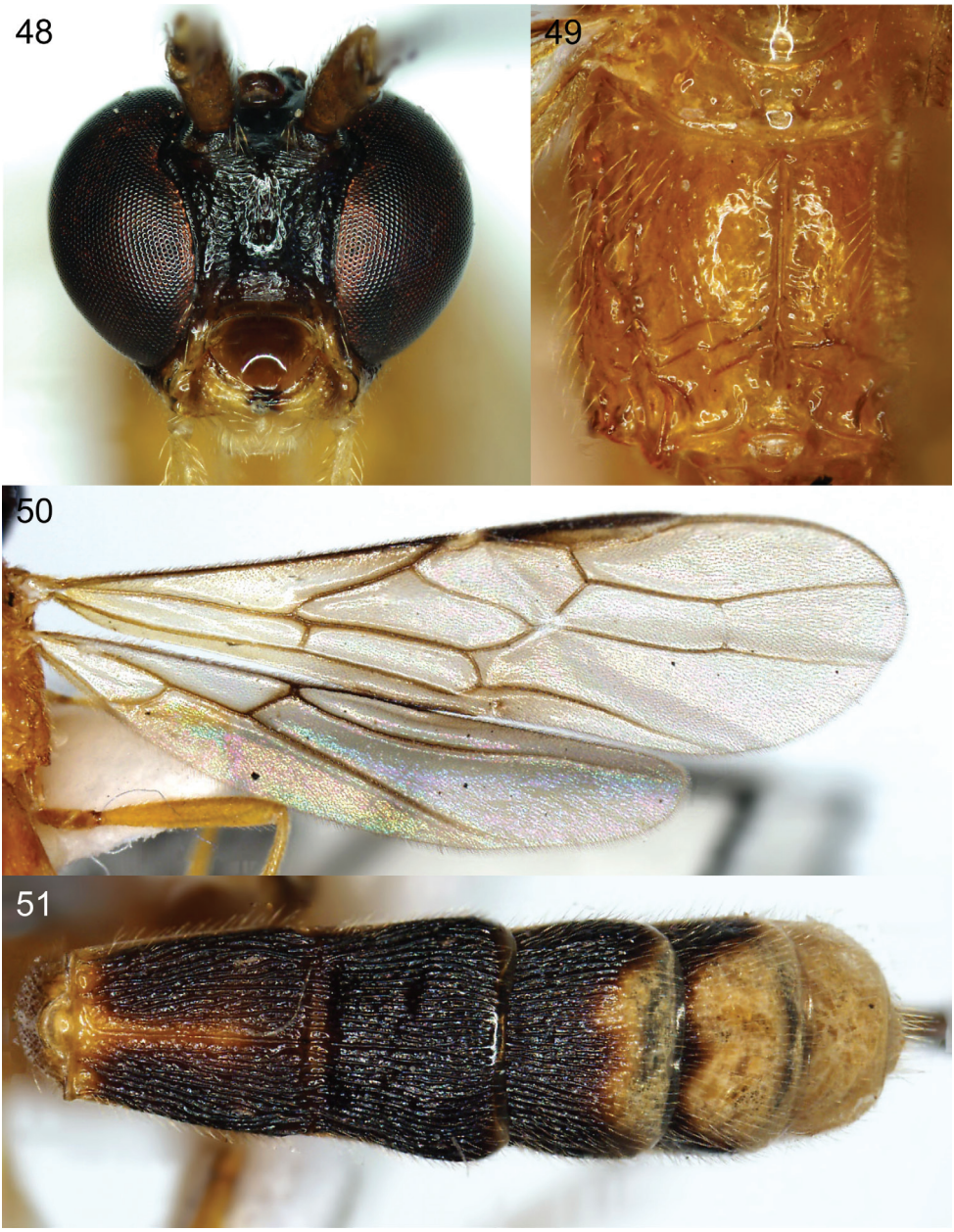
***Colastomion pukpuk* Quicke, sp. n.**
urn:lsid:zoobank.org:act:28EBB931-2A14-4544-AB0E-6A88C757CD21
http://species-id.net/wiki/Colastomion_pukpuk
Figs 48–51, 55

**Material examined.** Holotype female, Papua New Guinea, East Sepik Province, Wamangu, 11-Mar-05, 143°39.125'E, 03°47.228'S, 100m, PSS, ex caterpillar on *Psychotria micrococca* (Laut. & Schum.) Val. (Rubiaceae) (voucher USNM ENT 00505491; BOLD ASQSP060-08; Genbank JF271303)

**Morphology.** Length of body 10.0 mm, of fore wing 8.5–9.5 mm and of antenna 9.5–11.2 mm.

*Head*. Antenna with 56 flagellomeres. Terminal flagellomere strongly acuminate. Median flagellomeres 2 × longer laterally than wide. 3rd segment of maxillary palp of female moderately swollen, approximately 4 longer than maximally wide. 5th segment approximately 0.9 length of 6th. Base of mandible close to eye, closest point approximately 0.75 distance from middle of anterior tentorial pit and eye. Distance between anterior tentorial pits approximately 6 × shortest distance between pit and eye. Width of face: width of head across eyes: height of eye = 1.0 : 3.1 : 2.0. Face with a smooth triangular area above clypeus bordered by well developed transverse striation that more or less meets medially at level of antennal sockets. Shortest distance between posterior ocelli: transverse diameter of posterior ocellus: shortest distance between posterior ocellus and eye = 1.0: 2.0: 1.2. Occipital carina complete, rather wavy when viewed laterally.

*Mesosoma*. Notauli weakly impressed anteriorly, dorsally represented by converging lines of discrete pits. Mesoscutum smooth where notauli converge. . Mesopleuron




**Figures 48–51.** *Colastomion pukpuk* sp. n. holotype, Cell^D® light photomicrographs. **48** Face **49** propodeum showing largely smooth anterior **50** wings **51** metasomal tergites 2–6.

almost entirely smooth ad shiny, precoxal sulcus weakly impressed, unsculptured. Propodeum with complete strong midlongitudinal carina.

*Fore wing*. Vein 1-CU1 postfurcal. Vein 2-CU1 9.0 × longer than 1-CU1. Lengths of veins SR1: 3-SR: r = 4.8 : 3.5 : 1.0. Vein 2-SR 2.0 × 2-SR+M.

*Hind wing*. Vein M+CU 1.7 × length of 1-M. Vein SR gently curving basally and gradually getting closer to anterior margin towards wing tip.

*Metasoma*. 1st metasomal tergite 2.1 × longer than posteriorly wide. 2nd metasomal tergite 1.1 × longer than maximally wide, with well developed midbasal triangular area giving rise to complete midlongitudinal carina; irregularly longitudinally striate with approximately 11 striate lateral to midlongitudinal carina. 3rd metasomal tergite 1.2 × wider than long; longitudinally striate. 4th tergite largely longitudinally striate. 5th tergite longitudinally striate medially becoming smooth laterally with punctures. 6th tergite entirely smooth and punctate.

**Coloration.** Head, and tergites 2–4 entirely, anterior half of tergite 5, and extreme base of tergite 6 black, hind tibia dark brown, hind trochanter and trochantellus dark brown, mesosoma, 1st tergite and rest of legs orange red, metasomal tergites 4 and 5 posteriorly cream-white, tergites 6 and 7 largely cream-white. Antenna largely black with paler brown zone approximately occupying flagellomeres 22–39. Wing membrane largely pale brown, venation largely (except more basal veins, dark brown; pterostigma dark brown.

**Etymology.** Pukpuk in Melanesian Pidgin means crocodile, a favourite of the indigenous people living around Sepik river.

**Biology.** Unknown.

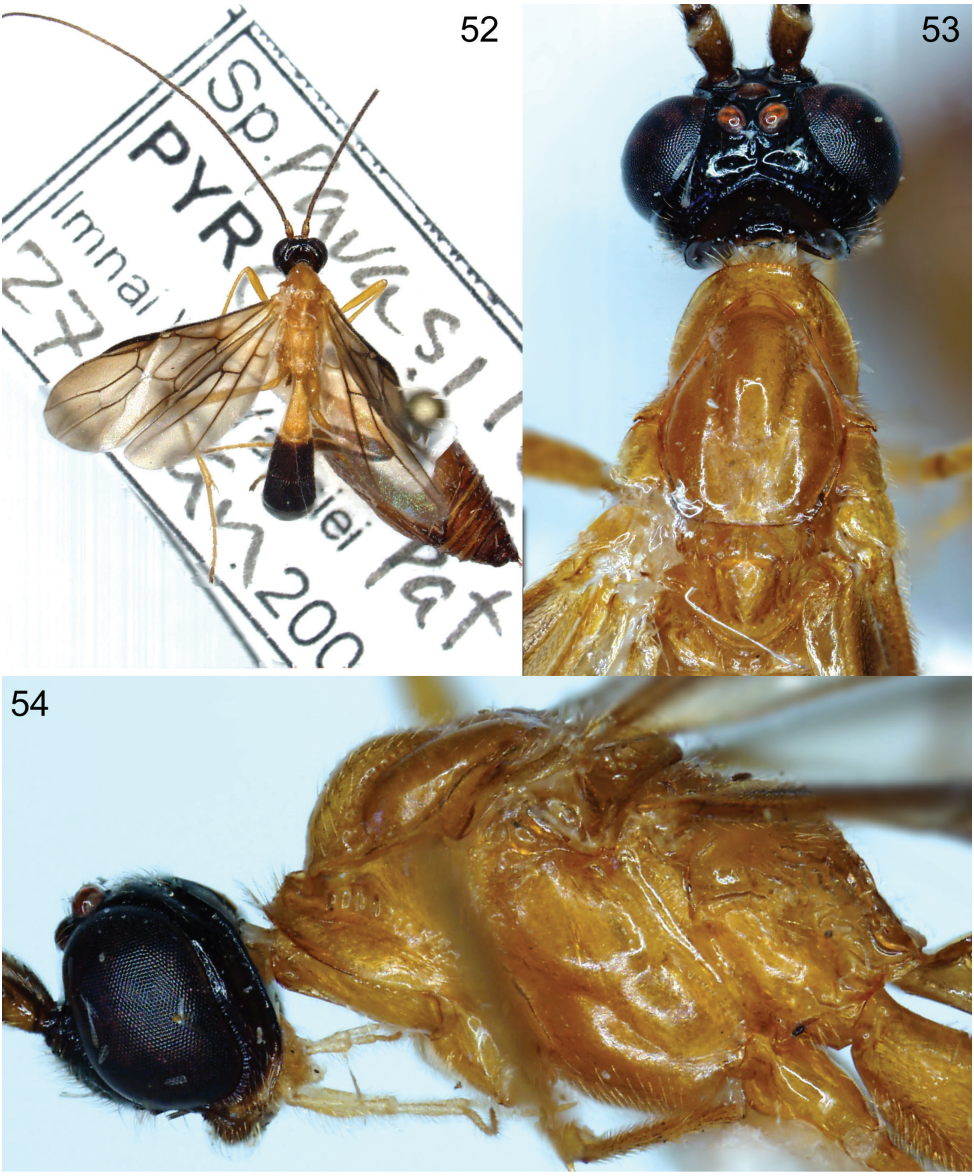
***Colastomion maclayi* Quicke, sp. n.**
urn:lsid:zoobank.org:act:DC1DB59F-2C17-45B6-9254-6DBD0A890EE8
http://species-id.net/wiki/Colastomion_maclayi
Figs 52–54, 56

