Species of Trichomalopsis (Hymenoptera: Pteromalidae) associated with flyth flies (Diptera: Muscidae) in North America

Gary AP Gibson
Eastern Cereal and Oilseed Research Centre, Agriculture and Agri-Food Canada, K.W. Neatby Building, 960 Carling Avenue, Ottawa, Ontario, Canada K1A 0C6

Kevin Floate
Lethbridge Research Centre, Agriculture and Agri-Food Canada, PO Box 3000, Lethbridge, Alberta, Canada T1J 4B1

The Canadian Entomologist 133: 49 – 85 (2001)

Abstract—Five species of Trichomalopsis Crawford associated with Haematobia irritans (L.) (horn fly), Musca domestica L. (house fly), Musca autumnalis DeGeer (face fly), and Stomoxys calcitrans (L.) (stable fly) in North America are reviewed. The species Trichomalopsis americana (Gahan), Trichomalopsis dubia (Ashmead), Trichomalopsis sarcophagae (Gahan), Trichomalopsis tachinae (Gahan), and Trichomalopsis viridescents (Walsh) are described, keyed, and differentiated from other recognized North American species. Lectotypes are designated for T. dubia, T. sarcophagae, and T. tachinae. Distribution and host associations are recorded for the species. Trichomalopsis americana and T. viridescents are newly recorded as parasitoids of M. domestica, T. dubia and T. sarcophagae are also newly recorded as parasitoids of Hypoderma lineatum (Villers) (common cattle grub) and Hypoderma bovis (L.) (northern cattle grub), respectively. Some previously published host associations and parasitoid identifications are corrected based on examination of voucher specimens. The known biology of each species is reviewed. The presence of Trichomalopsis albipilosa (Gahan) in North America is considered to be erroneous based on a misidentification of T. americana.


Résumé—Le statut de cinq espèces de Trichomalopsis Crawford associées à Haematobia irritans (L.) (la Mouchue des cornes), à Musca domestica L. (la Mouchue domestique), à Musca autumnalis DeGeer (la Mouchue faciale) et à Stomoxys calcitrans (L.) (la Mouchue des étables) a fait l’objet d’un nouvel examen. Une clé d’identification permettra de reconnaître les espèces Trichomalopsis americana (Gahan), Trichomalopsis dubia (Ashmead), Trichomalopsis sarcophagae (Gahan), Trichomalopsis tachinae (Gahan) et Trichomalopsis viridescents (Walsh), qui sont décrites et différenciées des autres espèces nord-américaines. Des lectotypes ont été désignés pour T. dubia, T. sarcophagae et T. tachinae. La répartition de chacune de ces espèces ainsi que les associations hôtes-parasitoïdes sont étudiées. C’est la première fois que l’on rencontre les parasitoïdes T. americana et T. viridescents chez M. domestica, T. dubia chez Hypoderma lineatum (Villers) (l’Hypoderme rayé) et T. sarcophagae chez Hypoderma bovis (l’Hypoderme du boeuf). À la suite d’un nouvel examen des spécimens témoins, nous sommes en mesure d’apporter des corrections à des publications antérieures dans lesquelles des parasitoïdes ont été identifiés et associés à des hôtes. La biologie de chacune des espèces est réexaminée.

1 Author to whom all correspondence should be addressed (E-mail: gibsong@em.agr.ca).
La mention de *Trichomalopsis albipilosa* (Gahan) en Amérique du Nord est considérée comme une erreur; l’espèce a probablement été confondue avec *T. americana*.

[Traduit par la Rédaction]

**Introduction**

During 3 years of surveying the pupal parasitoid fauna of *Musca domestica* L. (Diptera: Muscidae) in Alberta, using sentinel puparia, we reared what were initially identified as two species of the genus *Trichomalopsis* Crawford (Hymenoptera: Chalcidoidea, Pteromalidae). The two species were reported as *Trichomalopsis sarcophagae* (Gahan) and *Trichomalopsis* sp. in Floate *et al.* (1999b). Additional material and study subsequently revealed two morphological forms in what was originally identified as *Trichomalopsis* sp., resulting in one identified and two unidentified species.

Burks (1979) listed 10 species of *Trichomalopsis* from America north of Mexico, and Bouček and Heydon (1997) estimated that at least 15 species likely occur in the Nearctic region. Most host associations recorded for *Trichomalopsis* species involve the cocoons of Coleoptera and puparia of Lepidoptera, and species are often reported as hyperparasitoids through Braconidae and Ichneumonidae (Hymenoptera) (Bouček and Heydon 1997). Four species of *Trichomalopsis*, *T. dubia* (Ashmead), *T. sarcophagae*, *T. tachinae* (Gahan), and *T. viridescens* (Walsh), have also been reported as associated with the filth fly species *Haematobia irritans* (L.) (horn fly), *M. domestica* (house fly), *Musca autumnalis* DeGeer (face fly), and *Stomoxys calcitrans* (L.) (stable fly) (Diptera: Muscidae) in North America (see references under respective species).

Graham (1969) gave a key to the European and North American species of *Trichomalopsis* based on females, but the key and illustrations provided are insufficient to reliably differentiate the North American species. The purpose of this study was to determine the number and identities of the species of *Trichomalopsis* associated with filth flies in North America and to provide morphological features by which the species can be reliably identified within filth fly biological control programs. Although the key we provide differentiates only the five species we identify as filth fly parasitoids, additional features are given in the Recognition section to help differentiate the relevant species from other described Nearctic and similar Palearctic species based on current concepts.

**Materials and methods**

Morphological terms follow Gibson (1997, 2000). The mandibular formula is the number of teeth on the right and left mandible, respectively. The parapsiracular carina (Fig. 35, psc), formed in part by the parapsiracular furrow (Fig. 35, psf), differentiates the central portion of the propodeum, the plical region (Fig. 35, ppr), from the lateral callus (Figs. 34, 35, cal); the posterior, convex neck-like portion of the plical region is the nucha (Fig. 35, nuc). Measurements of eye height (EH), eye width (EW), and length of malar space (MS) (Fig. 7) are all maximum measurements when both end points are equally in focus. The distance between the eyes in frontal view is the minimum distance (Fig. 1, D+E). Head width (HW) and head height (HH) are measured in frontal view (Figs. 1, 2) and head length (HL) is measured in lateral view (Fig. 8). The length of the mesosoma is measured in lateral view between the anterior margin of the pronotal collar and the posterior margin of the propodeal nucha (Fig. 26, MsL); the height of the mesosoma is measured in lateral view between the dorsal margin of the scutellum and the ventral margin of the mesepisternum anterior to the mesocoxa (Fig. 26, MsH). Length (Fig. 42, TL) and width (Fig. 42, TW) of the first gastral tergite (Gt₁) are maximum
measurements in dorsal view. All measurements were made from dry-mounted specimens using an ocular micrometer with 100 divisions per millimetre. Method of preservation, air-dried versus critical-point dried, affects dimensions of the gaster in both sexes. The segments telescope naturally and usually are much more extensively expanded, both in total length and height, in critical-point dried than air-dried individuals (cf. Figs. 46, 47). Because of parallax problems, the margin of error in measurements is greater when measuring structures with greater curvature, such as head length and height of the mesosoma. Unless stated otherwise, all statistics are based on 10 measured individuals. To observe structure and sculpture properly, the glare from incandescent light sources must be reduced by passage through some light-diffusing material, such as a piece of translucent tracing acetate, placed close to the specimen (see Goulet and Mason 1993, p 60). This is particularly important to observe sculpture of the scutellar frenal and antennal flagellum.

Previously published host records for each species include the currently accepted name of the host, the reference of one or more publications citing the host association to validate the record (including the first known report), and the original combination used in the publication(s). The currently accepted name of tachinid (Diptera: Tachinidae) hosts is based on O’Hara and Wood (2000), whereas the currently accepted name of all other hosts is based on Poole and Gentili (1997). The publication citation is marked with an asterisk (*) if we verified the host association by confirming the identification of at least one voucher specimen, whereas the host record is marked with an asterisk if we did not see a voucher specimen of the relevant publication but did confirm the identification of at least one other specimen labelled with the host data. An asterisk also indicates that we saw specimens to validate province or state distribution records published previously in Peck (1951, 1963), Burks (1979), or Noyes (1998). The province or state is underlined if we saw specimens reared from one of the four species of filth flies. New host or distribution records are preceded by a superscript dagger (†) and followed either by the acronym of the collection that contains the specimen(s) on which the new record is based or by the citation of the relevant publication if the new record is based on a corrected identification.

Specimens for scanning electron microscopy (SEM) were prepared following Bolte (1996). The negatives were scanned into a computer with a 35-mm scanner, digitized, and enhanced, and the final plates were compiled using Adobe Photoshop™.

This study is based on specimens of *Trichomalopsis* reared from sentinel pupae of *M. domestica* in Alberta during 1996–1998 and specimens from the following collections (acronyms are used in the text to denote depositories):

- **CNCI** Canadian National Collection of Insects and Arachnids, Ottawa, Ontario.
- **CSUC** Department of Entomology, Colorado State University, Fort Collins, Colorado (BC Kondratieff).
- **CUIC** Cornell University Insect Collection, Department of Entomology, Cornell University, Ithaca, New York (J Liebherr).
- **DEBU** Department of Environmental Biology, University of Guelph, Guelph, Ontario (M Buck).
- **INHS** Illinois Natural History Survey Insect Collection, Champaign, Illinois (C Favret).
- **ISUI** Iowa State University Insect Collection, Iowa State University, Ames, Iowa (G Courtney).
- **JBWM** JB Wallis Museum of Entomology, Department of Entomology, University of Manitoba, Winnipeg, Manitoba (T Galloway).
Trichomalopsis Crawford

Trichomalopsis Crawford, 1913 (May 22): 251. Type species: Trichomalopsis shirakii Crawford, 1913; by monotypy.


Metadiclyus Girault, 1926[399]: 71. Type species: Metadiclyus australiensis Girault, 1926[399]; by monotypy. Synonymy with Trichomalopsis by Bouček, 1988: 438.

Diagnosis

Head with strong ◀-shaped carina posterodorsally (Fig. 6). Eye superficially bare (Figs. 1–18). Antenna 13-segmented with 2 anelli and 6 funicular segments (Figs. 55–65); flagellum clavate in female (Figs. 55–60), usually less conspicuously clavate in male (Figs. 61–65). Mesonotum reticulate, the sculpture formed by raised ridges, and with notauli incomplete posteriorly (Figs. 19–25). Metacoxa bare dorso-basally (Figs. 26–30). Propodeum with plical region and globose nucha uniformly punctate–reticulate except sometimes for median carina (Fig. 35). Petiole short, inconspicuous, and supported ventrally by flange-like extension of anterior margin of the first gastral sternum (St1) (Fig. 48). Gaster with anterior margin of St1 projecting as mediadly concave or otherwise sculptured flange (Figs. 49–54). Forewing without line of setae on basal fold; basal cell usually bare, only rarely with a few inconspicuous setae on dorsal surface; marginal vein uniformly slender; marginal fringe present.

