

Revision of the *asychis* species group of *Aphelinus* (Hymenoptera: Aphelinidae)

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Abstract

Aphelinus (Hymenoptera: Aphelinidae) is a genus of parasitoid wasps that has a long history of use in biological control programs against aphids. Past research shows that species delimitation within *Aphelinus* is greatly complicated by lack of comprehensive literature and the existence of cryptic species complexes. One of these complexes is the *Aphelinus asychis* species group. Through the development of a morphological character set, a revision of the *Aphelinus asychis* species group was conducted. Two new species, *Aphelinus sinensis* **sp. n.**, and *Aphelinus kazakhstanensis* **sp. n.**, are described, and the two existing valid species within the *asychis* group, *Aphelinus asychis* and *Aphelinus semiflavus* are redescribed and lectotypes are designated for *Aphelinus semiflavus* and *Aphelinus brevipennis* (a junior synonym of *A. semiflavus*). We also provide a key for identifying species in the *asychis* group.

Keywords

Taxonomy, Chalcidoidea, sibling species, description, distribution

Introduction

Aphelinus Dalman, 1820 is a genus of chalcidoid wasps in the family Aphelinidae, subfamily Aphelininae (see Hayat 1972). All species of *Aphelinus* are endoparasitoids of aphids, and the genus has a long association with biological control research against aphid pests (Arce Gomez and Rumiatto 1989, Cate et al. 1973, Clausen 1978, Elliott

et al. 1995, Raney 1971, Sell and Kuo-Sell 1989, Starks et al. 1976). The focus of this paper is the *Aphelinus asychis* group, which differs from other *Aphelinus* species groups in two traits: submarginal vein with only 2 [not 3 or more] setae (Hayat 1998) and oviposition probing/penetration site on host dorsal [not ventral] surface (De Farias and Hopper 1999). There are currently two valid species in the *asychis* group: *A. semiflavus* and *A. asychis*. *Aphelinus semiflavus* Howard, 1908 was originally collected near Fort Collins, Colorado, parasitizing *Myzus persicae* (Sulzer, 1776), green peach aphid. *Aphelinus asychis* Walker was described in 1839 from British and Irish material.

Aphelinus asychis is common in both the Old World and New World, and it is an important parasitoid of aphids (ca. 60 documented aphid hosts). It has been used in biological control of at least six aphid species (Kalina and Stary 1976, Noyes 2016). Prominent biological control targets of *A. asychis* include *Therioaphis trifolii* (Monell, 1882), the spotted alfalfa aphid, *A. asychis* was also the focus of work on biological control programs of *Schizaphis graminum* (Rondani, 1852), the greenbug, during the 1970s and 1980s (Cate et al. 1973, Johnson et al. 1979, Summy et al. 1979) and *Diuraphis noxia* (Mordvilko, 1921), the Russian wheat aphid, during the 1990s (Brewer et al. 2001, Hopper et al. 1998, Prokrym et al. 1998). During foreign exploration for natural enemies of the Russian wheat aphid in the 1990s, *A. asychis* was found in Europe, Asia, northern Africa, and South America, where it parasitizes *Diuraphis* spp. (Gonzalez et al. 1994, Hopper et al. 1998).

A major factor that impedes the success of biological control programs is delayed recognition of cryptic species. Testing for reproductive compatibility is one way to discover cryptic species. Kazmer et al. (1996) tested for interculture reproductive compatibility among seven lab cultures of *A. asychis* collected during foreign exploration. They examined all possible crosses (49), and found three completely and reciprocally reproductively incompatible groups: (1) Mediterranean basin, (2) Kazakhstan, and (3) China. These were also reflected in clusters from phenetic analysis of 61 RAPD loci banding patterns. As explained in the descriptions below, we were able to examine voucher material from the original collections referred to in Kazmer et al. (1996), or material from cultures established from these collections.