**Material examined.** Holotype female, Papua New Guinea, East Sepik Province, Yapsiei, 27-Jan-04, 141°05.839'E, 4°37.695'S, 100m, (voucher USNM ENT 00454207; BOLD ASQSP061-08; Genbank JF271312) [mounted on same pin is a pupal case, presumably of the host species, though not the host of this individual]

Paratypes. 1 male, East Sepik Province, Yapsiei, 27-Feb-04, 141°05.839'E, 4°37.695'S, 100m (voucher USNM ENT 00454275; BOLD ASQSP064-08; Genbank JF271310); 1 male, East Sepik Province, Yapsiei, 18-Feb-04, 141°05.839'E, 4°37.695'S, 100m (voucher USNM ENT 00454148; BOLD ASQSP062-08; Genbank JF271311)

**Morphology.** Length of body 11 mm, of fore wing 8.7 mm and of antenna 11 mm.

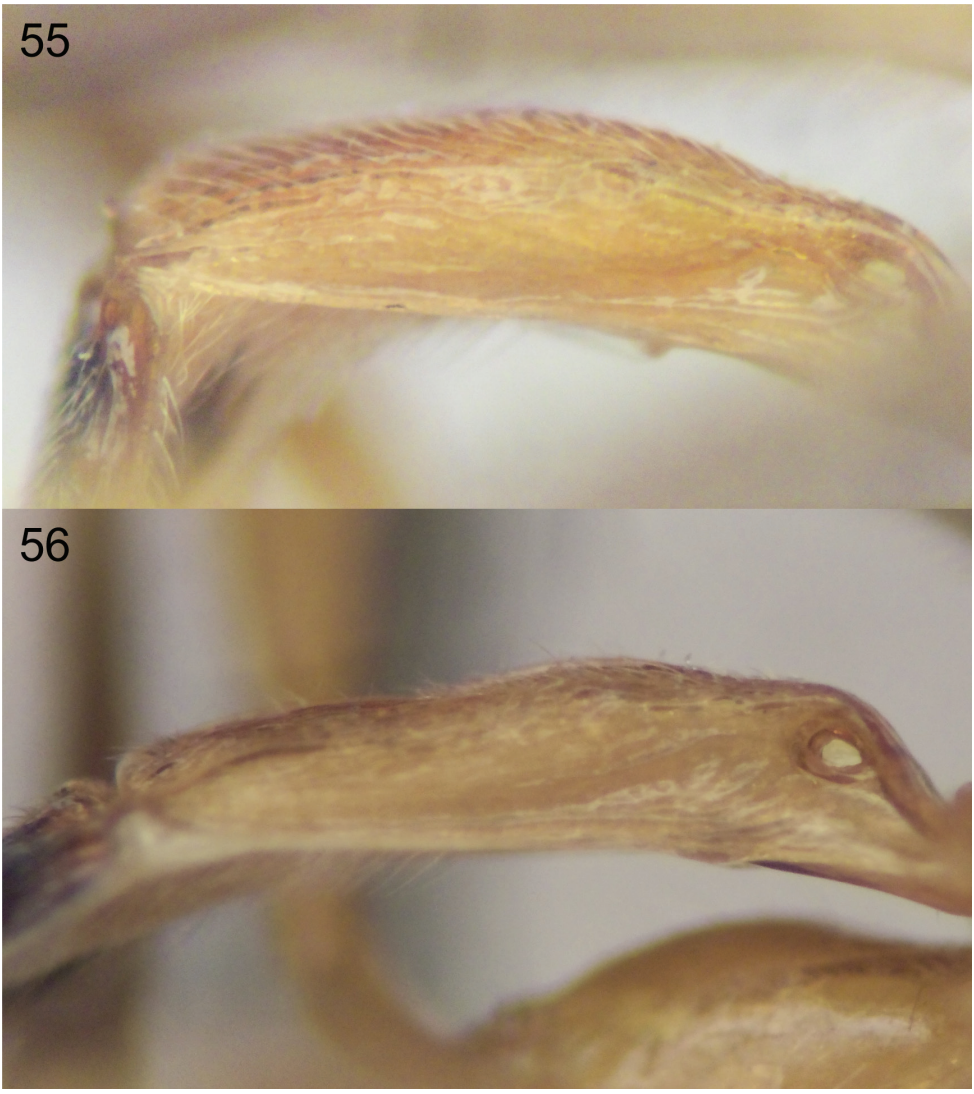
*Head*. Antenna with 57 flagellomeres. Terminal flagellomere distinctly acuminate. Median flagellomeres 1.8 × longer laterally than wide. 3rd segment of maxillary palp of female very weakly swollen medially swollen, approximately ?7 × longer than maximally wide. 5th segment approximately 0.65 length of 6th. Base of mandible very close to eye, closest point approximately 0.8 distance from middle of anterior tentorial pit and eye. Distance between anterior tentorial pits approximately 5.0 × shortest distance between pit and eye. Width of face: width of head across eyes: height of eye = 1.0 : 2.7




**Figures 52–54.** *Colastomion maclayi* sp. n. holotype, Cell^D® light photomicrographs. **52** Habitus, dorsal view **53** head and anterior mesosoma, dorsal view **54** head and mesosoma, lateral view.

: 1.9. Face largely finely transversely striate. Shortest distance between posterior ocelli: transverse diameter of posterior ocellus: shortest distance between posterior ocellus and eye = 1.0 : 3.0 : 1.1. Occipital carina well developed, complete mediodorsally.

*Mesosoma*. Notauli weakly impressed anteriorly, dorsally represented by converging lines of discrete pits. Mesoscutum smooth where notauli converge. Propodeum with complete midlongitudinal carina.




**Figures 55–56.** Lateral views of 1st metasomal tergite. **55** *Colastomion pukpuk* sp. n. **56** *Colastomion maclayi* sp. n.

*Fore wing*. Vein 1-CU1 postfurcal. Vein 2-CU1 8.5 × longer than 1-CU1. Lengths of veins SR1: 3-SR: r = 4.6: 3.2:1.0. Vein 2-SR 2.4 × 2-SR+M.

*Hind wing*. Vein M+CU 2.0 × length of 1-M. Hind wing vein 2-SC+R very thickened, almost quadrate. Vein SR gently curving basally and gradually getting closer to anterior margin towards wing tip.

*Metasoma*. 1st metasomal tergite 2 × longer than posteriorly wide. 2nd metasomal tergite 1.1 × longer than maximally wide, with well developed midbasal triangular area giving rise to complete midlongitudinal carina; irregularly longitudinally striate with approximately 12 striae lateral to midlongitudinal carina. 3rd metasomal tergite

1.4 × wider than long; longitudinally striate, with midlongitudinal carina distinct on anterior 0.5. 4th and 5th tergites finely longitudinally striate medially becoming weakly punctate-striate laterally

**Coloration.** Head, and tergites 2–4 entirely, and anterior half of tergite 5 black, hind tibia dark brown, mesosoma, 1st tergite and legs orange red, metasomal tergite 5 posteriorly cream-white, tergites 6 and 7 largely cream-white. Antenna largely black with paler brown zone approximately occupying flagellomeres 27–42. Wing membrane largely pale brown, venation largely (except more basal veins, dark brown; pterostigma dark brown.

**Biology.** Solitary endoparasitoid of *Meekiaria* (Crambidae) caterpillars on *Psychotria* sp. (Rubiaceae). *Meekiaria* have distinctive male genitalia with numerous closely related species in PNG (Munroe 1974, Craft et al. 2010: S2).

**Etymology.** Named after Nicholai Miklucho-Maklaj, a Russian explorer of New Guinea who lived around the Madang area for some time.