Remarks

North American species of Trichomalopsis were originally classified under the name Euperomalus Kurjdjumov (1913). Graham (1969) suggested that the two names likely were synonyms, but retained Euperomalus because he had not examined the type species of Trichomalopsis and because the name Euperomalus was so well known. Kamijo and Grissell (1982) formally synonymized the two names and selected Trichomalopsis as the valid name for the genus because it was published 2 months before Euperomalus. Subsequent changes of combination have necessitated changing the gender of many of the species names from masculine to feminine because "opsis" is feminine.

North American species of Trichomalopsis can be differentiated from those of other genera of Pteromalidae using the key of Bouček and Heydon (1997), and can be differentiated from other pupal parasitoids of filth flies using the key of Rueda and Axtell (1985) as modified by Hoebeke and Rutz (1988). Burks (1979) recorded 10 species of Trichomalopsis from North America, whereas Noyes (1998) recorded 12 species, including also Trichomalopsis hemiptera (Walker) and Trichomalopsis microptera.
(Lindeman). Graham (1969, pp 767, 773) considered that the North American records for these two names likely were based on either misidentifications or mislabeled specimens.

Individuals of *Trichomalopsis* are morphologically similar to those of *Urolepis* Walker, another pteromaline genus whose species parasitize filth flies (Gibson 2000). Specimens of these two genera are differentiated from those of other pteromaline genera parasitizing filth fly puparia by a combination of four features: occipital carina present (Fig. 6), mesonotal sculpture reticulate (*i.e.*, formed by raised ridges) (Figs. 19–25) rather than coriaceous (formed by impressed lines), marginal vein uniformly slender (not thickened basally), and forewing with marginal setae. Species of *Trichomalopsis* that parasitize filth flies differ from those of *Urolepis* by having bare eyes, the dorsal surface of the basal cell bare, and other relative features discussed in Gibson (2000). Individuals of *Trichomalopsis* are also very similar to those of the monotypic genus *Gyrinophagus* Ruschka. Specimens of *Gyrinophagus* differ most conspicuously from specimens of *Trichomalopsis* and *Urolepis* by having the metacoxa setose dorsobasally. Specimens of *Urolepis* and *Trichomalopsis* have the metacoxa bare dorsobasally, although there is a line of long erect setae dorsally from about the middle of the coxa to near its apex (Figs. 26–30). Furthermore, individuals of *Gyrinophagus* have setae on the ventral surface of the basal cell, although it is bare dorsally, and St₁ is smooth, shiny, and not extended in a flange under the petiole as occurs in individuals of *Trichomalopsis* and *Urolepis*. One or both of the genera *Gyrinophagus* and *Urolepis* may render *Trichomalopsis* paraphyletic.

**Key to species of *Trichomalopsis* parasitizing filth flies in North America**

1. Both sexes: ventral surface of costal cell with line of setae only within about apical one-third of cell in region anterior to parasigma (Fig. 66b); G₁ with several setae projecting posterolaterally from sinuate anterolateral margin (Figs. 31, 32, a3) and second gastral tergite (G₂) smooth and shiny (when visible). Female: G₁ in air-dried specimens making up conspicuously more than one-half length of gaster (Fig. 46). Male: G₁ occupying at least one-half length of gaster and at least 0.7 times as long as wide (Fig. 41); antenna sometimes completely yellow but usually yellow with pedicel and clava brownish ........................................... *T. tachinae*

   — Both sexes: ventral surface of costal cell with line of setae along entire length near leading margin of wing (Fig. 66a); other features variable, but G₁ sometimes without (Figs. 39, 40) or with only 1 or 2 setae (Figs. 33–36) on sinuate anterolateral margin (not to be confused with basolateral setae, Fig. 32, b3) or G₂ with coriaceous sculpture (Figs. 43, 44). Female: G₁ in air-dried specimens making up at most about one-half length of gaster. Male: G₁ sometimes obviously less than one-half length of gaster or more strongly transverse than above (Fig. 42); antenna entirely yellow or flagellum uniformly brownish ........................................... 2

2(1). Both sexes: scutellum with apical frenal area delineated by region of distinctly shallower (subeffaced) reticulations than elsewhere on scutellum (Figs. 22, 33, 34); head in lateral view comparatively thick and blunt below toruli because lower face curved down at abrupt, almost right angle relative to upper face (Fig. 8). Female: flagellum matte, with distinct reticulate sculpture on second anellus and first funicular segment basal to linear sensilla (Fig. 59) ....................................................... *T. sarcophagae*

   — Both sexes: scutellum with apical frenal area usually delineated by region of somewhat larger reticulations, but these of depth similar to that of reticulations elsewhere on scutellum (Figs. 35–40); head in lateral view comparatively thin and not conspicuously blunt because lower face curved down at obtuse angle from upper face (Figs. 7, 10, 12). Female: flagellum, including second anellus and first funicular segment, more or less shiny except for setal pores (Figs. 55–57) .................................................. 3

3(2). Both sexes: mesosoma in lateral view somewhat compressed, at least 1.8 times as long as high, with dorsal surface low convex, the scutellum almost flat, and with propodeum angled much less than 45° relative to mesonotum (Fig. 27); St₁ distinctly concave and smooth and shiny lateral to median ridge
Trichomalopsis americana (Gahan)

Eupteronalus americanus Gahan, 1933: 82–86, Figures 19a–19c; ♀, ♂. Holotype: ♀, USNM type no. 44839, examined.
Trichomalopsis americanus; Grissell in Rethwisch and Manglitz, 1986: 650.

Description

Female. Body dark with variably distinct green metallic luster, except metasoma sometimes completely dark, nonmetallic. Legs beyond coxae sometimes uniformly yellow but, more commonly, with femora and tibiae more or less distinctly orange to brown except for yellowish knees and tibiae apically. Antenna with scape entirely brownish yellow; pedicel yellow to brown; flagellum dark brown to black. Head in frontal view slightly transverse (HW:HH = 1.21–1.30) (Fig. 1), in dorsal view strongly transverse (HW:HL = 2.00–2.21), and in lateral view relatively thin (HH:HL = 1.55–1.78), usually appearing lenticular, with lower face angled at obtuse angle to upper face (Fig. 7); lower face with clypeus and paraclypeal region uniformly low convex and with paraclypeal margin not projecting beyond clypeal margin. Eye not conspicuously large (EH:EW = 1.30–1.49, MS:EH = 0.44–0.55, MS:EW = 0.60–0.81, Dm:EH = 1.26–1.42) (Figs. 1, 7). Mandibular formula 4:4 (cf. Fig. 2). Flagellum widening gradually toward clava (Fig. 55a), with flagellar segments 1 and 2 (fl2 and fl3) basal to sensilla shiny between setal sockets, without distinct reticulate sculpture (Fig. 55b), fl3 variably distinctly transverse but only about one-third length of fl2 (Fig. 55b); fl1 usually at least slightly and often distinctly longer than wide (Fig. 55b), subsequent segments decreasing in length but usually one or more segments at least slightly longer than wide (Fig. 55b). Pronotum with reticulate sculpture of neck extending over anterior of collar, sometimes with sculpture aligned into one or more fine, irregular (wavy) transverse ridges but without well-defined pronotal carina (Figs. 19, 25). Mesosoma in lateral view with dorsal surface distinctly convex (Fig. 30) (MsL:MSh = 1.55–1.79). Frenum sculptured similarly as elsewhere on scutellum, the reticulations usually of slightly different size but of similar depth (Figs. 19, 37). Propodeum (Figs. 37, 38) usually with median carina but at least with distinct, sinuate...
paraspiracular furrow and strong paraspiracular carina from base to nucha; callus often completely setose behind spiracle to paraspiracular carina. Forewing with complete line of setae on ventral surface of costal cell (cf. Fig. 66a); MV:STV = 1.27–1.68. Metasoma with Gt₁ of air-dried specimens usually occupying about one-half length of gaster, but at most about 0.6 length, smooth and shiny or with variably distinct coriaceous sculpture posteriorly, and with 3 or more curved setae projecting posteriorly from transverse portion of sinuate anterolateral carinate margin (Figs. 37, 38) in addition to basolateral setae (Fig. 38); Gt₂ with variably distinct coriaceous sculpture (Figs. 43, 44), the sculpture sometimes very fine and present only basally adjacent to posterior margin of Gt₁ (not apparent if Gt₂ extensively retracted under Gt₁); subsequent terga often with coriaceous sculpture; St₁ with several similar, sometimes irregular, longitudinal carinae, otherwise quite shiny (Fig. 49).

**Male.** Colour similar to that of female except legs uniformly yellow beyond coxa and antenna sometimes entirely yellow. Structure similar to that of female except eye size much more variable, the eye sometimes conspicuously large with concomitant shorter malar space and distance between eyes (MS:EH = 0.24–0.50, MS:EW = 0.29–0.66, DbE:EH = 0.72–1.33) (Figs. 9, 10). Head in frontal view with genae evenly curved to oral cavity (Fig. 9) and clypeus and paraclypeal region evenly convex (Fig. 17), Flagellum gracile–elavate (Fig. 61) to similarly elavate as for female, with ñ₁ longer than wide and subsequent funicular segments all longer than wide or decreasing in length to slightly transverse apically (Fig. 61). Forewing with MV:STV = 1.23–1.67. Gt₁ at most covering about two-thirds length of gaster in air-dried individuals (cf. Fig. 42), without coriaceous sculpture, and transverse, 0.58–0.72 times as long as maximum width; Gt₂ and subsequent terga with or without coriaceous sculpture.

**Distribution**

**CANADA:** ¹Alberta (CNCI), ¹Manitoba (JBWM), ¹New Brunswick (CNCI), ¹Nova Scotia (CNCI), ¹Saskatchewan (CNCI, USNM). **UNITED STATES:** *California, Colorado, District of Columbia (USNM), Idaho (USNM), Illinois (INHS), Iowa, Kansas (USNM), Michigan, Missouri (USNM), Nebraska (USNM), New Hampshire (USNM), New Mexico (USNM), North Dakota, Oregon, Utah (USNM), Virginia (USNM), Washington, Wisconsin, Wyoming.*

Gahan (1933) recorded *T. americana* from Michigan based on specimens from Okemos (Exp. no. 770), which was the basis for the state record in Hill (1953) and all subsequent catalogues. Examination of the Okemos specimens (USNM) proved that the record is based on a misidentification of *T. viridescens*. We did not see specimens from Wisconsin to validate the record of Burks (1958), although *T. americana* undoubtedly occurs both in Michigan and Wisconsin.