A second issue in this species group is considerable confusion over whether *A. asychis* and *A. semiflavus* are different species. Ferrière (1965) and Nikol'skaya and Yasnosh (1966) synonymized *A. semiflavus* with *A. asychis*. Mackauer and Finlayson (1967) argued that they should remain separate because they differ in host ranges, and could be cryptic species. *Aphelinus semiflavus* has since been treated as a valid species by several researchers (Raney 1971, Raney et al. 1973, Ro and Long 1997). However, distinguishing between these species has been difficult. For example, during the biological control program against *T. trifolii*, in the 1950's, *A. asychis* was initially recorded as *A. semiflavus* (Clausen 1978, Hagen and van den Bosch 1968).

Further work in the *asychis* species group is needed to (1) understand the nature and relationships among the three groups found by Kazmer et al. (1996) and among other species in the *asychis* species complex and (2) determine whether *A. asychis* and *A. semiflavus* are races of one species with different host ranges or are two distinct cryptic species.

Diagnosis of *asychis* species group

Following Hayat (1998), we consider a submarginal vein with only two setae to be diagnostic for the *A. asychis* group. In females, F1 and F2 are subquadrate, and F3 is 1.2–2.0× longer than wide. In males, F1 and F2 are wider than long, and F3 is >3.0× longer than wide. Brachyptery is also common in this group, particularly in males. There is marked sexual dimorphism, particularly in antennal proportions and coloration, which is not found in other *Aphelinus* species.

Material and methods

Specimens used in this study were killed in 95% ethanol and stored in freezers. Most were then critical-point-dried using a Samdri 790 CPD unit. Critical-point-dried specimens were card mounted with Franklin International's water soluble Titebond Liquid Hide Glue. Selected specimens were slide-mounted following Noyes' (1982) protocol. All card-mounted and slide-mounted specimens were assigned individual accession numbers (e.g., TAMU-ENTO X0852885, USNM ENT 4532898, etc.). Label data for type specimens are reported verbatim, where | signifies a new line on a label and || separates different labels. The following acronyms for museum collections are used, followed in some cases by the actual acronym used with specimen accession numbers: ANIC, Australian National Insect Collection (Canberra); BMNH [BMNH(E)], Natural History Museum (London); CNC (CNC HYMEN), Canadian National Collection of Insects and Nematodes (Ottawa); EMEC, Essig Museum Entomology, University of California (Berkeley); NHW, Naturhistorisches Museum (Vienna); TAMU (TAMU-ENTO), Texas A&M University Insect Collection (College Station, TX); UCR (UCRC ENT), University of California (Riverside, CA); USNM (USNM ENT) National Museum of Natural History (Washington, D.C.). Complete label data for any or all material examined are available upon request to the authors.

Images for figures were acquired using digital imaging and image-stacking. Specimens photographed for coloration were removed from alcohol storage, placed on a layer of water-based, water-soluble jelly in a small watch glass, submerged in alcohol, and photographed using a Leica M205 FA stereomicroscope and Leica Applications Suite software (ver. 4.5) as were card-mounted or point-mounted specimens. Slide-mounted specimens were photographed using an Olympus BH2 microscope with DIC illumination and Image-Pro Plus software (ver. 7.0). Zerene Stacker (<http://zerenesystems.com>) was used for all image stacking. Adobe Photoshop CS6, Adobe Lightroom 5, and Adobe InDesign CS6 were used for final modifications to images and layout of plates. All images were deposited in mx, a web-based content management database system. Morphological codings were conducted in mx. The mx system is open source, with further documentation available at <http://mx.phenomix.org>.

Morphology

See Appendix Table 1 for a list of the morphological terms used in this study, followed by a definition and a URI (uniform resource identifier) that links to more information on that character in the Hymenoptera Anatomy Ontology (Yoder et al. 2010) database.

Morphology measurements

Measurements from slide mounts were taken using an eyepiece reticle in a Zeiss standard 16 microscope. Measurements from card mounts were taken using an eyepiece reticle in a Leica MZ16 microscope. Raw measurements are only reported for body length, which is followed by the range and the number of specimens measured. The remaining measurements are reported as ratios.