## Discussion

The species described here comprise three groups based both on morphology and DNA (Fig. 1). *Colastomion gregarious* sp. n., *C. madangensis* sp. n. and *C. masalaii* sp. n. are all small, at least facultatively gregarious species with an antefurcal fore wing vein cu-a (Fig. 15) and an inverted 'V'-shaped carina on the propodeum (Fig. 7); *C. crambidiphagus* sp. n. and *C. parotiphagus* sp. n. are medium-sized, predominantly yellow species; *C. cheesmanae* sp. n., *C. maclayi* sp. n., *C. pukpuk* sp. n. and *C. wanang* sp. n. are all large, black headed species with largely black metasomas with whitish tips. The amount of morphological variation observed between these three groups of species is considerable, and might in the past have been deemed sufficient by some taxonomists to warrant division into different genera or subgenera, and the relatively long internal branches on the molecular phylogeny support their high level of differentiation. Addition molecular studies on the whole subfamily will be needed to determine whether, despite the vertical hind wing vein 2-SC+R, these taxa form a natural group to the exclusion of other members of the complex.

As with many rogadine wasps, *Colastomion* had no published host records prior to the current caterpillar rearing campaign in Papua New Guinea, despite it being widely distributed and occurring also in tropical Africa and S. E. Asia. In common with the closely related genus *Macrostomion* Baker, several of the new species described here are gregarious. This biology is unusual among the Rogadinae. A few species of the cosmopolitan genus *Aleiodes* Wesmael are gregarious (specifically *A. pallescens* on various Notodontidae, *A. stigmator* (Say) on Noctuidae, and *A. leptocarina* Fortier on an unidentified hairy host caterpillar). Another aspect of the gregariousness exhibited by some *Colastomion* is that the brood size is rather small, and at least one of the new species, *C. masalaii* sp. n., is facultatively gregarious. Thus they may make interesting study organisms for investigating the evolutionary transition

from solitary to gregarious life histories (Mayhew and van Alphen 1999, Mayhew and Glaizot 2001, Guinee et al. 2005).

It is interesting that all the reared *Colastomion* species are parasitoids of Crambidae, though these collectively feeding on a wide range of host plant families. Few tropical genera of Rogadinae have multiple host records, but of those that do, several appear to be relatively restricted in the range of host families attacked suggesting at least some degree of co-evolutionary tuning between host defence mechanisms and the parasitoid's ability to overcome them. However, before this can be investigated much further, a far larger body of host-parasitoid association data will be required.

## Acknowledgements

We thank the New Guinea Binatang Research Center parataxonomists, village assistants and Lauren Helgen for technical assistance and George Weiblen for plant identification. This paper stems from a rearing campaign led by Vojtech Novotny, George Weiblen, SEM, and Yves Basset and supported by the US National Science Foundation (DEB 0841885, 0816749, 0515678), Grant Agency of the Czech Republic (206/08/H044, 206/09/0115 and P505/10/0673), Czech Ministry of Education (LC06073, ME9082, and MSM6007665801) and project CZ.1.07/2.3.00/20.0064 co-financed by the European Social Fund and the state budget of the Czech Republic. Laboratory reagents and Barcode of Life Datasystem (BOLD; HYPERLINK http://www.boldsystems.org) infrastructure were funded by Genome Canada through the Ontario Genomics Institute. The Animal Systematic Research Unit and Integrated Ecology Lab, Department of Biology, Faculty of Science, Chulalongkorn University kindly allowed use of their Cell^D® imaging facility.

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JHR 28: 123–134 (2012)
doi: 10.3897/JHR.28.3118
www.pensoft.net/journals/jhr

RESEARCH ARTICLE

JOURNAL OF Hymenoptera RESEARCH
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The International Society of Hymenopterists

# *Orientopius* Fischer (Hymenoptera, Braconidae, Opiinae) new for Europe, with first notes on its biology and description of a new species

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Academic editor: *Gavin Broad* | Received 23 March 2012 | Accepted 2 July 2012 | Published 24 August 2012

*urn:lsid:zoobank.org:pub:0FF0F226-ABD1-452E-8735-8D7464A11C4B*

**Citation:** Achterberg C van, Gumez J-L, Martinez M, Rasplus J-Y (2012) *Orientopius* Fischer (Hymenoptera, Braconidae, Opiinae) new for Europe, with first notes on its biology and description of a new species. Journal of Hymenoptera Research 28: 123–134. doi: 10.3897/JHR.28.3118

## Abstract

The genus *Orientopius* Fischer, 1966 (Hymenoptera: Braconidae: Opiinae) is reported for the first time from Europe and the West Palaearctic region, its biology (parasitoids of *Phytobia* spp.) is given for the first time and a new species (*O. europaeus* **sp. n.**) is described from France and Bulgaria.

## Keywords

Braconidae, Opiinae, *Orientopius*, new species, *Epimicta*, *Trachionus*, Palaearctic, Europe, Bulgaria, France, biology, *Phytobia* spp., Diptera, Agromyzidae, *Crataegus monogyna, Prunus spinosa*

## Introduction

The large subfamily Opiinae (Braconidae), with 1,975 valid species according to Yu et al. (2009), is a common group containing generally small (2–5 mm) parasitoid wasps

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of mainly mining or fruit-infesting dipterous larvae. It has a worldwide distribution and the world fauna has been reviewed by Fischer (1972, 1977, 1986, 1987). Currently about 35 genera are used, but the number of genera and the limits of several genera are still matters of discussion. The genus *Orientopius* Fischer, 1966, is a small genus with 13 described species from the East Palaearctic, Oriental and Australian (New Guinea) regions. Up to now, its biology was unknown; the metasomal carapace may indicate that oviposition is through e.g. a woody substrate or an egg-shell, both difficult to penetrate.

The second and third authors reared a new species of *Orientopius* from two species of the genus *Phytobia* Lioy, 1864 (Diptera: Agromyzidae) mining in the cambium of trees and shrubs of *Crataegus monogyna* Linnaeus and *Prunus spinosa* Linnaeus in northern France. The same species was collected in Central Bulgaria by the first author. Opiinae are solitary koinobiont endoparasitoids of larvae of cyclorrhaphous Diptera, but oviposition may take place into the egg of the host (ovo-larval parasitoids). They may play an important role in the control of dipterous pests such as fruit-infesting Tephritidae and mining Agromyzidae. The parasitoid larva has its final development when the host larva has made its puparium, and the adult parasitoid emerges from the host puparium.

## Material and methods

The larvae and pupae of *Phytobia* were collected by J.L. Gumez in North France (Aisne, Bouconville-Vauclair, forêt domaniale de Vauclair and forêt domaniale de Samoussy). Some puparia were collected directly from the soil under the host plants (Fig. 30), others were obtained from young seedlings of *Crataegus monogyna* and *Prunus spinosa* with larvae at the ends of their branches. The infested branches were cut and placed in containers to obtain the puparia. These puparia were kept indoors under semi-natural conditions by the second and third authors to obtain adults of the *Phytobia* miner and its parasitoids. The identifications of the larvae and adults of *Phytobia* were made by M. Martinez and of the parasitoids by the first and last authors. Beside the fairly large series of Braconidae (10–20 specimens per species) some Ichneumonidae were reared, but these (together with more recently reared *Phytobia* parasitoids) will be treated in a second paper dealing with all reared material of *Phytobia* spp. in North France.

The specimens are deposited in the collection INRA (CBGP) at Montpellier and in the NCB Naturalis collection (RMNH) at Leiden. For identification of the subfamily Opiinae, see van Achterberg (1990, 1993, 1997), for identification of the genus, see Fischer (1966), Tobias (1998) and Chen and Weng (2005), for references to the Opiinae, see Yu et al. (2009) and for the terminology used in this paper, see van Achterberg (1988, 1993). Measurements are taken as indicated by van Achterberg (1988).

***Orientopius* Fischer, 1966**
http://species-id.net/wiki/Orientopius
Figs 1–33

**Type species.** *Orientopius curiosigaster* Fischer, 1966 (original designation).

**Diagnosis.** Clypeus truncate medio-ventrally (Figs 6, 20); labrum exposed (Figs 20, 22); occipital carina present latero-dorsally and weakly or not protruding in lateral view (Figs 2, 13, 23); head comparatively long in anterior view (Figs 6, 20) and malar space longer than basal width of mandible (Figs 13, 22); malar suture complete and distinctly impressed (Figs 6, 22); inner sides of antennal sockets normal, not protruding (Fig. 10); around base of middle coxa no circular carina; medio-posterior depression of mesoscutum present (Figs 7, 16, 33); notauli absent posteriorly or as row of punctures (Figs 7, 16, 33); postpectal carina variable, usually partly present medio-ventrally; vein 3-SR of fore wing about as long as vein 2-SR (Figs 3, 15, 32); metasoma with carapace (Figs 1, 2, 18, 32, 33), but less developed in males (Figs 13, 14); second tergite sculptured and distinctly longer than third tergite (Figs 1, 2, 14, 18, 32, 33); dorsal carinae of first tergite variable, separated basally (Fig. 14) or medially united in a median carina (Fig. 18); second metasomal suture distinctly crenulate (Figs 14, 18); third tergite of female with a sharp lateral crease (Figs 1, 2, 32).