**Hosts**

**COLEOPTERA—Curculionidae:** ¹*Hydera brunniennis* (Boheman) (UCRC). **DIPTERA—Calliphoridae:** ¹*Phormia regina* (Meigen) (USNM). **Cecidomyiidae:** Mayetiola (as Phytophaga) destructor (Say) (*Gahan 1933). **Coelopidae:** ¹*Coelopa vanduzeei* Cresson (CNCI). **Ephyridae:** Hydrelia griseola (Fallen) (USNM) (for *Grigarick 1959, see T. viridescens*). **Muscidae:** ¹*Musca domestica* L. (based on *Floate et al. 1999b*). **Tephritidae:** ¹*Rhagoletis cingulata* (Loew) (USNM). **HYMENOPTERA—Braconidae:** ¹*Cotesia* (as Apanteles) medicaginis (Muesebeck) in Colias eurytheme Boisdruval (Lepidoptera: Pieridae) (*Allen and Smith 1958, as T. viridescens*). **Cepheididae:** ¹*Cephus cinctus* Norton (CNCI). **Eupholidae:** Oomyzus (as Tetrastichus) incertus (Ratzburg) in *Hydera postica* (Gyllenhal) (Coleoptera: Curculionidae) (Best and Simpson 1975). **Ichneumonidae:** Bathyplectes curculionis (Thomson) in *Hydera postica* (Gyllenhal) (*Pike and Burkhardt 1974; *Best and
Simpson 1975). **LEPIDOPTERA—Gelechiidae:** ¹Phthorimaea (as Gnórímoschema) operculella (Zeller) on potato (UCRC). **Noctuidae:** ¹Heliothis sp. (UCRC).

**Biology**

*Trichomalopsis americana* appears to be a solitary primary pupal parasitoid of Diptera (Gahan 1933; Floate et al. 1999b), but a solitary hyperparasitoid of Coleoptera and Lepidoptera pupae (Allen and Smith 1958; Best and Simpson 1975). Best and Simpson (1975) described courtship and mating, host-finding stimuli, host feeding, and life-history parameters of *T. americana*, including description and illustration of the eggs and larval stages. They stated that there were strong indications that *T. americana* might have a wide range of hosts because females attempted to drill into empty puparia of Cuterebridae and Tachinidae (Diptera), and not only oviposited but completed development in the mummies of larvae of *H. postica* containing the primary parasite *O. incertus*. Their hypothesis is supported by such new host records as *P. regina* (black blow fly), *R. cingulata* (cherry fruit fly), and *C. cinctus* (wheat stem sawfly). The solitary nature of *T. americana* will help distinguish the species from *T. dubia* and *T. sarcophaga*, which are gregarious pupal parasitoids of *M. domestica*; usually more than one specimen of *T. dubia* and *T. sarcophaga* emerge from a single puparium (Hoebke and Rutz 1988; Wylie 1973, 1976; Lysyk 1995, 1998).

Reexamination of the 33 individuals reported as *Trichomalopsis* sp. in Floate et al. (1999b) showed that 13 specimens are *T. americana* and 20 are *T. viridescens* (all CNCI). We also saw 1 female and 1 male (UCRC) of *T. americana* from California labelled as reared from *M. domestica*. Of 16 specimens examined (ISUI, USNM) that definitely are voucher specimens of the laboratory rearing of Best and Simpson (1975), all are *T. americana*. Three other females reared from *B. curculionis* by Best (USNM) are also *T. americana*. These specimens (Fort Collins, Colorado, June and July 1973) likely are voucher specimens of rearing from field-collected pupae described in Best and Simpson. We also saw 5 females and 1 male (USNM) from localities in Wyoming reared from unidentified species of *Bathyplectes* by KS Pike and identified as *T. albipilosus* Graham in Pike and Burkhardt (1974). Graham (1969) described *T. albipilosus* from Sweden, and the Wyoming records were the first records of the species from North America according to BD Burks (cited as personal communication in Pike and Burkhardt 1974). Although we have not seen type material of *T. albipilosus*, the females and male identified as this species are, in our opinion, *T. americana*. The Colorado record of *T. albipilosus* by Burks (1979) apparently is based on the females collected by Best, discussed above. Finally, we saw a single female in the USNM collection identified as *T. americana* that likely is a voucher specimen from Grigorick (1959). Although this specimen is a misidentification of *T. viridescens*, the host association of *T. americana* with *H. griseola* appears to be valid because there is another female with this labelled host in the USNM collection. It was collected in California in 1953 by WH Lange and may be one of the specimens identified as *Trichomalopsis* sp. in Grigorick. The biological data given in Dobesh et al. (1994) and likely Rivers et al. (1998) for *Trichomalopsis* sp. near *americana* refer to *T. sarcophaga* (see under *T. sarcophaga*).

**Recognition**

When Gahan (1933) originally described *E. americanus* as a parasite of the Hessian fly, *M. destructor*, he described two forms of males based on a difference in eye size. He stated that “the difference between small-eyed and normal-eyed males of this species is so striking that with only a few specimens for examination one would hardly suspect that the two forms are the same species” (Gahan 1933, p 84). Best and Simpson (1975) also reported recovering two forms of males based on eye size and two forms of
females based on leg colour, stating that "generally one form was produced by a given female, although some females produced both" (Best and Simpson 1975, p 1119). We recovered two morphological forms in our survey of Alberta feedlots, one represented by females with infuscate femora and males with large eyes, and another represented by females with uniformly yellow legs and males with small eyes. Because of this, we initially considered that these two forms might constitute a single highly variable species as described by Gahan and Best and Simpson. However, all the paratypic material of Gahan and the few remaining voucher specimens of Best and Simpson which we subsequently examined fell within the limits of the concept of T. americana described herein. A longitudinally carinate St₁ (Fig. 49) and setae on the transverse portion of the sinuate anterolateral margin of Gt₁ (Figs. 37, 38) are the most conspicuous features to distinguish T. americana from the second form that we recovered and identify as T. viridescens.

Among other described North American species, females of T. americana could be confused with Trichomalopsis leguminis (Gahan) because both species have a longitudinally carinate St₁ (Fig. 49). Trichomalopsis leguminis is much rarer based on museum specimens, but we have seen individuals reared from B. curculionis through H. postica. It is therefore possible that T. leguminis could also potentially parasitize filth flies. Specimens of T. leguminis differ from those of T. americana by having Gt₉ and Gt₁ smooth (without coriaceous sculpture) and by lacking setae from the transverse portion of the sinuate anterolateral margin of Gt₁ (cf. Figs. 39, 40). Females of T. leguminis are also somewhat more robust in habitus with a comparatively thicker head; they also have a shorter propodeum with shorter setae on the plicial region, the scape and pedicel are always yellow in distinct contrast to the dark flagellum, and they have a more distinct reticulate sculpture on the flagellum (similar to T. tachinae or T. sarcophagae; cf. Figs. 59b, 60b) compared with T. americana females. Males of T. leguminis are slightly short winged. A relatively few macropterous individuals assigned to Trichomalopsis subaptera (Riley) also have a longitudinally carinate St₁ and have coriaceous sculpture on at least Gt₉ if not also on Gt₁. Individuals of T. subaptera do not have setae on the anterolateral sinuate margin of Gt₁, the propodeum lacks a median carina and has a posteriorly obsolete parapleurar furrow and carina (cf. Figs. 31, 32), and in macropterous individuals the costal cell is bare at least medially (sometimes setose only apically; cf. Fig. 66b) (see further under T. tachinae). Trichomalopsis subaptera appears to be host specific, reared principally from the Hessian fly or from one of its primary parasitoids (Noyes 1998), and is not likely to be recovered as a parasitoid of filth flies.

**Trichomalopsis dubia** (Ashmead)
(Figs. 4, 13, 14, 21, 27, 35, 36, 50, 57, 58, 62, 66a)


Paragraphotypes: two point-mounted specimens of undetermined sex. One specimen labelled as for lectotype except with "Type No. 41240 U.S.N.M."

**Meraporus dubius** Ashm. ♂ lacks head, metasoma, wings (about basal one-third of left forewing remaining in glue), right middle leg beyond coxa, right hind leg entirely, and apical tarsomeres of left middle and hind legs. One specimen labelled as
for lectotype except with “Paratype No. 41240 U.S.N.M.” and without name label lacks head, metasoma, right set of wings and right middle and hind legs. One slide labelled “Meroporus dubius Ashm. ♀ type” with crushed head, one middle leg beyond coxa, one complete antenna, and one scape plus pedicel probably belongs to the first designated paratype.

Although labels designate the three specimens as type, allotype, and paratype, a holotype was not fixed in the original publication and all the specimens have equal status for lectotype designation. The only individual with a complete head and metasoma is the one we select as lectotype. This female is labelled as a male, but the label has three pinholes in it, which indicates the label was removed from the pin at least three times in the past and might have been transferred from one of the other pins. The description of the metasoma given for the male in the original description does not match the metasoma glued to the point and one of the other two broken specimens must be the described male.

Eup teromalus dubius; Gahan, 1921: 240.
Trichomalopsis dubia; Grissell in Figg et al. 1983: 962.

Description

Female. Body dark with variably distinct green metallic luster, except metasoma sometimes completely dark, nonmetallic. Legs beyond coxae yellow. Antenna with scape entirely yellow or brownish apically for length less than or equal to length of pedicel; pedicel yellow to brown; flagellum brown to yellowish brown. Head in frontal view slightly transverse (HW:HH = 1.21–1.30) (Fig. 4), in dorsal view strongly transverse (HW:HL = 2.02–2.17), and in lateral view relatively thin (HH:HL = 1.55–1.70), lenticular to ovate, with lower face angled at obtuse angle to upper face; lower face with clypeus usually noticeably flat or depressed compared with slightly convex paracypeal region and paracypeal region protruding slightly beyond clypeal margin. Eye not conspicuously large (EH:EW = 1.40–1.55, MS:EH = 0.43–0.51, MS:EW = 0.63–0.76, Db:E:EH = 1.29–1.48) (Fig. 4). Mandibular formula 4:4 (cf. Fig. 2). Flagellum widening gradually toward clava (Fig. 57a), with f1 and f2 basal to sensilla shiny between setal sockets, without reticulate sculpture (Fig. 57b); f3 variably distinctly transverse but always less than one-half length of f2 (Fig. 57b); f4 and subsequent segments obviously longer than wide (Fig. 57) to slightly transverse (Fig. 58). Pronotum with reticulate sculpture of neck extending over anterior of collar, without pronotal carina (Fig. 21). Mesosoma in lateral view relatively compressed with dorsal surface low convex (Fig. 27), MS:L:MSH = 1.82–2.07, Frenum sculptured similar to rest of scutellum, the reticulations usually of slightly different size but of similar depth (Figs. 21, 35). Propodeum with or without median carina but at least with distinct, sinuate parapsiracular furrow and strong parapsiracular carina from base to nucha (Figs. 35, 36); callus bare behind spiracle (Fig. 35) but with long setae lateral to spiracle usually projecting over nonsetose area (Fig. 36). Forewing with complete line of setae on ventral surface of costal cell (Fig. 66a); MV:STV = 1.48–1.91. Metasoma with Gt1 of air-dried specimens occupying less than one-half length of gaster, smooth and shiny, and with at most 1 setae projecting from lateral portion of sinuate anterolateral carinate margin (Figs. 27, 35, 36); Gt1 and Gt2 smooth and shiny, Gt3–Gt5 smooth and shiny or with obscure transverse band of coriaceous sculpture, and subsequent terga more distinctly coriaceous; St1 with median ridge and strongly concave, elongate triangular paramedial regions, the concave regions smooth and shiny or at most with only extremely fine and obscure coriaceous sculpture (Fig. 50).