Head. The length of the head was measured from the anterior to the posterior margin in dorsal view (Fig. 1a, hl). The frontovertex length was measured in dorsal view from the dorsal margin of the scrobal impression to the occiput (Fig. 1a, fvl). Head and frontovertex widths were both measured at their widest points. The posterior ocellar diameter (Fig. 1a, ow), distance from posterior ocelli to eye margin, (Fig. 1a, ool), distance between ocelli (Fig. 1a, pol) and distance from posterior ocelli to occipital margin (Fig. 1a, ocp) were measured as illustrated. The widths of each antennal segment (scape, pedicel, F1, F2, F3, and club) were measured at their widest points. The lengths of each antennal segment were measured from proximal to distal end. The scape of males in the *asychis* group bears a longitudinal row of pores on a convex ridge on the anterior (ventral) surface (Fig. 2), that appear to be openings for internal glands.

Meso/Metasoma length. Meso/metasoma length of specimens was measured from the anterior margin of the pronotum to the apex of the epiproct using slide-mounted specimens. The lengths of the mesosoma, the mid lobe of mesoscutum, and the scutellum were measured from their anterior to posterior margins along the mid line and widths were measured at their widest points.

Wings. Fore wing measurements are shown in Figure 1b; hind wing measurements follow those of the fore wing.

Male Genitalia and Ovipositor. The length of the phallobase was measured from the anterior margin of the genital capsule to the posterior end of the digiti (Fig. 1c, phl). The width of the phallobase was measured at its widest point (Fig 1c, phl). The length of the digitus was measured between its most anterior to most posterior points, and its width was measured at its widest point (Fig. 1c, dig). Ovipositor length was measured as illustrated in Figure 1d.