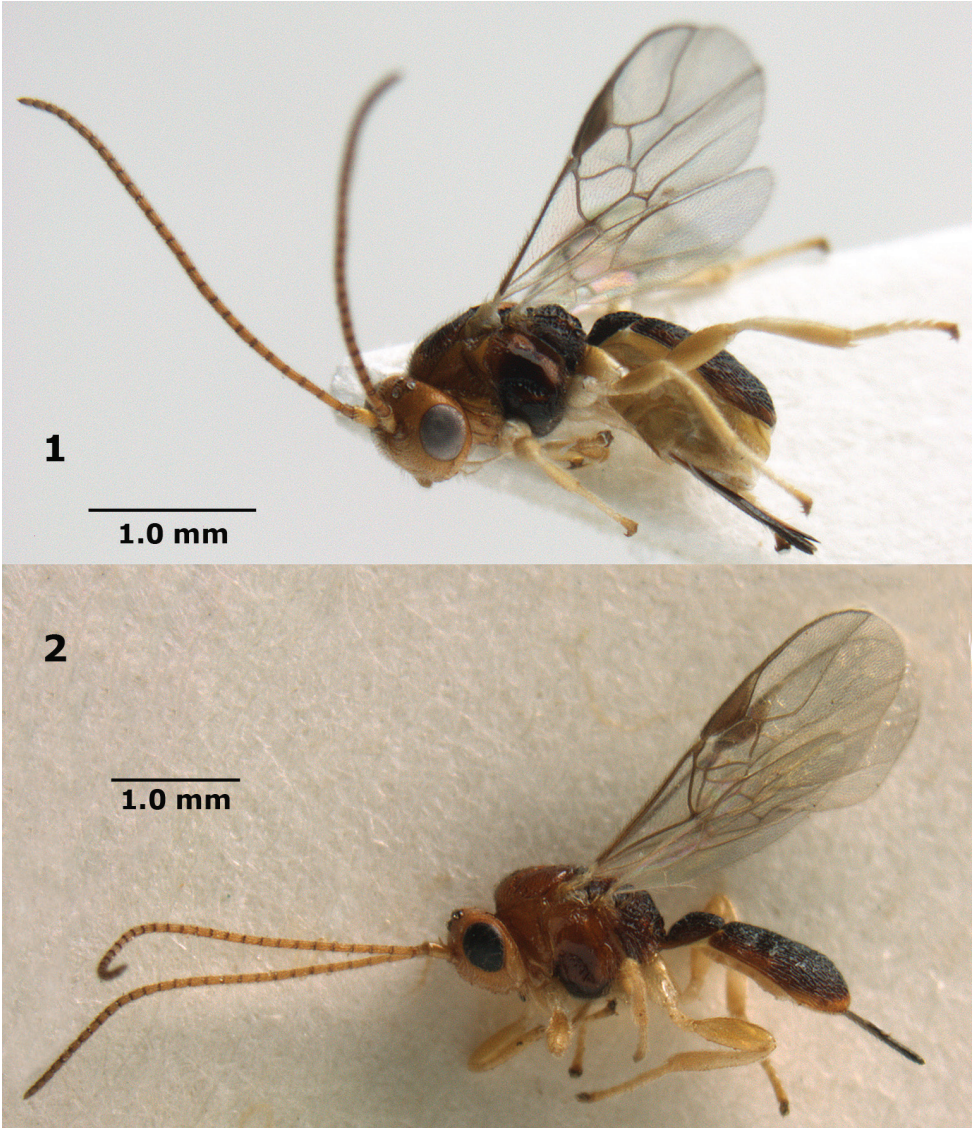
**Notes.** *Orientopius* Fischer, 1966, is closely related to *Coleopius* Fischer, 1964; both have the female metasomal carapace covering the fourth and following tergites, the second metasomal tergite distinctly (1.3–1.9 times) longer than the third tergite, the third tergite with a sharp lateral crease and the second submarginal cell of the fore wing short. They can be separated as follows:

1 Malar suture complete and distinctly impressed; medio-posterior depression of mesoscutum present; second metasomal suture distinctly crenulate ..... ..... ***Orientopius* Fischer**

– Malar suture incomplete and obsolescent; medio-posterior depression of mesoscutum absent; second metasomal suture finely sculptured, without distinct crenulae ..... ***Coleopius* Fischer**

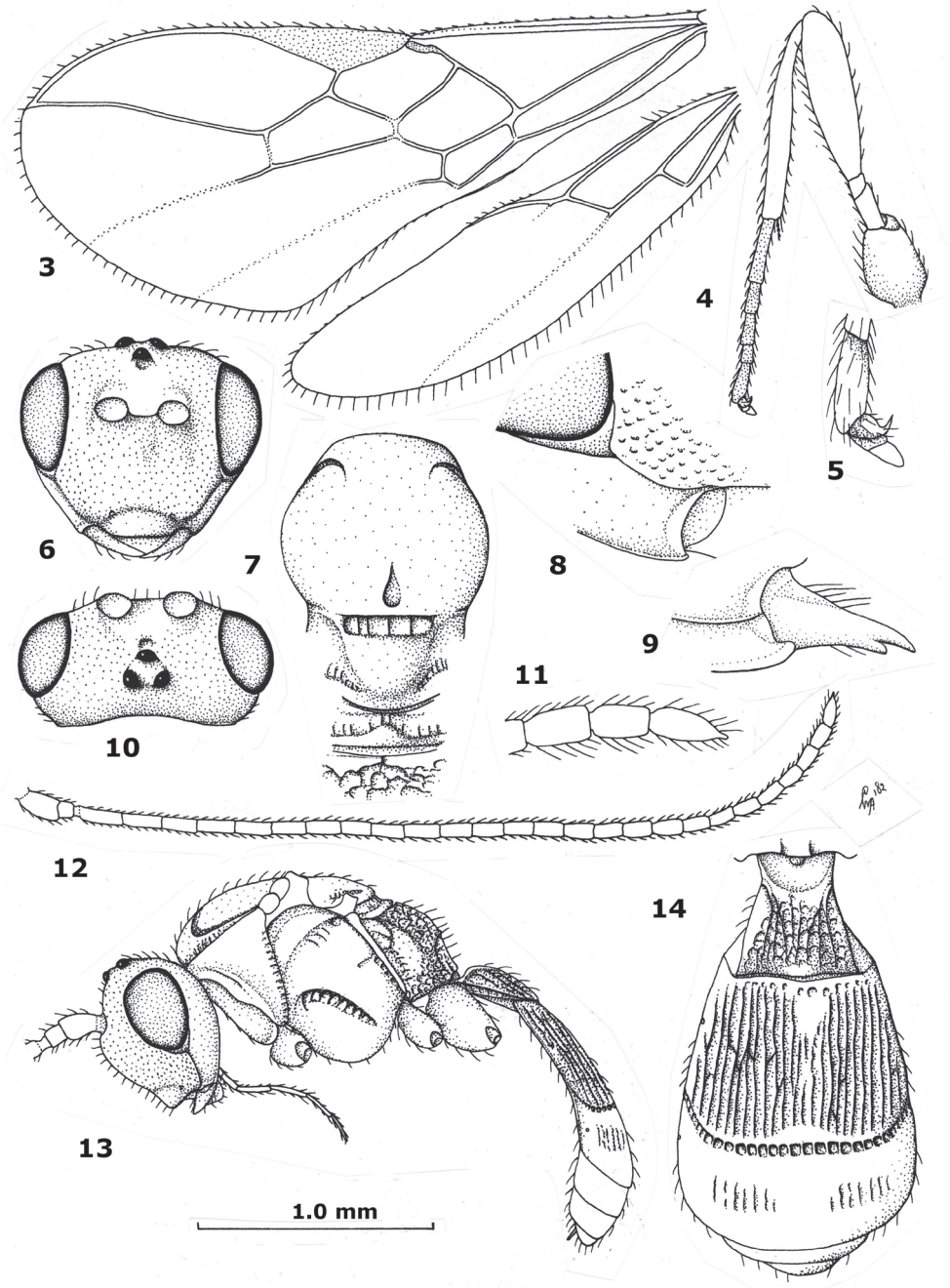
***Orientopius europaeus* van Achterberg, sp. n.**
urn:lsid:zoobank.org:act:6A85FD4E-3487-4F92-91EE-28452FB05EE2
http://species-id.net/wiki/Orientopius_europaeus
Figs 1, 2, 15–25, 32, 33

**Type material.** Holotype (RMNH), ♀, "C. Bulgaria, Bania, nr [= between Panagyurishte and] Pazardzhik, 25.VII.-10.VIII.2006, c. 500 m, Malaise trap in garden, C. v. Achterberg, RMNH'06". Paratypes (INRA (CBGP), RMNH: 13 ♀): 1 ♀, "[N.