Male. Colour similar to that of female except legs beyond coxae and antennae always yellow. Structure similar to that of female with MS:EH = 0.42–0.55, MS:EW = 0.58–0.69, and Db:E:EH = 1.29–1.88, but in frontal view lower face comparatively
broad with genae angulate (Fig. 13) and in frontolateral view paraclypeal region slightly convex or buccate relative to flat or depressed clypeus (Fig. 14), and paraclypeal margin extending slightly below level of clypeal margin. Flagellum gracile-clavate with f1–f4 all longer than wide (Fig. 62). Forewing with MV:STV = 1.59–1.85. Gt1 covering at most about two-thirds length of gaster in air-dried individuals (cf. Fig. 42) and strongly transverse, 0.42–0.55 as long as maximum width; Gt1 and Gt2 without coriaceous sculpture.

Distribution

CANADA: ¹Alberta (CNCl), ¹British Columbia (CNCl), ¹Manitoba (JBWM), ¹Ontario (CNCl, DEBU, UCDC), ¹Quebec (CNCl, UCDC), ¹Saskatchewan (CNCl).
UNITED STATES: ¹Colorado (USNM), ¹Connecticut (USNM), ¹Delaware (USNM), *District of Columbia, *Illinois, *Indiana, ¹Idaho (ISU), ¹Iowa, ¹Maryland (USNM), ¹Massachusetts (ISUI), ¹Michigan (ISUI, USNM), *Minnesota, *Missouri, ¹Nebraska, ¹New Jersey (USNM), *New York, ¹North Carolina (USNM), *Ohio, ¹Oklahoma (INHS, USNM), ¹Pennsylvania (USNM), ¹South Dakota (USNM), ¹Texas (USNM), ¹Virginia (USNM), ¹West Virginia (USNM), *Wisconsin.

Noyes (1998) listed British Columbia as a distributional record for T. dubia, citing Ashmead (1896). Although T. dubia occurs in British Columbia, Noyes’s citation is a lapsus because Ashmead recorded the District of Columbia.

Hosts

DIPTERA—Anthomyiidae: ¹Hylemyia sp. (USNM). Caliphoridae: Cynomya cadaverina Robineau-Desvoidy [as Masiceria myoidea (R.-D.)] in Ostrinia (as Pyrausta) nubilalis (Hübner) (Lepidoptera: Pyralidae) and Papapaema nebris (Guenée) [as Papaipema nitela (Guenée)] (Lepidoptera: Noctuidae) (*Kelsheimer and Neiswander 1928). Muscidae: Haematobia irritans (L.) (Thomas and Morgan 1972); Musca autumnalis DeGeer (*Wylie 1973), M. domestica (*Wylie 1976); Stomoxys calcitrans (L.) (*Hoebbeke and Rutz 1988); Neomyia (as Orthelia) caesarian (Meigen) (Wylie 1973). Oestridae: ¹Hypoderma lineatum (Villers) (USNM). Sarcophagidae: Ravinia querula (Walker) (Wylie 1973). Sciomyzidae: ¹Dictya sp. (USNM); ¹Perthellia seticosa Styskal (USNM). Syrphidae: Toxomerus (as Mesogaster) polita (Say) (*Heiss 1938). Tachinidae: Erinthix (as Pyraustomyia) penitalis (Cqulillet) in ?Papaipema nebris (Guenée) (Decker 1935); ¹Lixophaga sp. (USNM); Lydella radicis (Townsend) (as Masiceria senilis) (Decker 1931) in Papaipema nebris (Guenée) (Ceroma sia (= Masiceria) senilis (Meigen) does not occur in the New World; the use of this name in North America is based on misidentifications of L. radicis according to Arnaud 1978); Lydella thompsoni Herting (as Lydella stabulans griscens Robineau-Desvoidy) in Ostrinia nubilalis (Hübner) (*Baker et al. 1949) and Ostrinia (as Pyrausta) sp. (Blickenstaff et al. 1953). HYMENOPTERA—Braconidae: ¹Bracon (as Microbracn) lutus Provancher in Achatodes zeae (Harris) (Lepidoptera: Noctuidae) (*Balduf 1929, as T. viridescens); ¹Macrocentrus grandi Goidianch in Ostrinia nubilalis (Hübner) (USNM); Microplitis gortynae Riley in Achatodes zeae (Harris) (*Breakey 1950) and in *Papaipema spp. (Lepidoptera: Noctuidae) (*Bird 1927, as T. viridescens); ¹Perilitis coccinellae (Schrank) in Coleomegilla maculata (DeGeer) (as Coleomegilla maculata lengi Timberlake) (Coleoptera: Coccinellidae) (DEBU); Rhogas stigma tator (Say) in Simyra heleni (Grote) (Lepidoptera: Noctuidae) (Franq and O’Neil 1993). Eulophidae: ¹Pedioius foveolatus (Crawford) in Epilachna varivestis Mulsant (Coleoptera: Coccinellidae) (*Zungoli 1979, as T. viridescens). Ichneumonidae: ¹Bathyplectes ansus (Thomson) (USNM) and ¹Bathyplectes curculionis (Thomson) in ¹Hyopa postica (Gyllenhal) (Coleoptera: Curculionidae) (*Puttler 1966, as T. viridescens); ¹Exenterus amictorus (Panzer) in ¹Diprion similis
(Hartig) (Hymenoptera: Diprionidae) (*Mertins and Coppel 1973, as T. viridescens); Lissonota sp. ? brunea Cresson in Achatodes zeae (Harris) (*Breakey 1930); Phaeogynes phyedi Ashmead in Acrobasis rubrifasciella Packard (Lepidoptera: Pyralidae) (*Balduf 1968). LEPIDOPTERA—Lasiocampidae: 1Malacosoma disstria Hubner (USNM). Noctuidae: 1Bellura (as Arzana) sp. (USNM); ? tachinid in 1Pseudaleia unipuncta (Haworth) (CNCI). Pyralidae: 1Diatreae sp. in wild rice (USNM); 1Ostrinia obumbratalis (Lederer) [as Pyrausta ainsliei (Heinrich)] (ISUI, USNM); 1Ostrinia (as Pyrausta) pentitalis (Grote) (ISUI). Tortricidae: 1Epiblema otiosana (Clemens) (USNM), 1Epiblema strensana (Walker) (ISUI).

Biology

Trichomalopsis dubia is a gregarious hyperparasitoid of Lepidoptera puparia and Coccinellidae via Ichneumonoidea and Tachinidae primary parasitoids. Peck (1963) questioned the host records in Decker (1931, 1935) based on Blickenstaff et al. (1953). We did not locate definite voucher specimens from these publications but can find nothing in Blickenstaff et al. to justify Peck’s action. We have seen several series labelled as reared from L. stabulans, but this is a Palearctic species that does not occur in North America. It is possible that the identifications of L. stabulans are misidentifications of L. thompsoni. Trichomalopsis dubia is also a gregarious pupal parasitoid of filth flies and other Diptera, although it is uncertain whether it is always a primary parasitoid or may also act as a hyperparasitoid. Wylie (1976), through rearings, determined that T. dubia can be a primary parasitoid of M. domestica, but Figg et al. (1983) suggested that it might also be a hyperparasitoid of M. domestica, possibly exploiting Muscidifurax sp. (Pteromalidae) as a primary host. In their study, T. dubia was always associated with the emergence of adults of Muscidifurax sp., and occurred several days later. The new records associated with filth flies from Alberta and Manitoba result from reexamination of specimens reported in Floate et al. (1999)b and McKay and Galloway (1999), respectively. The Alberta record is based on three males from a single puparium from Red Deer, 28 August 1996 (CNCI).