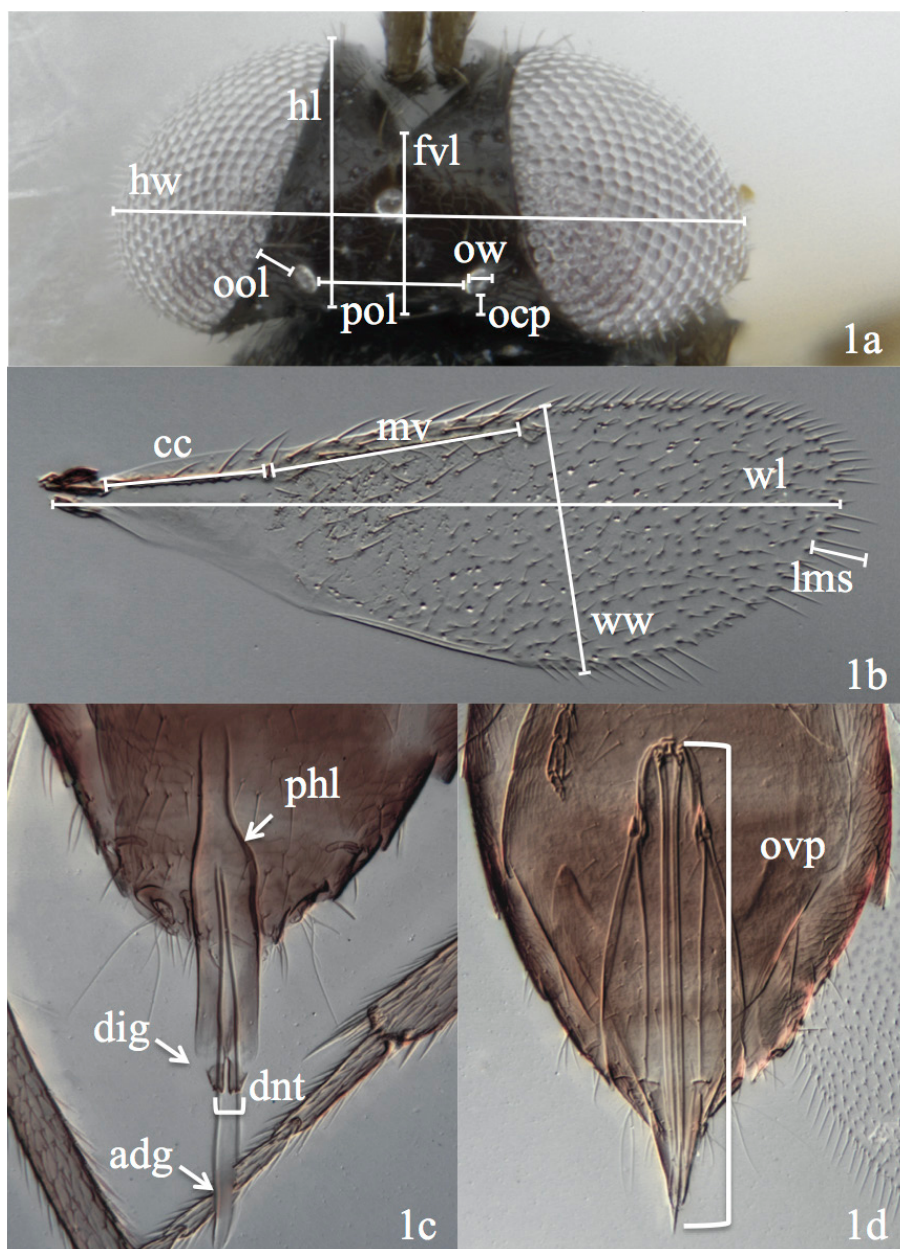


Figure 1. Measurements and terminology. **1a** *Aphelinus kazakhstanensis* sp. n. female, head, dorsal view (TAMU-ENTO X0856040) (fvl: frontovertex length; hl: head length; hw: head width; ocp: posterior ocellus to occipital margin distance; ool: posterior ocellus to eye margin distance; ow: posterior ocellus width; pol: posterior interocellar distance) **1b** *Aphelinus sinensis* sp. n. female, fore wing, dorsal view (TAMU-ENTO X0852875) (cc: costal cell length; lms: longest marginal seta length; mv: marginal vein length; wl: wing length; ww: wing width) **1c** *Aphelinus certus* male genitalia, ventral view (TAMU-ENTO X0616479) (adg = aedeagus; dig = digiti; dnt = denticles; phl = phallobase) **1d** *Aphelinus atriplicis* female, metasoma, ventral view (TAMU-ENTO X0616471) (ovp = ovipositor).