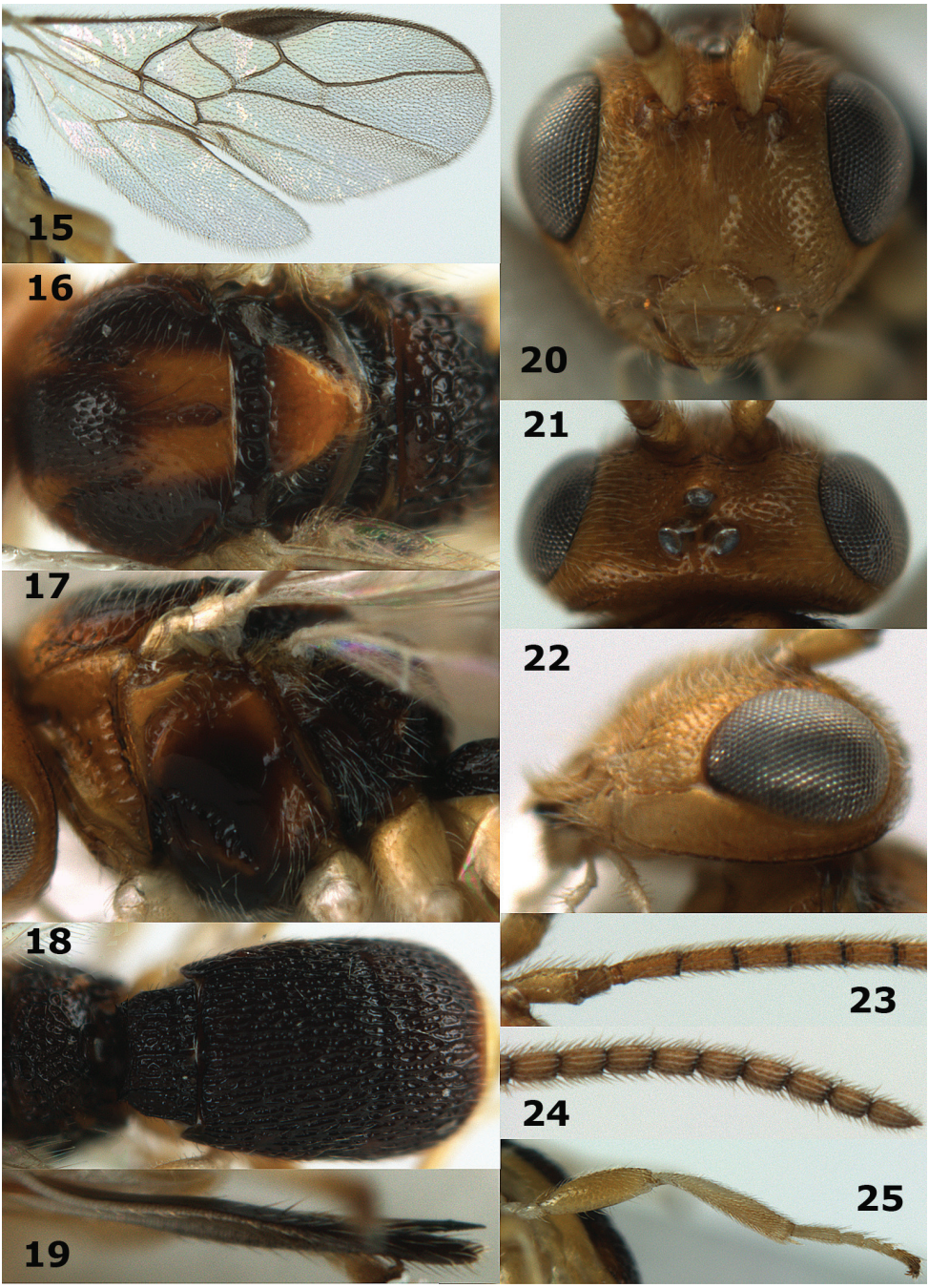



**Figures 1–2.** *Orientopius europaeus* sp. n., female, holotype (upper) and paratype. Habitus lateral.

France], Aisne (02), Bouconville-Vauclair, forêt domaniale de Vauclair, J.L. Gumez", "pupe le 23.V.1990, éclos sous abri le 15.VI.1990", "Ex pupe de *Phytobia carbonaria* (Zetterstedt) sur *Crataegus monogyna*"; 1 ♀, "[N. France], Aisne (02), Bouconville-Vauclair, forêt domaniale de Vauclair, J.L. Gumez", "pupe le 18.VII.1990, éclos sous abri le 9.X.1990", "Ex pupe de *Phytobia cerasiferae* (Kangas) sur *Prunus spinosa*"; 1 ♀, "[N. France], Aisne 02, Bouconville-Vauclair, forêt domaniale de Vauclair, J.L.




**Figures 3–14.** *Orientopius curiosigaster* Fischer, male, holotype. **3** wings **4** hind leg **5** outer hind claw **6** head anterior **7** mesosoma dorsal **8** malar space **9** mandible and ventral part of occipital carina **10** head dorsal **11** apex of antenna **12** antenna **13** habitus lateral **14** metasoma dorsal.




**Figures 15–25.** *Orientopius europaeus* sp. n., female, holotype. **15** wings **16** mesosoma dorsal **17** mesosoma lateral **18** metasoma dorsal **19** ovipositor sheath lateral **20** head anterior **21** head dorsal **22** malar space **23** base of antenna **24** apex of antenna **25** hind leg.

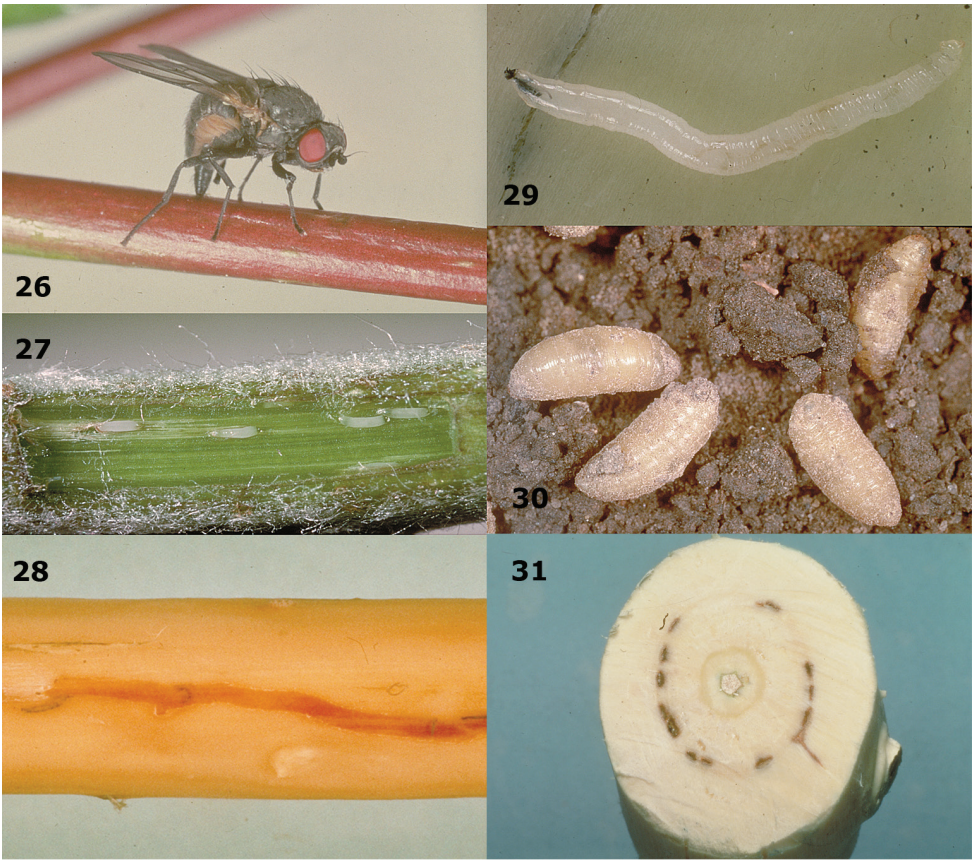
Gumez", "pupe le 1-VI-1989, éclos sous abri le 2-VI.1989", "Ex pupe de *Phytobia carbonaria* prélevée sous un *Crataegus monogyna*"; 1 ♀, id., but emerged 19.VI.1989; 1 ♀, "[N. France], Aisne (02), forêt domaniale de Samoussy, J.L. Gumez", "pupe le 26-V-1989, éclos sous abri le 20.VI.1989", "Ex pupe de *Phytobia carbonaria* prélevée sous un *Crataegus monogyna*"; 3 ♀, "[N. France], Aisne (02), Bouconville-Vauclair, forêt domaniale de Vauclair, J.L. Gumez", "pupes les 19 et 20-V-1990, éclos sous abri le 11-VI-1990", " Ex pupes de *Phytobia carbonaria* sur *Crataegus monogyna*"; 2 ♀, id., but emerged 12.VI.1990; 2 ♀, "[N. France, Aisne], 02, forêt [domaniale] de Vauclair, J.L. Gumez", "ex pupe de *Phytobia* sur *Crataegus monogyna*", "pupe le 19 et 23.V[I].1990, éclos [sous] abri [le] 11.VI.1990"; 1 ♀, "[N. France, Aisne, 02, forêt domaniale de Vauclair, J.L. Gumez] CN E1", "ex [pupe de] *P[hytobia] carbonaria* [sur *Crataegus monogyna*]", "[éclos sous abri le] 15.VI.1990".

**Diagnosis.** Vein SR1 ends near apex of fore wing (Figs 15, 32); vertex moderately densely punctate, with interspaces mostly equal to diameter of punctures or wider (Fig. 21); antenna yellowish-brown; pterostigma dark brown; second tergite 1.7–1.9 times as long as third tergite; third tergite 0.5 times longer than its basal width; third metasomal tergite subparallel-sided, subrectangular and densely reticulate-rugose (Figs 18, 33); fourth tergite of female smooth and retracted (Figs 1, 2, 32); setose part of ovipositor sheath 0.6–0.7 times as long as combined first-third metasomal tergites, 0.3 times as long as fore wing and 1.0–1.1 times as long as hind tibia (Fig. 32).