Recognition

Trichomalopsis dubia is distinguished from other species of Trichomalopsis associated with filth flies by its distinctly compressed mesosoma with a relatively flat or low convex dorsal surface (Fig. 27). Structure of St₁ will also help distinguish T. dubia from T. viridescens, the species with which it is most often been confused. Individuals of T. dubia have St₁ relatively deeply concave and smooth and shiny paramedially (Fig. 50), whereas individuals of T. viridescens have St₁ shallowly concave and distinctly coriaceous paramedially (Fig. 53). Females of T. viridescens typically also have the scape more extensively brown apically and the pedicel darker brown. A subtle difference in structure of the lower face, the paraclypeal region appearing slightly convex relative to a flat or depressed clypeus, will often also help distinguish females of T. dubia, although this feature is more obvious for males. Males have the cheeks slightly though obviously convex or buccate relative to the clypeus (Fig. 14). As a result, in frontal view the lower face is abruptly angled (Fig. 13) compared to more smoothly curved in males of other species (cf. Figs. 9, 11, 15). Unfortunately, curvature of the dorsal surface of the mesosoma and structure of the lower face are relative features, and other described species, including Trichomalopsis cognata (Gahan), have structures of St₁ that are similar to that of T. dubia. Gahan (1924) described T. cognata from Ohio for a series of specimens reared from the egg masses of three species of spiders. The species has not been reared since, but individuals of the type series (USNM) are similar to those of T. dubia except that the mesosoma is much more robust (MsL about 1.5 times MsH) with a distinctly convex dorsal surface (cf. Fig. 29). Furthermore,
all the funicular segments are subquadrat to slightly transverse (cf. Fig. 58), unlike most specimens we assign to *T. dubia* (Fig. 57). We have seen individuals reared from various hosts which have a structure of St₁ similar to that of *T. dubia* (Fig. 50) and a comparatively robust mesosoma with a distinctly convex dorsal surface. Some of these lack setae from the anterolateral margin of Gt₁ similar to that of *T. cognata* and *T. dubia*, whereas others have two or more setae directed from the sinuate anterolateral margin of Gt₁. Relative length of the funicular segments varies in these specimens, with some females having the basal funicular segments oblong, as for typical *T. dubia* (Fig. 57), and others having at least the first funicular segment and sometimes all funicular segments slightly transverse (Fig. 58) similar to that of *T. cognata* and rare specimens that we assign to *T. dubia* based on mesosomal structure. Specimens with this suite of features sometimes are identified in collections as *Trichomalopsis peregrina* (Graham) or as one of the names previously used for this taxon in North America. Graham (1969) described *T. peregrina* from Europe and stated that in his opinion it was the same as a species that had been introduced from Europe into North America in the early 1900s to control the brown-tail moth, *Euproctis chrysorrhoea* (L.) (Lepidoptera: Lymantriidae). Prior to Graham, the species had been identified as *Eupteromalus nidulans* (Thomson), *Eupteromalus egregius* Förster, or *Eupteromalus hemipterus* (Walker) in North America (Peck 1963). Graham (p 773) further stated that “there is no undoubted record of the true hemipterus from North America,” but he had not seen specimens from North America and based his opinions only on the fact that both the North American and European species are parasitoids of the brown-tail moth (see Graham 1969 and Burks 1979 for discussion of confusion). Graham described the marginal vein as 1.18–1.45 times as long as the stigmal vein in *T. peregrina*, whereas in *T. dubia* the marginal vein is at least 1.45 times as long as the stigmal vein. The females discussed above that are similar to *T. dubia* sometimes have a short marginal vein, similar to that described for *T. peregrina*, and sometimes have a longer marginal vein (up to 1.75 times as long as the stigmal vein) more similar to females of *T. dubia* and *T. cognata*. The females often, although not always, have a relatively long metasoma (cf. Fig. 43), which is one of the features used by Graham (pp 746, 764) to key and differentiate *T. peregrina* females. When associated, males are distinct from *T. dubia* males because they do not have the buccate lower face that is characteristic of *T. dubia* males (Fig. 14). We have not seen type material of *T. peregrina*, but based on specimens reared from *E. chrysorrhoea*, the name *T. peregrina* likely applies to females with an St₁ similar to that of *T. dubia* but with two or three setae directed from the anterolateral margin of Gt₁, a relatively short marginal vein, and often slightly transverse funicular segments. *Trichomalopsis dubia* apparently is also similar in appearance to the European species *Trichomalopsis genalis* (Graham) because of a similarly structured mesosoma and slightly buccate cheeks (Graham 1969). This species was recorded by Graham as a hyperparasitoid of two species that have also been recorded as hosts for *T. dubia*: *C. senilis* and *O. nubilalis*. *Trichomalopsis genalis* was stated to differ from *T. dubia* by having a longer temple and hence less transverse head in dorsal view (cf. Graham 1969, Figs. 618, 623); females were also stated to have slightly transverse funicular segments and males to have at least the basal funicular segments subquadrat (Graham 1969). As noted above, some individuals from North America with this antennal structure (Fig. 58) (none reared from filth flies) we assign to *T. dubia*. A single comprehensive revision of the Palearctic and Nearctic faunas of *Trichomalopsis* is necessary to determine how useful measurements of the marginal vein and funicular segments are for distinguishing species that have an St₁ structure similar to that of *T. dubia* and to determine the number and identities of the species involved.
Trichomalopsis sarcophagae (Gahan)
(Figs. 3, 8, 15, 16, 22, 28, 33, 34, 45, 48, 51, 52, 59, 63)


Paratypes: 4 females, 1 male, and 2 broken specimens without metasomae (? 1♀ and 1♂) labelled as for lectotype except single male labelled as “Allotype” and other specimens labelled as “Paratype.”

Although labels designate specimens of the type series as type, allotype, and paratype, a holotype was not fixed in the original publication and all the specimens have equal status for lectotype designation. We designate the female labelled “type” as the lectotype. There are eight specimens labelled as part of the type series rather than the seven stated in the original description. In addition, there is a single male glued to a card rectangle along with a puparium plus a separate puparium pinned below which are not labelled as part of the type series but which have the other labels of the type series. Additional labels read: “Host puparia of Type No. 18333” and “Pupa det. by C.T. Green as Sarcophaga hunteri Hough and Hemitrichia plankii Walt. Nov. 1923.”

Trichomalopsis sarcophagae; Grissell in Johnson and Miller, 1994: 373.

Description

Female. Body dark with variably distinct green metallic luster, except metasoma sometimes completely dark, nonmetallic. Legs beyond coxae yellow. Antenna with scape entirely yellow or brownish apically for length less than or equal to length of pedicel; pedicel yellow to brownish yellow; flagellum dark brown to black. Head in frontal view slightly transverse (HW:HH = 1.27–1.40) (Fig. 3), in dorsal view strongly transverse (HW:HL = 1.98–2.09), and in lateral view ovate, relatively thick or slightly protuberant at level of antennal insertion, with lower face angled at abrupt angle to upper face (Fig. 8); lower face with clypeus and paraclypeal region similarly convex and paraclypeal region not protruding beyond clypeal margin. Eye not conspicuously large (EH:EW = 1.34–1.46, MS:EH = 0.47–0.53, MS:EW = 0.66–0.79, DB:EH = 1.25–1.49) (Figs. 3, 8). Mandibular formula usually 4:3, rarely 4:4. Flagellum robust–clavate (Fig. 59a) with f1 and f3 basal to sensilla matte with reticulate sculpture (Fig. 59b); f12 distinctly transverse, sometimes subquadrangular and then about twice as long as f1 and one-half as long as f2; f3 longer than wide, subsequent segments decreasing in length to slightly transverse apically (Fig. 59a). Pronotum without prontoral carina, with reticulate sculpture extending from neck over anterior of collar (Fig. 22). Mesosoma in lateral view with dorsal surface distinctly convex (Fig. 28), MsL:MsH = 1.49–1.76. Frenum with abruptly shallower (subeffaced) sculpture than elsewhere on scutellum (Figs. 22, 33, 34). Propodeum (Figs. 33, 34) with or without median carina but median carina not extending to nucha, without distinct paraspiracular furrow and usually without strong paraspiracular carina at least posteriorly near nucha (Fig. 34); callus bare or setose behind spiracle to paraspiracular carina. Forewing with complete line of setae on ventral surface of costal cell (cf. Fig. 66a); MV:STV = 1.23–1.43. Metasoma (Fig. 45) with G1 of air-dried specimens extending at most about one-half length of gaster, smooth and shiny, and with at most 2 setae projecting laterally to posterolaterally from sinuate anterolateral carinate margin (Figs. 33, 34); G1 and G2 smooth and shiny, subsequent terga with or without variably distinct carinate sculpture (usually present at least on apical terga depending on extent terga are retracted) (Fig. 45); St1 with median
ridge and strongly concave triangular paramedial regions, the concave regions shiny with, at most, short basal carinae (Fig. 51).

**Male.** Colour similar to female except antenna entirely yellow or flagellum light brown. Structure similar to that of female, with following ratios: $MS:EH = 0.42-0.53$, $MS:EW = 0.70-0.81$, and $DbE:EH = 1.22-1.42$. Head in frontal view with genae evenly curved to oral cavity (Fig. 15) and clypeus and paraclypeal region evenly convex (Fig. 16). Flagellum gracile-clavate with $f_1$ longer than wide and subsequent segments decreasing in length to slightly transverse apically (Fig. 63a). Forewing with $MV:STV = 1.23-1.42$. $G_1$ covering at most about two-thirds length of gaster in air-dried individuals (cf. Fig. 42) and strongly transverse, 0.34-0.59 times as long as maximum width; $G_1$ and $G_2$ without coriaceous sculpture.

**Distribution**

**CANADA:** *Alberta, **Manitoba** (JBWM), **Saskatchewan** (CNCl). **UNITED STATES:** Arizona, **California** (INHS, UCRC, USNM), *Idaho, *Kansas, Michigan, **Nebraska, **Washington* (USNM).

We were unable to confirm previously published records of *T. sarcophaga* from Arizona and Michigan. A single female from Arizona identified as *T. sarcophaga* in the USNM is a misidentification of *T. leguminis*. Of all the species associated with filth flies, *T. sarcophaga* is recorded from the least number of states and provinces. This may be correlated with the species being reared from fewer economically important hosts than the other species.

**Hosts**

**DIPTERA—Anthomyiidae:** *Delia radicum* (L.) (*Floate et al. 1999a). **Muscidae:** *Musca domestica* L. (*Dobesh et al. 1994; *Lysyk 1995); *Stomoxys calcitrans* (L.) (*Lysyk 1998). **Oestridae:** *Hypoderma bovis* (L.) (CNCl). **Tachinidae:** *Frerarea montana* (Coquillett) in *Amara quensel* (Schönherr) (Coleoptera: Carabidae) (*Johnson and Miller 1994). **Sarcophagidae:** *Blaesoxipha* (as *Sarcophaga*) kelleyi (Aldrich) (*Gahan 1914); *Sarcophaga bullata* Parker (Rivers et al. 1998, as *Trichomalopsis near americana*). **LEPIDOPTERA—Geometridae:** *Semiaothisa* sp. (CNCl). **Nepticulidae:** mine of *Stigmella* sp. (as *Nepticula* sp.) (Frohne 1939). **Noctuidae:** *Heliothis ononis* Denis and Schiffermüller (CNCl); *Trichoplusia ni* Hübner (UCRC). **Pyralidae:** *Loxostege sticticalis* (L.) (CNCl). **Zygaenidae:** *Harrisina metallica* Stretch (as *Harrisina brillians* Barnes and McDunnough) (USNM).

We did not see voucher material of Rivers et al. (1998), but their colony was established from colony material on which the study by Dobesh et al. (1994) was based, which subsequently was identified as *T. sarcophaga* (Floate et al. 1999b).

**Biology**

*Trichomalopsis sarcophaga* is a gregarious primary parasitoid of *M. domestica* and other dipterous hosts. Dobesh et al. (1994) and Lysyk (1998) investigated temperature effects on developmental rates, fecundity, and other life-history parameters of *T. sarcophaga* reared on *M. domestica*, and Lysyk compared parameters of *T. sarcophaga* reared on *M. domestica* and *S. calcitrans*. Floate et al. (1999a) compared parasitism rates and developmental time of *T. sarcophaga* reared on *M. domestica* and *D. radicum* (cabbage root maggot), and Rivers et al. (1998) investigated envenomation and reproductive strategies of *T. sarcophaga* on *S. bullata* (flesh fly). We saw four females from Macleod (= Fort Macleod), Alberta (17 August 1949, J. McInlinock) (CNCl), reared from the northern cattle grub, *H. bovis*, which we provisionally identify as *T. sarcophaga* (see the next section). Johnson and Miller (1994)
also reared *T. sarcophagae* as hyperparasitoid of *A. quenseli* through a tachinid. They recovered 11 specimens but found only a single puparium with an exit hole. Although this suggests that it was gregarious, they doubted whether all recovered specimens could have developed in the single pupa.