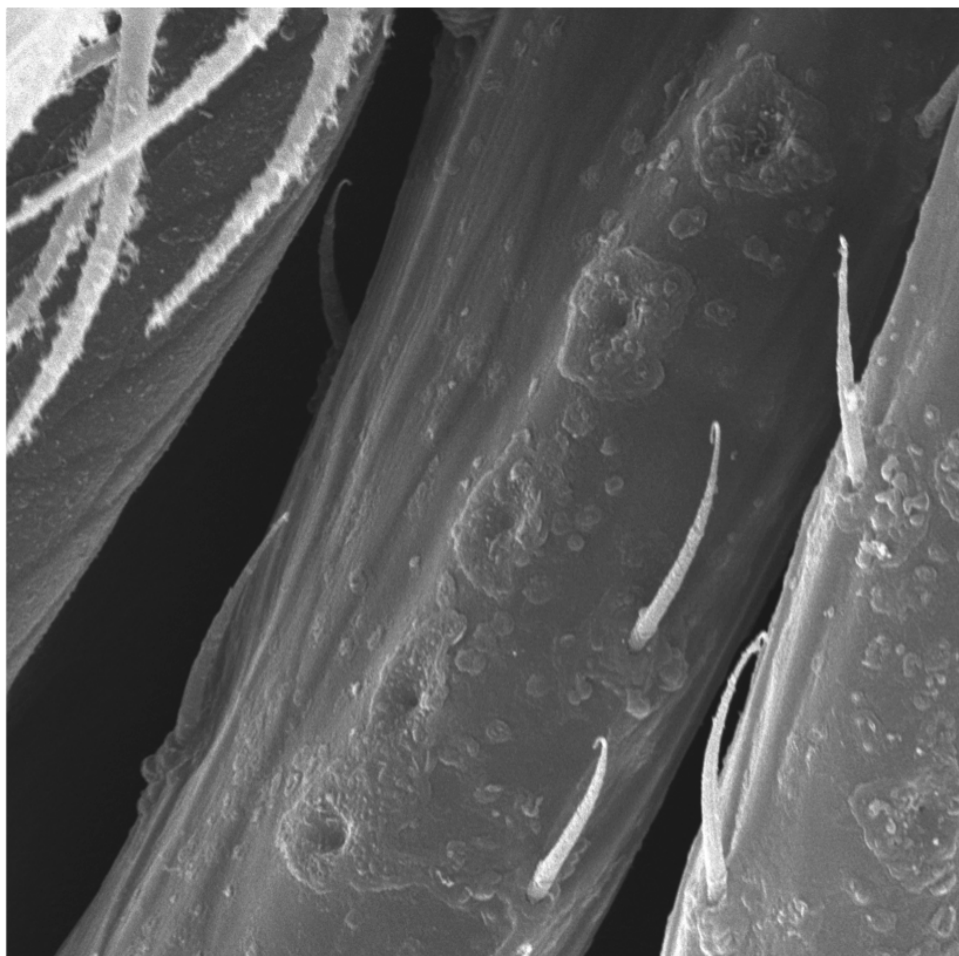


Figure 2. *Aphelinus sinensis* n. sp., male, scape, ventral view. Note the five linearly arranged exocrine gland pores.

Results

Key to species in the *asychis* group of *Aphelinus*, male or female specimens.

- | | | |
|---|--|---|
| 1 | Procoxa yellow (Fig. 9c–f) | <i>sinensis</i> Shirley & Woolley, sp. n. |
| – | Procoxa brown (Figs. 3c, 3d, 5c–5f, 7c, 7d) | 2 |
| 2 | Profemur entirely yellow or pale (Figs. 7c, 7d) | <i>semiflavus</i> Howard |
| 3 | Profemur brown at base (Figs. 3c, 3d, 5c–5f) | 3 |
| 4 | Mesotibia entirely yellow (Figs. 5c–5f) | <i>kazakhstanensis</i> Shirley & Woolley, sp. n. |
| 5 | Mesotibia brown at base or dark with apex pale (Figs. 3c, f) | <i>asychis</i> Walker |

***Aphelinus asychis* Walker, 1839**

Figs 3, 4

Aphelinus asychis Walker, 1839, lectotype designation by Graham (1976).*Aphelinus euthria* Walker, 1839, synonymy and lectotype designation by Graham (1976).*Myina affinis* Förster, 1841, synonymy and lectotype designation by Graham (1976).*Aphelinus affinis* (Förster, 1841): Dalla Torre (1898).*Aphelinus brevicealcar* Thomson, 1876, synonymy and lectotype designation by Graham (1976).*Aphelinus brachyptera* Kurdjumov, 1913, synonymy and lectotype designation by Graham (1976).*Aphelinus dubia* Kurdjumov, 1913, synonymy and lectotype designation by Graham (1976).

Diagnosis. Females and males. Legs with procoxa brown (Fig. 3d) [not yellow (Fig. 9d)], profemur and mesofemur dark brown with apex yellow or pale (Fig. 3d) [not entirely yellow (Figs. 7d, 9d) or light brown with apex yellow or pale (Fig. 5d)], mesotibia dark brown with apex yellow (Figs. 3c, 3d) [not entirely yellow (Figs. 5d, 7d, 9d)] and metatibia dark brown with apex yellow (Figs. 3c, 3d) [not entirely yellow (Fig. 9d) or light brown with apex yellow or pale (Figs. 5d, 7d)].

Description. Female (Figs. 3b, 3d, 3f and 4b, 4d–4g).

Color (Fig. 3b, 3d, 3f). Head and mesosoma dark brown; radicle and basal portion of scape yellow/white, apical portion of scape and pedicel brown, and F1, F2, F3, and club yellow, tip of club dusky; legs with mesocoxa and metacoxa brown, metafemur yellow, protibia yellow; metasoma yellow from base to apex, lateral margins of metasoma darker than mesal area except in basal quarter.

Body length. 0.9 mm (n=2; slide mounts).