**Description.** Holotype, ♀, length of body 2.8 mm, of fore wing 2.5 mm.

*Head*. Antenna with 28 segments and 1.2 times as long as fore wing; third segment 1.3 times as long as fourth segment, length of third, fourth and penultimate segments 3.1, 2.5 and 1.5 times their width, respectively; length of maxillary palp 0.9 times height of head; labial palp segments slender; occipital carina widely removed from hypostomal carina and dorsally absent; hypostomal carina narrow; length of eye in dorsal view 7.3 times temple; temples directly narrowed (Fig. 21) and largely sparsely punctulate; frons slightly depressed behind antennal sockets and with some rugulae, remainder slightly convex and setose, largely coarsely punctate, with interspaces mostly somewhat wider than punctures; face medio-dorsally elevated, coarsely punctate, with interspaces slightly wider than punctures and some rugae latero-dorsally; width of clypeus 2.7 times its maximum height and 0.55 times width of face; clypeus flat, smooth and its ventral margin rather thin and medially straight; hypoclypeal depression wide and deep (Fig. 20); labrum flat but with upcurved rim; malar suture complete; with punctures between malar suture and clypeus; length of malar space 1.3 times basal width of mandible (Fig. 22); mandible strongly constricted and twisted apically, without distinct ventral carina (Fig. 22), second tooth medium-sized.

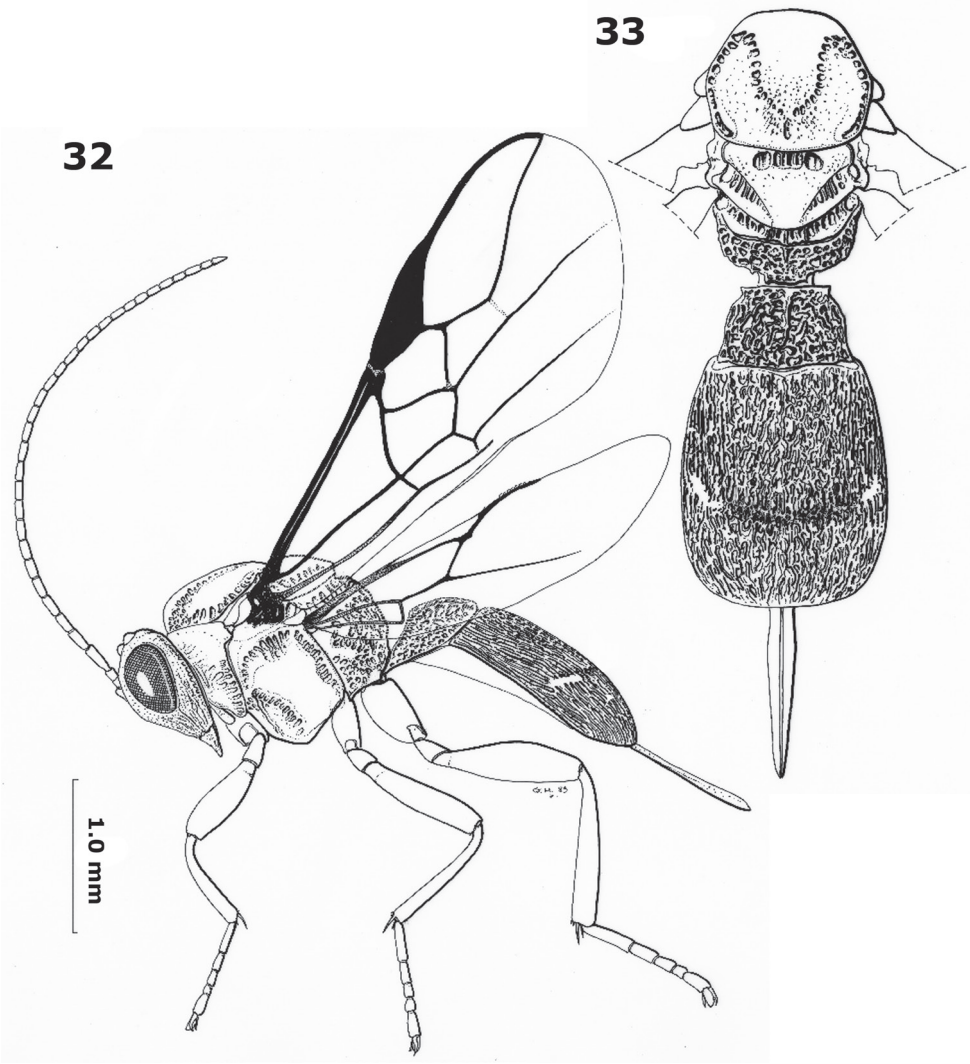
*Mesosoma*. Length of mesosoma 1.2 times its height; dorsal pronope not visible because of head, but in paratypes obsolescent, small and round; pronotum short and steep anteriorly; pronotal sides smooth but oblique and posterior grooves coarsely crenulate (Fig. 17); epicnemial area crenulate dorsally; precoxal sulcus distinctly im-




**Figures 26–31.** *Phytobia cambii* (Hendel) in *Populus* x *canadensis*. **26** adult ovipositing in young twig **27** tunnels inside twig **28** tunnel made by larva **29** larva **30** puparia **31** transverse section of tunnels made by larvae. Photographs by N. R. Coutin.

pressed, but absent posteriorly, and coarsely crenulate (Fig. 17); pleural sulcus distinctly crenulate; mesosternal sulcus deep and coarsely crenulate; postpectal carina only medio-ventrally present; metapleuron coarsely punctate-reticulate, but medially smooth; notauli crenulate and largely present on disk, only posteriorly absent near elongate elliptical medio-posterior depression mesoscutum setose and punctulate, but middle lobe largely moderately punctate; scutellar sulcus wide and with 3 coarse crenulae (Fig. 16); scutellum rather flat and sparsely punctulate; metanotum with complete median carina; surface of propodeum coarsely reticulate (Fig. 16).

*Wings*. Fore wing (Fig. 15): pterostigma elliptical; 1-R1 ending close to wing apex and 1.3 times as long as pterostigma; r:3-SR:SR1 = 5:15:49; 2-SR:3-SR:r-m = 17:15:7; r slender; 1-M and SR1 slightly curved; m-cu just postfurcal; cu-a slightly postfurcal and 1-CU1 hardly widened; first subdiscal cell closed, CU1b medium-sized; M+CU1 sclerotized. Hind wing: M+CU:1-M:1r-m = 25:18:14; cu-a straight; m-cu absent.




**Figures 32–33.** *Orientopius europaeus* sp. n., female. Habitus lateral and dorsal, respectively. Drawings by Gilbert Hodebert.

*Legs*. Length of femur, tibia and basitarsus of hind leg 3.0, 5.9 and 3.4 times as long as wide, respectively (Fig. 25); hind femur with medium-sized setae and tibia densely short setose; third and fourth segments of fore tarsus about as long as wide.

*Metasoma*. Length of first tergite 0.8 times its apical width, its surface punctate in front of dorsal carinae and longitudinally reticulate behind carinae, convex and dorsal carinae united and with median carina posteriorly (Fig. 18); second suture crenulate, nearly straight and moderately impressed; second and third tergites longitudinally reticulate-rugose; median length of second tergite 1.7 times median length of third

tergite; following tergites smooth and largely retracted below carapace; length of setose part of ovipositor sheath 0.32 times fore wing, 0.6 times first-third tergites combined and 1.1 times longer than hind tibia; hypopygium far retracted, truncate apically and about 0.3 times as long as metasomal carapace.

*Colour*. Dark brown (including pterostigma and veins); antenna (but scapus yellow), mesoscutum (but laterally and antero-medially dark brown), scutellum and mesopleuron dorsally, posteriorly and narrowly below precoxal sulcus yellowish-brown; head and mandible yellow; ovipositor sheath blackish; clypeus, labrum, palpi, tegulae and legs (but telotarsi slightly darkened) pale yellow; wing membrane slightly infuscate.

*Variation*. Length of fore wing 2.5–3.2 mm and of body 2.8–3.4 mm, antenna of female with 28 (1), 30 (3) or 31 (7) segments, vein 3-SR of fore wing 0.7–0.9 times as long as vein 2-SR; setose part of ovipositor sheath 0.29–0.32 times as long as fore wing.

**Distribution.** Bulgaria, France.

**Biology.** Reared from puparia of Agromyzidae (Diptera) cambium miners, *Phytobia carbonaria* (Zetterstedt, 1848) in *Crataegus monogyna* and *Phytobia cerasiferae* (Kangas, 1955) in *Prunus spinosa.*

**Etymology.** Name derived from "Europa", because it is the first species of this genus known from Europe.

**Notes.** The species can be separated from the other (all East) Palaearctic species as follows:

1 Vein SR1 removed from apex of fore wing; vertex densely sculptured, with interspaces less than diameter of punctures . ***O. sculpticapitis*** **Tobias, 1998**

– Vein SR1 ends near apex of fore wing (Fig. 15); vertex less densely sculptured, with interspaces at least equal to diameter of punctures (Fig. 21) ..... **2**

2 Third metasomal tergite subparallel-sided, subrectangular (Fig. 18); antenna yellowish-brown; pterostigma dark brown; fourth tergite smooth and more or less retracted (Figs 1, 2) ..... **3**

– Third tergite roundly narrowed laterally, semicircular; colour of antenna and of pterostigma and sculpture of fourth tergite variable ..... **4**

3 Second metasomal tergite about 1.3 times as long as third tergite; third tergite 0.6 times longer than its basal width; setose part of ovipositor sheath as long as combined first-third metasomal tergites; East Palaearctic ..... ..... ***O. quadratus*** **Tobias, 1998**

– Second tergite 1.7–1.9 times as long as third tergite (Fig. 18); third tergite 0.5 times longer than its basal width; setose part of ovipositor sheath 0.6–0.7 times as long as combined first-third metasomal tergites (Figs 1, 2); West Palaearctic..... ***O. europaeus*** **van Achterberg, sp. n.**

4 Fourth metasomal tergite largely smooth; second and third tergites partly smooth ..... ***O. semilissus*** **Tobias, 1998**