**Recognition**

*Trichomalopsis sarcophagae* is distinguished from all other North American *Trichomalopsis* by its unique scutellar sculpture pattern (Figs. 22, 33) in combination with its distinctively “blunt” lower face (Fig. 8). Colour and sculpture pattern of the flagellum also help to distinguish females of *T. sarcophagae* from those of other species associated with filth flies except for *T. tachinae*. In females of *T. sarcophagae* and *T. tachinae* and in females of *T. leguminis* and *T. subaptera* the flagellum is matte with distinct reticulate sculpture beyond fl1 (Figs. 59b, 60b). Usually the scape and pedicel are also much lighter and more distinctly contrasted in colour with the dark flagellum than in the other species. Both sexes of the last three species have the sculpture of the frenum similar to elsewhere on the scutellum or the frenal sculpture is differentiated only by size and not by depth of the reticulations (Figs. 20, 31, 32). In addition, *T. sarcophagae* has a complete line of setae on the ventral surface of the costal cell (cf. Fig. 66a), whereas *T. tachinae* has setae only apically (Fig. 66b). The setal pattern of *T. subaptera* is similar to that of *T. tachinae* or at least the middle part of the cell is bare. Further, both sexes of *T. tachinae* and *T. subaptera* usually have a conspicuously longer Gt1 (Figs. 41, 46) and coriaceous sculpture on Gt2. *Trichomalopsis leguminis* is readily differentiated from *T. sarcophagae* by its longitudinally carinate St1 (cf. Fig. 49).

Although we provisionally identify the four females reared from *H. bovis* as *T. sarcophagae*, they differ in some respects from other females that we identify as this species. Most conspicuously, the females reared from *H. bovis* have the propodeal spiracle separated from the anterior margin of the propodeum by a distance greater than the length of spiracle rather than by a distance only about equal to or less than the width of the spiracle (Figs. 33, 34). Furthermore, the second flagellar segment is distinctly transverse and the propodeum is somewhat shorter and hence more distinctly transverse than in other females. We currently interpret this as infraspecific, possibly host-induced variation.

**Trichomalopsis tachinae (Gahan) comb.nov.**

(Figs. 5, 20, 26, 31, 32, 41, 46, 47, 54, 60, 64, 66b)

*Euteromalus tachinae* Gahan, 1917: 211–212; ♀. Lectotype: ♀, here designated. Lectotype information: “Reared from tachinid parasite of *L. unipuncta*,” “Nashville Tenn,” “WH Larrimer Collector,” “Webster No. 11332,” “Type No 20390 U.S.N.M.,” “Type *Euteromalus tachinae* Gahan ♀ type,” “LECTOTYPE *Euteromalus tachinae* Gahan (Gibson 2000).”

Paralectotypes: 3 females with same labels as lectotype except with USNM “Paratype” labels, plus 3 females mounted on minute pins labelled: “Guelph Canada,” “A.W. Baker Collector,” “7,” “ex. *Leucania unipuncta*.” Although the type locality was given as “Nashville, Tennessee” in the original description, 5 species from Guelph (Ontario), Canada, were listed and not explicitly excluded from the type series.

**Description**

**Female.** Body dark with variably distinct green metallic luster, except metastoma sometimes completely dark, nonmetallic. Legs beyond coxae yellow or with femora and
tibiae more orangy-yellow. Antenna with scape entirely yellow or brownish apically for length less than or equal to length of pedicel; pedicel usually brownish, intermediate in colour between scape and darker brown to black flagellum. Head in frontal view slightly transverse (HW:HH = 1.25–1.40) (Fig. 5), in dorsal view strongly transverse (HW:HL = 2.14–2.45), and in lateral view often appearing more or less wedge-shaped, relatively thick or slightly protuberant at level of antennal insertion (HH:HL = 1.68–1.84) with lower face angled at obtuse angle to upper face and tapered dorsally toward vertex; lower face with clypeus and paraclypeal region similarly convex and paraclypeal region not protruding beyond clypeal margin. Eye relatively large (EH:EW = 1.42–1.66, MS:EH = 0.38–0.44, MS:EW = 0.56–0.69, DbE:EH = 1.33–1.43) (Fig. 5). Mandibular formula 4:3. Flagellum stout, compact (Fig. 60a) with fl₂ and fl₃ basal to sensilla matte with reticulate sculpture (Fig. 60b); fl₁ subquadrate to distinctly wider than long but about twice as long as fl₁ and one-third to one-half as long as fl₃ (Fig. 60b); fl₃ longer than wide, subsequent segments decreasing in length to transverse apically (Fig. 60a). Pronotum without pronotal carina, reticulate sculpture extending from neck over anterior of collar (Fig. 20). Mesosoma in lateral view with dorsal surface distinctly convex (Fig. 26), MSL:MSH = 1.57–1.70. Frenum sculptured as for rest of scutellum, the reticulations usually of slightly different size but of similar depth (Figs. 20, 31). Propodeum (Figs. 31, 32) without median carina except possibly at extreme base and with parapsiracular furrow and parapsiracular carina usually obsolete posteriorly toward nucha; callus densely setose behind spiracle to plical region. Forewing with line of setae on ventral surface of costal cell over at most apical half of cell (Fig. 66b); MV:STV = 1.29–1.48. Metasoma with G₄ extending at least slightly over one-half length of gaster (Fig. 47) and usually to much greater extent in air-dried specimens (Fig. 46), smooth and shiny, with several curved setae extending posterolaterally from along sinuate anterolateral carinate margin (Figs. 31, 32); G₅ smooth and shiny when exposed; S₅ with median ridge and strongly concave paramedial triangular region, the region usually coriaceous and often subdivided by finer oblique carina (Fig. 54).

Male (all measurements n = 7). Colour similar to that of female except antenna either entirely yellow or, much more commonly, pedicel, clava, and sometimes apical funicular segment brown. Structure similar to that of female with following ratios: MS:EH = 0.35–0.40, MS:EW = 0.44–0.58, and DbE:EH = 1.20–1.33. Head in frontal view with genae evenly curved to oral cavity and clypeus and paraclypeal region evenly convex. Flagellum clavate with all funicular segments longer than wide (Fig. 64). Forewing with MV:STV = 1.27–1.35. G₅ usually bell-shaped and covering at least two-thirds length of gaster in air-dried individuals, 0.70–0.98 times as long as maximum width, and without coriaceous sculpture (Fig. 41).

Distribution


Hosts

Biology

Although Blume (1970), reared T. tachinae from bovine droppings in an ecological study of H. irritans, the species might well have been a parasitoid of some other species in the dung and probably is a hyperparasitoid. Blickenstaff et al. (1953) reared T. tachinae as a gregarious parasitoid of O. nubilalis and quoted Gahan in lit. as considering it probable that it was a hyperparasitoid through some tachinid. The species is a known hyperparasitoid of B. curculionis.

Recognition

Trichomalopsis tachinae is usually readily distinguished from other Trichomalopsis associated with filth flies because of its unusually large Gt, which in air-dried females usually is at least two-thirds the length of the gaster (Fig. 46), though rarely only slightly more than one-half the length of the gaster. A Gt, that covers less than two-thirds the total length of the gaster is most apparent in critical-point-dried females (Fig. 47), which usually have the posterior segments extended to a much greater extent than in air-dried females (Fig. 46). Males also have a large Gt, (Fig. 41), with the extent to which it covers the rest of the terga being highly variable because of the degree to which the terga can telescope. Trichomalopsis tachinae differs from other species associated with filth flies by its costal setal line. In T. tachinae the line of setae on the ventral surface of the costal cell extends only about the apical one-third of the cell (Fig. 66b) as compared with a complete line of setae (Fig. 66a) in the other species. A costal cell that is completely bare basally is also characteristic of some macropterous individuals that are assigned to T. subaptera. Such macropterous individuals resemble T. tachinae because they have a similar antennal structure and sculpture (cf. Fig. 60), usually a large Gt, (cf. Figs. 41, 46), and an obsolescent paraspiracular furrow and carina (cf. Figs. 31, 32). Males of T. subaptera sometimes also have a yellow antenna with the flagellum apically brown, although the pedicel is always yellow unlike in most T. tachinae males. Macropterous females of T. subaptera differ from those of T. tachinae by lacking setae from the sinuate anterolateral margin of Gt, (cf. Figs. 39, 40), by having the callus bare in the region posterior to and mesal to the spiracle, and usually by having a more yellowish pedicel (similar in colour to the scape). Both sexes of T. subaptera can be subapterous to fully winged (Gahan 1933). Subapterous individuals always have a few scattered setae or a broadly interrupted transverse row of setae across about the middle to apical one-third of Gt,. Macropterous individuals often lack these dorsal setae and have only about the middle one-third of the costal cell bare, the costal cell having a few setae in a line basally as well as apically. We saw a single male from Utah (USNM) that we tentatively identify as T. subaptera because Gt, and Gt, have coriaceous sculpture, the costal cell is setose basally as well as apically, and there is an entire, distinct paraspiracular furrow and carina, though this male also has several setae on the anterolateral sinuate margin of Gt, similar to that for T. tachinae males. Other macropterous males that we assign to T. subaptera do not have coriaceous sculpture on Gt, or Gt, and are similar in appearance to T. tachinae males except that the anterolateral sinuate margin of Gt, does not have setae, the callus is bare in the region posterior to and mesal to the spiracle (excluding setae along the extreme posterior margin of the propodeum), and the costal cell has a few setae basally. Based on observed variability in structure of St, for T. subaptera [either coriaceous (cf. Fig. 53) or carinate (cf. Fig. 49) in both macropterous and subapterous forms; see under T. americana], presence or absence of coriaceous sculpture and dorsal setae on Gt,, and different setal
patterns of the costal cell, more than one species may be included within current concepts of T. subaptera.

**Trichomalopsis viridescens (Walsh)**
(Figs. 2, 11, 12, 18, 23, 24, 29, 39, 40, 42, 53, 56, 65)

*Glyphye viridescens* Walsh, 1861: 364, 370; 9. **Note:** The types of *G. viridescens* are lost (Gahan 1921). Our concept of this name is based on the remains of 3 females and 3 males reared in 1875 from the army worm, *P. unipuncta*, and labelled as "*Glyphye viridescens* Walsh" by CV Riley, which according to Gahan (1921, p 241) were reared by Riley, "fit Walsh's description perfectly," and "are undoubtedly representative of the species to which he [Walsh] gave the name *Glyphye viridescens*.”

*Glyphye viridescens*; Walsh, 1865: 11, 463 (valid emendation).
*Gastrancistrus viridescens*; Dalla Torre, 1898: 205.
*Hypopteromalus viridescens*; Girault, 1912[113]: 31–46 (in part).