Head (Figs. 3b and 4b). Width 0.8–1.1 head length in anterior view; frontovertex width 0.5× head width and 1.4–2.6× frontovertex length; posterior ocelli diameter 0.5× posterior ocelli to eye margin distance and 1.5× posterior ocelli to occipital margin distance; antenna as in Figure 4b with scape length 6.5–6.6× scape width, pedicel length 1.9–2.1× pedicel width, F1 and F2 subquadrate, length of both 1.1× width, F3 length 1.3–1.5× F3 width, and club length 2.9–3.2× club width and 2.8–3.4× F3 width, club with 8 longitudinal sensilla.

Mesosoma (Figs. 3d, 3f and 4g). Mid lobe of mesoscutum length 0.7–0.8× mid lobe width with two pairs of long setae (one pair lateral and one pair posterior) and 29 short setae; side lobes of mesoscutum each with one pair of long setae and one pair of short setae; scutellum with two pairs of long setae (one pair anterior and one pair posterior); mesotibial spur length 0.6× mesobasitarsus length, metatibial spur length 0.6–0.8× metabasitarsus length.

Fore wing (Fig. 4d). Length 2.8× fore wing width, longest marginal seta 0.2× fore wing width; costal cell length 0.7× length of marginal vein, with one line of 5 setae



Figure 3. *Aphelinus asychis*, card-mounted specimens **3a** male, antennae and head, lateral view (BMNH 1038770) **3b** female, antennae and face, anterior view (BMNH 1038772) **3c** male, habitus, lateral view (BMNH 1038770) **3d** female, habitus, lateral view (BMNH 1038772) **3e** male, habitus, dorsal view (BMNH 1038770) **3f** female, habitus, dorsal view (BMNH 1038772).

on ventral surface and 1 dorsal setae in apical quarter; marginal vein with two rows of 10 large dorsal setae, one row of 5 small dorsal setae, and one row of 7 ventral setae; interspace between basal cell and linea calva with 25 setae arranged in three complete line and one incomplete line; linea calva closed with three setae at its posterior end, setae bordering linea calva proximally are arranged uniformly and evenly to posterior margin of wing.