– Fourth tergite distinctly sculptured; second and third tergites evenly sculptured..... **5**

5 Second and third metasomal tergites mainly rugose-punctate, with only a few striae; fourth tergite punctate and no striae; antenna yellow and apically brownish; pterostigma yellow..... ***O. flavicornis*** **Tobias, 1998**

– Second and third tergites distinctly striate; fourth tergite with striae; antenna dark brown, but yellowish in *O. flavicapitis*; pterostigma brown..... **6**

6 Precoxal sulcus extensively punctate; second and third metasomal tergites finely striate; setose part of ovipositor sheath about half as long as metasoma; dorsal half of head blackish ..... ***O. belokobylskii*** **Tobias, 1998**

– Precoxal sulcus rugose medially; second and third metasomal tergites distinctly striate; setose part of ovipositor sheath about as long as metasoma; dorsal half of head yellowish..... **7**

7 First metasomal tergite with strong rugae; mesosoma blackish or largely so; antenna largely yellowish ..... ***O. flavicapitis*** **Tobias, 1998**

– First tergite without strong rugae; mesosoma largely brownish-yellow; antenna largely yellowish-brown, apically brown ..... ***O. nadezhdae*** **Tobias, 1998**

## Other Braconidae reared from *Phytobia* spp. in North France

### Alysiinae-Dacnusini

***Epimicta marginalis*** (Haliday, 1839)
Reared from *Phytobia carbonaria* in *Sorbus aucuparia* Linnaeus and in *Crataegus monogyna*. First record of a host of this species.

***Trachionus hians*** (Nees, 1816)
Reared from *Phytobia cambii* (Hendel, 1931) in *Populus* x *canadensis* [cv. "*robusta*"] and in *Betula verrucosa* Linnaeus.

***Trachionus pappi*** (Zaykov, 1982)
Reared from *Phytobia cerasiferae* in *Prunus spinosa*. *Trachionus pappi* is new for France and this is the first host record for this species.

***Trachionus ringens*** (Haliday, 1834)
Reared from *Phytobia cambii* in *Populus* x *canadensis* [cv. "*robusta*"] and *Carpinus betulus* Linnaeus.

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JHR 28: 135–141 (2012)
doi: 10.3897/JHR.28.3192
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RESEARCH ARTICLE

JOURNAL OF Hymenoptera RESEARCH
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# First host record for the Palaeotropical braconine wasp genus *Cassidibracon* Quicke (Hymenoptera, Braconidae) with the description of a new species from India

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Academic editor: *Stefan Schmidt* | Received 5 April 2012 | Accepted 6 June 2012 | Published 24 August 2012

*urn:lsid:zoobank.org:pub:0A09B4EF-24EB-4879-9D8E-79A6B5039BCE*

**Citation:** Quicke DLJ, Broad GR, Areekul Butcher BA (2012) First host record for the Palaeotropical braconine wasp genus *Cassidibracon* Quicke (Hymenoptera, Braconidae) with the description of a new species from India. Journal of Hymenoptera Research 28: 135–141. doi: 10.3897/JHR.28.3192

## Abstract

A new species, *Cassidibracon gracillariae* Quicke **sp. n.** from India, is described and illustrated and differentiated from other Indian species. The three known specimens were each reared from distinctive, exposed, bubble-coated cocoons of the gracillariid moth *Stomphastis chalybacma* (Meyrick, 1908), which superficially resemble insect egg clusters. This is the first reported host record for the genus *Cassidibracon* Quicke.

## Keywords

Cocoon, Gracillariidae, *Plesiobracon* group, parasitoid

## Introduction

The Braconinae is one of the largest and most generically diverse subfamilies of braconid parasitic wasps with 177 genera and 2,442 species described up until 2005 (Yu et al. 2005). The vast majority of species for which biology is known are ectoparasitoids of concealed hosts, principally Lepidoptera and Coleoptera and less frequently, Dip-

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tera. A few taxa belonging to the Aspidobraconina have been know for a while to be endoparasitoids of butterfly pupae (van Achterberg 1984; Quicke 1987a) and possibly of Limacodidae prepupae (Austin 1987; van Achterberg 1989). However, in recent years, several species have been shown to have aberrant biologies including adult ant ectoparasitism (Yu and Quicke 1997), ant brood parasitism including egg predation (Quicke and Stanton 2005), or even seed predation (Flores et al. 2006), or, in the case of *Pycnobraconoides* Quicke, carrying a potential host around (Quicke and Marshall 2011). Therefore, it s not unlikely that other atypical biologies remain to be discovered.

During searching of the braconid accessions collection in the Natural History Museum, London, three 100 years old specimens of a small braconine were found, each mounted above a small leaflet with what superficially looked like a white egg-mass. However, on closer examination, these white masses were found to be the distinctive bubble-like ornamentation of the cocoon of a gracillariid moth. The specimens were labelled as having been reared from *Epicephala chalybacma*, now treated as *Stomphastis chalybacma* (Meyrick, 1908) (Lepidoptera: Gracillariidae) which is recorded from India and is widespread in S. Asia.

The wasps were all rather dirty, and too fragile to attempt all but the most superficial of cleaning. Nevertheless, they were in sufficiently good condition to be described. The three possess a combination of characters used to describe a putatively monophyletic group of genera referred to as the *Plesiobracon* Cameron (1903) group as defined by van Achterberg (1983) – viz, scapus truncate and shorter ventrally than dorsally in lateral aspect, claws with a pointed basal lobe which is characteristic of members of the Braconini, a densely setose mesoscutum, fore wing veins 1-SR and C+SC+R forming an angle of >60°, propodeum with a complete midlongitudinal carina and strong and complete dorso-lateral carinae of the 1$^{st}$ metasomal tergite.

In the key to the *Plesiobracon* group genera provided by Quicke (1988), they run with a bit of difficulty to *Cassidibracon* Quicke, which was originally described from Africa, but has since also been recorded from India (Narendran et al. 1994). Based on the descriptions the reared specimens here appear to represent a different species from the three known Indian species, and they are accordingly described as new. This provided the first host record for the genus *Cassidibracon*.

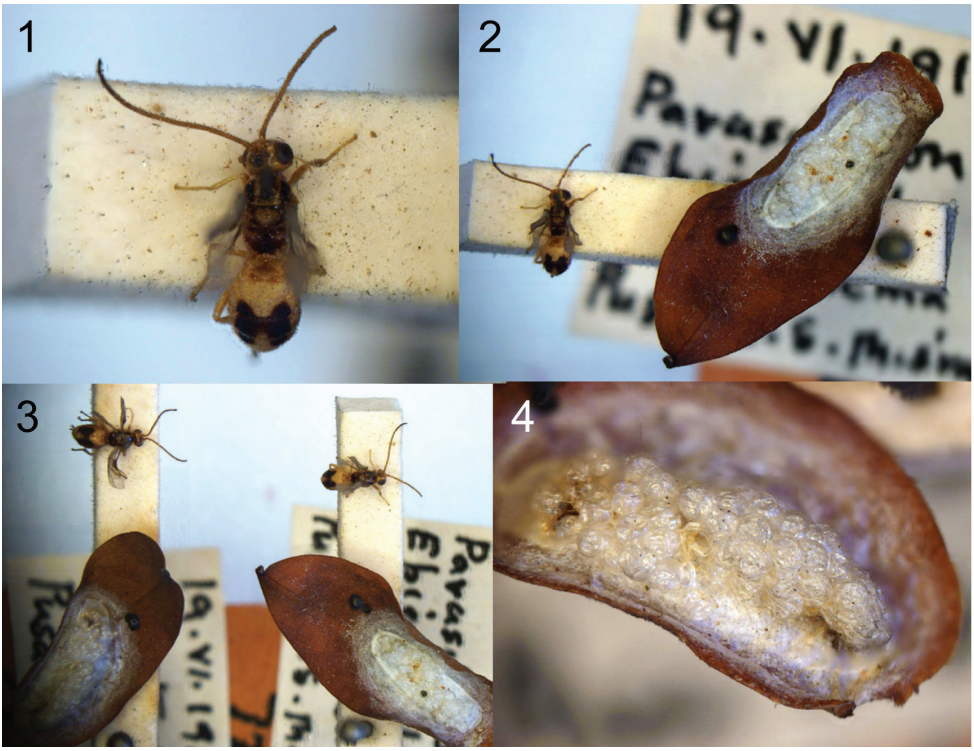
## Taxonomy

### Genus *Cassidibracon* Quicke

http://species-id.net/wiki/Cassidibracon
Figures 1–2

*Cassidibracon* Quicke 1987b: 142 Type species *Cassidibracon castus* Quicke, by original designation.

**Description.** *Head*. Terminal flagellomere strongly acuminate. Scapus small, shorter ventrally than dorsally in lateral aspect, not apicolaterally emarginate. Eyes moder-




**Figures 1–4.** *Cassidibracon gracillariae* Quicke sp. n., specimens and host cocoon Cell^D® light micrographs. **1** holotype, habitus **2** holotype and associated host remains **3** holotype and paratype **4** detail of host remains of paratype.

ately large, glabrous, not emarginate. Malar suture well-developed. Dorsal margin of hypoclypeal depression not strongly protruding and lamelliform. Clypeus sharply demarkated from face by deep groove. Anterior tentorial pits large. Frons not impressed behind antennal sockets, with strong midlongitudinal groove. Head strongly contracted behind eyes.