**Description**

**Female.** Body dark or with variably distinct green metallic luster on head and mesosoma. Legs beyond coxae yellow or with femora and tibiae darker orange to brownish except for knees and tibiae apically. Antenna with scape yellowish over about basal one-third or more but brownish apically; pedicel brown; flagellum brown to yellowish brown. Head in frontal view slightly transverse (HW:HH = 1.24–1.32) (Fig. 2), in dorsal view strongly transverse (HW:HL = 2.03–2.13), and in lateral view relatively thin (HH:HL = 1.57–1.67), lenticular with lower face angled at obtuse angle to upper face (cf. Fig. 7); lower face with clypeus and paraclypeal region similarly convex and paraclypeal region not protruding beyond clypeal margin. Eye not conspicuously large (EH:EW = 1.28–1.47, MS:EH = 0.48–0.59, MS:EW = 0.60–0.77, DbE:EH = 1.21–1.44) (Fig. 2). Mandibular formula 4:4 (Fig. 2). Flagellum widening gradually toward clava (Fig. 56a), with fl2 and fl3 basal to sensilla shiny between setal sockets, without reticulate sculpture (Fig. 56b); fl2 variably distinctly transverse but always obviously less than one-half the length of fl3 (Fig. 56b); fl3 slightly to distinctly longer than wide and subsequent segments longer than wide to subquadrates apically (Fig. 56a). Pronotum usually with definite pronotal carina (Figs. 23, 24). Mesosoma in lateral view with dorsal surface distinctly convex (Fig. 29); MsL:MsH = 1.47–1.65. Frenulum sculptured the same as rest of scutellum, the reticulations usually of slightly different size but of similar depth (Figs. 23, 29). Propodeum (Figs. 39, 40) usually with median carina but at least with distinct, sinuate paraspircular furrow and strong paraspircular carina from base to nucha; callus bare behind spiracle to paraspircular carina, though with long setae lateral to spiracle projecting over non-setose area. Forewing with complete line of setae on ventral surface of costal cell (cf. Fig. 66a); MV:STV = 1.33–1.91. Metasoma with Gt1 of air-dried specimens occupying less than one-half length of gaster, smooth and shiny, and without setae on sinuate anteriolateral carinate margin (Figs. 39, 40); Gt1 and Gt2 smooth and shiny, Gt3–Gt4 smooth and shiny or with obscure transverse band of coriaceous sculpture, and subsequent terga more distinctly coriaceous; St1 with median ridge and paramedially shallowly concave with distinct coriaceous sculpture (Fig. 53).

**Male.** Colour similar to that of female. Structure similar to that of female with following ratios: MS:EH = 0.53–0.66, MS:EW = 0.69–0.86, and DbE:EH = 1.20–1.47. Head in frontal view with lower face sometimes relatively broad and with gena moderately angulate relative to oral margin (Fig. 11) but not distinctively buccate (Fig. 18). Flagellum clavate with all funicular segments longer than wide (Fig. 65). Forewing with
MV:STV = 1.59–1.95. Gt, covering at most about two-thirds length of gaster in air-dried individuals (Fig. 42) and transverse, 0.40–0.66 times as long as maximum width; Gt, and Gt2 without coriaceous sculpture.

**Distribution**


We also saw specimens (USNM) labelled “So Amer. Paras. Lab” but without additional locality data.

**Hosts**

**DIPTERA—Cecidomyiidae:** *Mayetiola (as Phytophaga) destructor* (Say) (USNM). **Chloropidae:** *Liohippelates (as Hippelates) collutor* (Townsend) (USNM). **Drosophilidae:** *Drosophila sp.* (USNM). **Ephyridae:** *Hydrellia griseola* (Fallen) (*Grigarick 1959, as T. americana). **Musciidae:** *Haematobia irritans* (L.) (Peck 1974 based on *Depner 1968); *Musca domestica* L. (based on *Hoebeke and Rutz 1988; *Floate et al. 1999*; and USNM specimens). **Sarcophagidae:** *Opelousia* sp. in snail (USNM). **Syrphidae:** *syrphid puparium* (USNM). **Tachinidae:** *Eriothis* (as *Pyrastomyia) penialis* (Coquillett) in *Ostrinia obumbratalis* (Lederer) [as *Pyrausta ainsliei* (Heinrich)] (Lepidoptera: Pyralidae) (Blickenstaff et al. 1953).

**HYMENOPTERA—Braconidae:** *Apanteles sp.* in *Manduca* (as *Phlegethonius quinquemaculata* (Haworth)) (Lepidoptera: Sphingidae) (Girault 1912); *Apanteles sp.* in *Ochloides sylvanoides* (Boisdruval) (Lepidoptera: Hesperiidae) (Essig 1926); *Apanteles sp.* in *Phylctaenia coronata* (Hufnagel) [as *Phylctaenia tertia]is* (Guenée)] (Lepidoptera: Pyralidae) (Balduf 1929); *Apanteles sp.* in *Sphecodina abbotii* (Swainson) (Lepidoptera: Sphingidae) (Girault 1912); *Apanteles sp.* in *Spadastiba* (as *Laphycoma frugiperda* (Smith) (Lepidoptera: Nocidae) (Hofmaster and Greenwood 1949); *Bracon* (as *Microbracon) cauliola* (Gahan) in *Papaipema nebris* (Guenée) (Lepidoptera: Noctuidae) (Deckers 1935); *Cotesia (as Apanteles) congregata* (Say) in *Ceratomia catalpa* (Boisdruval) and *Manduca* (as *Phlegethonius) sexta* (L.) (Lepidoptera: Sphingidae) and *Pseudoletia* (as *Heliophila) unipuncta* (Haworth) (Lepidoptera: Noctuidae) (Girault 1912); *Cotesia limenitidis* (Riley) in *Pseudaletia unipuncta* (Haworth) (Girault 1912); *Cotesia (as Apanteles) marginiventris* (Cresson) in *Hymenia fascialis* Cramer (Lepidoptera: Pyralidae) (Poos 1928); *Cotesia orobena* (Forbes) in *Evergestis rimosalis* (Guenée) (Lepidoptera: Pyralidae) (Gaines and Kok 1995); *Cotesia pluteellae* (Kurdjimov) (USNM); *Cotesia* (as *Apanteles) smerinthis* (Riley) (Girault 1912); *Glyptapanteles* (as *Apanteles) militaris* (Walsh) in *Leucania* (as *Cirphis) latiuscula* Herrich-Schäffer (*Vickery 1926* and *Pseudoletia unipuncta* (Haworth) (Riley 1870) (Lepidoptera: Noctuidae); *Lathrapanteles* (as *Apanteles) papaipemae* (Muesebeck) (Decker 1935); *Macrocentrus pallisteri* DeGant (Decker 1935); *Microplitis ceratomiae* (as *M. catalpa*) Riley in *Ceratomia catalpa* (Boisdruval) (Girault 1912); *Microplitis gortynae* Riley in *Achatodes zae* (Harris) (Balduf 1929) and *Papaipema nebris* (as *P. nitelae* (Guenée) (Balduf 1929) (Lepidoptera: Noctuidae).

**Ichneumonidae:** *Bathyplectes curculionis* (Thomson) in *Hypera postica* (Gyllenhall) (Coleoptera: Curculionidae) (Hamlin et al. 1949); *Pike and Burkhardt 1974); *Cryptochneumon* (as *Amblytes) astutus* (Holmgren) (Essig 1926); *Diadegma* (as *Horogenes) insulare* (Cresson) [as *Angitia hellulae* (Viereck)] in *Plutella xylostella* (L.)
[as *P. maculipennis* (Curtis)] (Lepidoptera: Plutellidae) (*Walker and Anderson 1936; Harcourt 1960); ichneumonid in *Pseudaletia unipuncta* (Haworth) (Walsh 1861).

**LEPIDOPTERA—Noctuidae**: *Hemerocampa leucostigma* (J.E. Smith) (Walsh 1865), *Sphinxidae*: Darapsa (as *Ampelophaga*) myron (Cramer) (Girault 1912); *Smerinthus jamaicensis* (Drury) (as *Smerinthus geminatus* Say) (Girault 1912); *Sphink kalmiae* Smith (in some “microgaster cocoon”) (Girault 1912).

**Erroneous host records**

**Hymenoptera—Braconidae**: *Bracon* (as *Microbracon*) *luts* Provancher in *Achatodes zeae* (Harris) (Lepidoptera: Noctuidae) (*Balduf 1929, see T. dubia*; *Microlis gortynae* Riley in *Papaipema* spp. (Lepidoptera: Noctuidae) (*Bird 1927, see T. dubia*; *Cotesia* (as *Apanteles*) *medicaginis* (Muesebeck) in *Colias eurytheme* Boisduval (Lepidoptera: Pieridae) (*Allen and Smith 1958, see T. americana*), *Eulophidae*: *Pediobius foveolatus* (Crawford) in *Epilachna varivestis* Mulsant (Coleoptera: Coccinellidae) (*Zungoli 1979, see T. dubia*). **Ichneumonidae**: *Bathyplectes curculionis* (Thomson) in *Hypera postica* (Gyllenhal) (Coleoptera: Curculionidae) (Putler 1966, see T. dubia); *Exenterus amictorius* (Panzer) in *Dipron similis* (Hartig) (Hymenoptera: Diprionidae) (*Mertins and Coppel 1973, see T. dubia*).

**Biology**

*Trichomalopsis viridescens* is a primary and likely a solitary parasitoid of *M. domestica*. Of the specimens originally identified as *Trichomalopsis* sp. in Floate *et al*. (1999b), we identified 20 individuals (CNCI) of *T. viridescens*. Only solitary individuals were reared from puparia that were reared separately (Floate *et al*. 1999b), although the method of rearing was insufficient to determine whether *T. viridescens* was solitary in all instances. It was not possible to determine whether three female voucher specimens (CNCI) of *T. viridescens* from Depner (1968) were reared individually, although two specimens have the same labels. We also saw 29 voucher specimens (CUCI, USNM) of *Trichomalopsis* sp. reared from *M. domestica* sentinel puparia in New York (Cayuga Co.) during 1983–1985, on which the studies of Hoebeke and Rutz (1988) and Smith and Rutz (1991a, 1991b) are based. Of these, two females and one male (CUCI) are *T. viridescens*, whereas the other specimens were correctly identified as *T. dubia*. Finally, the USNM collection has one female from Ohio and three females from Missouri labelled as reared from *M. domestica*.