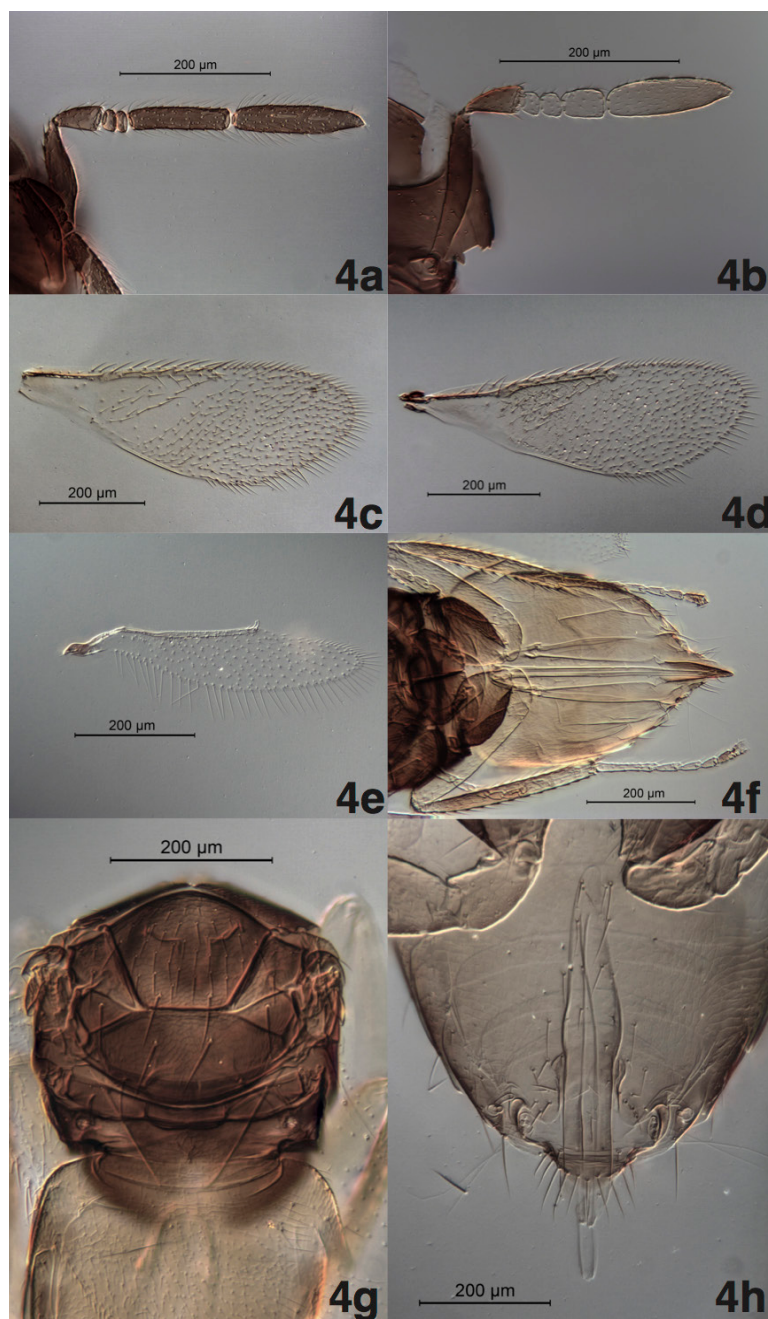


Figure 4. *Aphelinus asychis*, slide-mounted specimens **4a** male, antenna, lateral view (BMNH 1039637) **4b** female, antenna, lateral view (TAMU-ENTO X0856569) **4c** male, fore wing, dorsal view (TAMU-ENTO X0856303) **4d** female, fore wing, dorsal view (TAMU-ENTO X0856301) **4e** female, hind wing, dorsal view (TAMU-ENTO X0856301) **4f** female, metasoma, ventral view (TAMU-ENTO X0856301) **4g** female, mesosoma, dorsal view (TAMU-ENTO X0856301) **4h** male, genitalia, ventral view (TAMU-ENTO X0856303).

Hind wing (Fig. 4e). Length $4.4\times$ hind wing width, longest marginal seta $0.5\times$ hind wing width.

Metasoma (Figs. 3d, 3f and 4f). Length $1.8\text{--}2.0\times$ mesosoma length; ovipositor length $1.2\text{--}1.3\times$ mesotibia length and $1.0\text{--}1.2\times$ metatibia length; third valvula length $0.2\text{--}0.3\times$ ovipositor length.

Description. Male (Figs. 3a, 3c, 3e and 4a, 4c, 4h). Similar to female except:

Color (Fig. 3a, 3c, 3e). All antennal segments yellow/brown; metasoma yellow at base darkening gradually to light brown at apex.

Head (Figs. 3a and 4a). Antenna with scape length $4.7\text{--}4.8\times$ scape width with five pores along mid line of single continuous convex ridge on ventral surface, pores small, approximately same diameter as base of adjacent seta, pedicel length $1.8\text{--}1.9\times$ pedicel width, F1 length $0.6\times$ F1 width, F2 length $0.5\text{--}0.6\times$ F2 width, F3 length $3.5\text{--}3.7\times$ F3 width, club length $3.3\text{--}6.5\times$ club width and $1.5\text{--}1.6\times$ F3 length.

Metasoma (Fig. 3c, 3e and 4h). Length $1.1\text{--}1.4\times$ mesosoma length; phallobase length (including digiti) $5.4\text{--}7.0\times$ phallobase width; digiti length $3.6\text{--}4.5\times$ digiti width.

Type material examined.

Aphelinus asychis Walker, 1839, lectotype female (BMNH, examined). Card-mounted.

Label data: “*A. asychis* | Walker || *Aphelinus* | *asychis* | LECTOTYPE | M. de V. Graham | det. 1974 || B.M.N.H. TYPE | HYM | 5.2881”.

Aphelinus euthria Walker, 1839, lectotype female and paralectotype female (BMNH, examined). Three paralectotype females.

Myina affinis Förster, 1841, lectotype female (NHW, examined). Card-mounted. Label data: “*Myina affinis* | Förster | Lectotype ♀ || *M. affinis* Förster || Collect. G. Mayr”. Paralectotype female (NHW, examined). Card-mounted. Label data: “*M. affinis* | Förster, Type || Collect. | G. Mayr”.