*Mesosoma*. Mesoscutum shiny, moderately densely with punctures at the bases of setae. Notauli very weak anteriorly, not impressed on dorsal surface. Mesopleuron smooth and shiny, largely glabrous. Precoxal suture not impressed. Pleural suture finely crenulate. Median area of metanotum with complete midlongitudinal carina. Midlongitudinal propodeal carina complete. Lateral carinae of propodeum absent, propodeum and metapleuron separated by deep groove.

*Wings*. Wings evenly setose. Forewing vein 1-SR+M virtually straight. Veins 1-SR and C+SC+R forming angle of aproximately 70°. 2$^{nd}$ submarginal cell trapezoidal. Fore wing vein 1r-m with 2 distinct bullae. Hind wing vein 1-M more than 6 × length or r-m. Hind wing vein 2-SC+R longitudinal.

*Legs*. Hind tibia robust, without disting longitudinal groove. Claws with small, acutely pointed basal lobes.

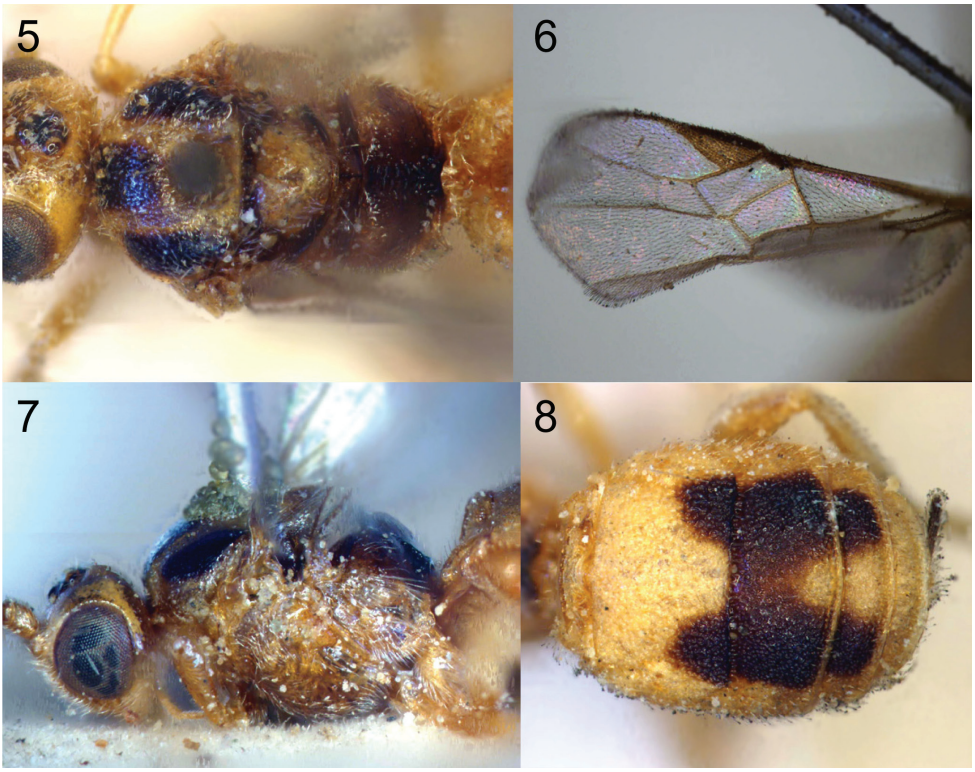



**Figure 5–8.** *Cassidibracon gracillariae* Quicke sp. n., holotype, Cell^D® light micrographs. **5** posterior of head and mesosoma, dorsal aspect. **6** Fore wing **7** Head and mesosoma, near lateral aspect **8** Metasoma, dorsal aspect.

*Metasoma*. Metasoma short and robust, with 5 exposed, coarsely sculptured tergites. 1st tergite with spiracle approximately at midlength, with complete though somewhat irregular dorso-lateral carina behind spiracle, with dorsal carinae fused to form a semicircular transverse carina that runs far closer to posterior margin of tergite than its base. 2nd+3rd tergites large, their combined medial length more than 3 × length of exposed (coarsely sculptured) parts of tergites 4 and 5. 2nd tergite without midbasal or anterolateral areas, with weak sublateral, posteriorly converging grooves on anterior 0.5 2nd suture curved, narrow, crenulate. 3rd tergite without anterolateral areas. Tergites without transverse subposterior grooves. Ovipositor short, sheaths approximately 1.2 × length of hind basitarsus.

**Comments.** *Cassidibracon* Quicke (1987b) belongs to the *Plesiobracon* Cameron (1903) group of genera as defined by van Achterberg (1983). It was originally described from the Afrotropical region (Sierra Leone) on the basis of three females and a male collected in seasonal woodland (Quicke 1987b). The type species *C. castus* Quicke has a distinct knob between the antennal sockets which is absent in the new species described here as well as in the three other the Indian species described by Narendran et al. (1994).

The type specimens of the three oriental species described by Narendran et al. (1994), viz. *C. indicus* Narendran & Rema, *C. malabaricus* Narendran and *C. sumodani* Narendran & Madhavikutty are now deposited in the collection of the Termeszettudomanyi Muzeum Allattara, Budapest, Hungary (van Achterberg and Narendran 1997).

***Cassidibracon gracillariae* Quicke, sp. n.**
urn:lsid:zoobank.org:act:A7AE1BB5-7C5C-44F8-8606-6E215FF89DCC
http://species-id.net/wiki/Cassidibracon_gracillariae

**Material examined.** Holotype. Female, "19.vi.1911, Parasite on *Epicephala chalybacma*, Pusa [INDIA], C. S. Misra", "72" (BMNH)

Paratypes. 2 females, same data as holotype.

**Diagnosis.** In Narendran et al.'s (1994) key to species, the new species runs to *C. sumodani* Narendran because of its complete propodeal carina, but differs in having more (24 as opposed to 21) flagellomeres and in the dark pattern on the metasoma. The new species differs from all other known species of the genus in having a large 'H'-shaped black mark extending over tergites 2–4.

**Narendran et al.'s (1994) key can be modified as follows to include the new species.**

1 Propodeum with complete midlongitudinal carina. Body yellowish brown 2a
– Propodeum with incomplete midlongitudinal carina. Body brown or blackish brown ..... **3**
2a Metasoma entirely yellowish. Face with midlongitudinal ridge which is produced to form knob between antennal sockets [Afrotropical] ..... *castus*
– Metasoma with distinct pattern of dark marks. Face without midlongitudinal ridge [Oriental] ..... **2b**
2b Antenna with 21 flagellomeres. Dark posterior marking on tergite 2 and anterior of tergite 4 entire ..... ***sumodani***
– Antenna with 24 flagellomeres. Dark posterior marking on tergite 2 and anterior of tergite 4 completely divided medially by pale brown yellow zone giving rise to 'H'-shaped pattern ..... ***gracillariae* sp. n.**

**Description.** Length of body 2.9 mm, of forewing 2.6 mm and of antenna 2.8 mm.

*Head*. Antenna with 24 flagellomeres. Median flagellomeres approximately 1.4 × longer than wide. 1st flagellomere 1.1 × longer than both the 2nd and 3rd segments separately. Face shiny with numerous punctures at bases of setae. Height of eye: width of head: width of face = 1.0: 2.5 : 1.05. Intertentorial distance 1.7 × tentorio-ocular distance. POL: transverse diameter of posterior ocellus: shortest distance between posterior ocellus and eye = 1: 1 : 3.

*Mesosoma*. Mesosoma approximately 1.5 × longer than high. Midlongitudinal propodeal carina running within a deep, foveolate groove. Propodeum largely shiny,

anteriorly smooth becoming distinctly weakly longitudinally striate medially merging to punctate sculpture posteriorly.

*Wings*. Fore wing vein cu-a marginally postfurcal. Lengths of fore wing veins r:3-SR:SR1 = 1.0: 1.7: 5.0.

*Legs*. Length of hind femur: tibia: tarsus = 1.2: 1.0: 1.0. Hind tibia 4.5 × longer than maximally deep.

*Metasoma*. Metasomal tergites irregularly densely punctulate. 2nd tergite 1.9 × wider than medially long. 3rd tergite 2.5 × wider than medially long.

*Coloration*. Antenna orange-brown becoming black on apical third. Head cream-yellow with stemmaticum black. Mesosoma largely cream-yellow with dark marks on lateral lobes and anterior of middle lobe of mesoscutum. Metasoma cream-coloured with large 'H'-shaped black mark extending over tergites 2-4.

**Notes on biology.** The type series of *Cassidibracon gracillariae* sp. n. are labelled as having been reared from '*E*[*picephala*]. *chalybacma*' (now *Stomphastis chalybacma* (Meyrick, 1908)) (Lepidoptera: Gracillariidae). Specimens of *S. chalybacma* in BMNH share the highly distinctive cocoons and there is no doubt that the original host identification was correct. The host is a widespread moth in south-east Asia which mines leaves of *Caesalpinia* and *Samanea* species (Fabaceae). The gracillariid, which feeds solitarily as a leaf-miner, pupates in a flattened silken cocoon ornamented with a cluster of distinctive bubbles, excreted by the larva, along the whole length of the cocoon. These bubbles presumably serve a defensive (or camouflage) function and resemble an egg mass, or possibly a parasitoid cocoon mass. The ovipositing *Cassidibracon* presumably attacks either pre-pupal larva or pupal hosts.

## Acknowledgements

We are grateful to David Lees, David Notton and Martin Honey (all BMNH) for (independently) confirming the host identity and stage. The Animal Systematic Research Unit and Integrated Ecology Lab, Department of Biology, Faculty of Science, Chulalongkorn University kindly allowed use of their Cell^D® imaging facility.

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