*Trichomalopsis viridescens* appears to be a hyperparasitoid of the prepupal and pupal stages of various lepidopterous hosts through mostly braconid and ichneumonid primary parasites. Most host records and published biological data for *T. viridescens* should be considered as unreliable. The species was generally considered to be a synonym of *Hypopteromalus tabacum* (Fitch) (Pteromalidae) until Gahan (1921). We are uncertain which of the host records given in Girault (1912) are valid records for *T. viridescens* and which are incorrect records based on misinterpretation of *H. tabacum*. More recently, *T. viridescens* has often been confused with *T. dubia*. For example, of 39 collection records that originally made up the *T. viridescens* collection of the USNM, only 14 proved to be *T. viridescens*, whereas 22 were *T. dubia*, two were *T. americana*, and one was *T. sarcophagae*. The misidentifications included some localities in states which we have been unable to confirm for *T. viridescens*. Furthermore, about 40 hosts are recorded in the literature for *T. viridescens*. Excluding records relating to flies, we were able to locate definite voucher specimens for only 10 publications citing host records, of which five were based on misidentifications of *T. dubia* and one on a misidentification of *T. americana*. It seems likely that some of the other species listed above as putative hosts are inaccurate, possibly based on misidentifications of *T. dubia*. This may explain why *T. viridescens* has sometimes been reported in the
literature as a gregarious hyperparasitoid (Balduf 1929; Bird 1927; Blickenstaff et al. 1953; Puttler 1966; Rethwisch and Manglitz 1986) and sometimes as a solitary hyperparasitoid (Gilmore 1938; Gaines and Kok 1995). It is possible that the records recording *T. viridescens* as a gregarious species are all based on misidentifications of *T. dubia*.

**Recognition**

A distinct pronotal carina (Figs. 23, 24), when present, helps to distinguish individuals of *T. viridescens* from other North American species of *Trichomalopsis*. The species is also readily distinguished from other species of *Trichomalopsis* associated with filth flies by its comparatively shallowly concave and distinctly coriaceous St₂ (Fig. 53). Most *T. subaptera* have an St₂ structure similar to that of *T. viridescens*, and females of *T. tachinae* have an St₂ with a finer coriaceous sculpture (Fig. 54). Macrapterous individuals of *T. subaptera* have the scape entirely yellow, the costal cell is bare at least medially, and the propodeum lacks a median carina and has a posteriorly obsolescent paraprocticular furrow and carina (cf. Figs. 31, 32). Individuals of *T. tachinae* are distinguished by the setal pattern of their costal cell (Fig. 66b) among other features (see *T. tachinae*). The new host record, *Cotesia plutellae*, is based on two females from Hawai'i, which is the first record of *T. viridescens* outside of continental North America. The only other species of *Trichomalopsis* recorded as a parasitoid of *C. plutellae* is *Trichomalopsis apantelocleta* (Crawford) from the Palearctic and Oriental regions (Noyes 1998). Based on examination of type material (USNM), *T. apantelocleta* is easily differentiated from *T. viridescens* by the presence of several setae on the sinuate anterolateral margin of GT₁ in combination with a structure of St₂ that is similar to that of *T. dubia* (cf. Fig. 50).

**Conclusions**

Much has been written on the role of systematics in biological control and the importance of correct identifications of the pest species and beneficial parasitoids for successful biological control (e.g., Clausen 1942; Compere 1969; Danks 1988; Schauff and LaSalle 1998). Noyes (1994) listed misidentification of either the host or parasitoid species due to “inadequate” or “poor” taxonomy and unrecognized mixed series of parasitoids as two of several possible reasons for erroneous host-parasitoid records. Both of these factors are illustrated by previous identifications of species of *Trichomalopsis*. Four of five species were incorrectly or incompletely identified when first recorded in the literature as parasitoids of filth flies and our reexamination of specimens revealed more than one species in some previously identified series. The problem of inadequate taxonomy results primarily from the lack of modern, well-illustrated revisionary studies of the species for most insect genera, which certainly will remain a chronic problem because of the few taxonomists available relative to the existing fauna (see Grissell 1999). However, even when taxonomic studies are completed to enable accurate identification of economically important species in the future, it is not possible to confirm previously published distributional or biological information if biological-control workers and other biologists do not retain sufficiently representative series of well-preserved and appropriately labelled voucher specimens (see Huber 1998). Collector and date label data allowed us to confirm or correct some previous identifications based on presumed voucher specimens for some publications, though we did not see a single specimen specifically labelled as a voucher specimen. Our inability to locate voucher specimens for many publications results in unreliable host lists for most of the species and such uncertainties as whether *T. viridescens* is a solitary or gregarious parasitoid. All the species of *Trichomalopsis* known to parasitize filth flies in North America appear to be both
Figures 1–6. 1–5, ♀ head, frontal: 1, Trichomalopsis americana; 2, Trichomalopsis viridescens; 3, Trichomalopsis sarcophagae; 4, Trichomalopsis dubia; 5, Trichomalopsis tachinae. 6, Trichomalopsis americana, ♀ head, posterolateral. DdB, minimum distance between eyes; HH, head height; HW, head width. Scale bars in micrometres.
Figures 7-12. Head. 7, Trichomalopsis americana ♀, lateral; 8, Trichomalopsis sarcophaga ♀, lateral; 9, Trichomalopsis americana ♂, frontal; 10, Trichomalopsis americana ♂, lateral; 11, Trichomalopsis viridescens ♂, frontal; 12, Trichomalopsis viridescens ♂, lateral. EH, eye height; EW, eye width; HL, head length; MS, malar space. Scale bars in micrometres.
Figures 31–36. 31 and 32, ♀ propodeum, *Trichomalopsis tachinae*: 31, posterior; 32, posterolateral. 33 and 34, ♀ propodeum, *Trichomalopsis sarcophaga*: 33, posterior; 34, posterolateral. 35 and 36, ♀ propodeum, *Trichomalopsis dubia*: 35, posterior; 36, posterolateral. als, anterolateral setae; bls, basolateral setae; cal, calulus; nuc, nucha; ppr, propodeal plical region; psc, paraspiracular carina; psf, paraspiracular furrow. Scale bars in micrometres.
Figures 43–48. 43–47, ♀ metasoma, dorsal: 43, Trichomalopsis americana (box outlines area of enlargement for Fig. 44); 44, Trichomalopsis americana, sculpture of Gt1; 45, Trichomalopsis sarcophaga; 46, Trichomalopsis tachinae (air-dried); 47, Trichomalopsis tachinae (critical-point dried). 48, Trichomalopsis sarcophaga ♀, junction of mesosoma and metasoma. Gt1, first gastral tergite; ptl, petiole; St1, first gastral sternum. Scale bars in micrometres.
Figures 49–54. Anterior margin of St₁, ventral: 49, Trichomalopsis americana ♂; 50, Trichomalopsis dubia ♀; 51, Trichomalopsis sarcophagae ♀; 52, Trichomalopsis sarcophagae ♂; 53, Trichomalopsis viridescens ♀; 54, Trichomalopsis tachinae ♀. Scale bars in micrometres.
Figures 55–60. ♀ antenna: 55, Trichomalopsis americana (55a, entire; 55b, anelli + fu₁); 56, Trichomalopsis viridescens (56a, entire; 56b, anelli + fu₁); 57, Trichomalopsis dubia (57a, entire; 57b, anelli + fu₁ and fu₂); 58, Trichomalopsis dubia (58a, entire; 58b, anelli + fu₁ and fu₂); 59, Trichomalopsis sarcophagae (59a, entire; 59b, anelli + fu₁); 60, Trichomalopsis tachinae (60a, entire; 60b, anelli + fu₁). an, anelli; cl, clava; fl, flagellar segment; fu, funicle. Scale bars in micrometres.
FIGURES 61–66. 61–65, ♂ antenna: 61, Trichomalopsis americana (61a, entire; 61b, anelli + fu₁); 62, Trichomalopsis dubia (62a, entire; 62b, anelli + fu₁); 63, Trichomalopsis sarcophagae (63a, entire; 63b, anelli + fu₁); 64, Trichomalopsis tachinae (64a, entire; 64b, anelli + fu₁); 65, Trichomalopsis viridescens (65a, entire; 65b, anelli + fu₁); 66, ventral surface of costal cell (66a, Trichomalopsis dubia; 66b, Trichomalopsis tachinae). Scale bars in micrometres.
primary parasitoids of various Diptera and hyperparasitoids of Lepidoptera, Coleoptera, and rarely other hosts. This indicates that their potential host range includes a diversity of hosts in brownish puparia or cocoons. Species of Trichomalopsis have been reared from filth flies in relatively few areas in the United States (California, Missouri, Nebraska, New York, Ohio) and Canada (Alberta, Manitoba, Ontario), but this probably reflects existing surveys because known distribution of all the species is much greater. Alberta is by far the most extensively surveyed of all the areas (Floate et al. 1999b) and is the only state or province to have all the species (excluding T. tachinae) recorded as parasitoids of M. domestica and other filth flies. More comprehensive surveys in other areas likely will also recover the species.

Acknowledgements

We thank the curators listed in the Materials and methods section for the loan of specimens on which this study was based. Jennifer Read (Eastern Cereal and Oilseed Research Centre) produced the scanning electron photomicrographs and the plates of illustrations. John Huber (Canadian Forest Service, Ottawa) and Peter Mason are also thanked for critically reviewing the manuscript.

References


Balduf WV. 1929. Bioluminescent notes on some parasites of Achetaodes zeae Harris (Noctuidae, Lep.) and Phlyctaenius tertialis (Guen.) (Pyralidae, Lep.). Ohio Journal of Science 29: 218–42


Burks BD. 1958. Superfamily Chalcidoidea, pp 62–84 in KV Krombien (Ed), Hymenoptera of America north of Mexico — sympatric catalog. United States Department of Agriculture Agricultural Monograph 2 (first supplement)
Volume 133

THE CANADIAN ENTOMOLOGIST

83


Clausen CP. 1942. The relations of taxonomy to biological control. Journal of Economic Entomology 35: 744–8


Dalla Torre KW von. 1898. Catalogus Hymenopterorum hucusque descriptorum systematicus et synonymicus. V. Chalcididae et Proctotrupoidea. Leipzig


Decker GC. 1931. The biology of the stalk borer Papaipema nebris (Gn.). Iowa Agricultural Experiment Station Research Bulletin 143: 289–351


— 1933. The sorphoid and chalcidoid parasites of the Hessian fly. United States Department of Agriculture Miscellaneous Publication 174

Gaines DN, Kok LT. 1995. Cotesis oroebanae (Hymenoptera: Braconidae), a gregarious endoparasitoid of Evergestis rimosalis (Lepidoptera: Pyralidae), and hyperparasitoids in Virginia Brassica crops. Biological Control 5: 573–80


— 1917[330]. Descriptions Hymenoptera Chalcidoicarum variorum cum observationibus. V. Glendale, Maryland: private publication


Riley CV. 1870. Annual report of the Missouri State Board of Agriculture 5


Thomson CG. 1878. *Hymenoptera Scandinaviae S. Pteromalus (Svederus) continuatio*. Lund, Sweden


(Received: 20 June 2000; accepted: 11 October 2000)