Aphelinus brevicealcar Thomson, 1876, lectotype female (LUZN, examined). Card-mounted. Label data: “*Aphelinus brevicealcar* | Lectotype ♀. Thomas. | M. de V. Graham || Lectotype || Type No. 1574:1”.

Aphelinus brachyptera Kurdjumov, 1913, lectotype female (NHW, examined). Card-mounted. Label data: “*Aphelinus brachyptera* | (Först. MS). | Lectotype | M. de V. Graham || *A. brachyptera* | Förster Type || Collect. G. Mayr || 182”.

Aphelinus dubia Kurdjumov, 1913, lectotype female (NHW, examined). Mounted on minuten pin on block. Label data: “*Aphelinus* | (Föst. MS.) K | Lectotype || *M. dubia* | Förster, Type || Collect. | G. Mayr”. Paralectotypes, five females. Mounted on minuten pins on block. Label data as lectotype.

Other material examined. **AUSTRALIA:** Australian Capital Territory: 1 sex unknown, 3 males, 17 females. ANIC 64571–64591 (ANIC). **BRAZIL:** 57 females. TAMU-ENTO X0852695–X0852751 (TAMU). **CANADA:** 16 females, 1 mixed series, 1 unknown. CNC HYMEN 122773–122774, 122777, 122805, 122828, 122830, 122832–122833, 122835–122839, 122843, 122849, 122891, 122893, 122897 (CNC). **CANADA:Nova Scotia:** 1 sex unknown. CNC HYMEN 122825 (CNC). **CANADA:Ontario:** 1 male, 2 sex unknowns, 4 females. CNC HYMEN 122728 (EMEC); TAMU-ENTO X0854432 (TAMU); CNC HYMEN

18232, 122727, 122738–122740 (CNC). **CHILE**: 7 males, 29 females. TAMU-ENTO X0852752–X0852753, X0852784–X0852793, X0852834–X0852837, X0852839–X0852844, X0852846–X0852847, X0852849–X0852854, X0852856–X0852861 (TAMU). **EGYPT**: 1 male, 3 females. BMNH(E) 1039587–1039590 (BMNH). **FRANCE**: 52 males, 1 mixed series, 8 sex unknowns, 3 unknowns, 81 females. EMEC 749093 (EMEC); BMNH(E) 1039558, 1039562, 1039575; ANIC 64736–64746, 64749–64765, 64772–64779 (ANIC); TAMU-ENTO X0616384–X0616385, X0852794–X0852803, X0852893–X0852917, X0852947, X0853323–X0853325, X0855642–X0855645, X0855777–X0855778, X0856082–X0856095, X0856301–X0856304, X0856306–X0856307, X0856319, X0856321–X0856322, X0856325, X0856327–X0856328, X0856330, X0856333, X0856337–X0856345, X0856568–X0856569, X0856625, X0856674 (TAMU); CNC HYMEN 19026 (CNC); UCRC ENT 75231–75232, 326836, 326868, 326870 (UCRC); USNM ENT 1212186–1212195, 1212272 (USNM). **GERMANY**: 2 males, 2 females. USNM ENT 763812, 1119640–1119642 (USNM). **INDIA**: 1 sex unknown, 20 females. BMNH(E) 1039638 (BMNH); USNM ENT 1119615, 1119620–1119631, 1119633–1119634, 1119637, 1119639, 1212205, 1212213–1212214 (USNM). **ISRAEL**: 7 males, 1 mixed series, 3 sex unknowns, 15 females. UCRC ENT 300205, 300211, 300225 (UCR); EMEC 749000, 749098–749099; UCRC ENT 300206–300208, 300210, 300212–300224, 300226–300227, 326859 (UCRC). **ITALY**: 9 males, 2 sex unknowns, 19 females. BMNH(E) 1039570, 1039574, 1038774; X0856351, X0856358–X0856360, X0856361–X0856368, X0856564–X0856567 (TAMU); CNC HYMEN 19045 (CNC); USNM ENT 1212200–1212204, 1212206–1212209, 1212435 (USNM). **JAPAN**: 4 females, 5 males. CNC HYMEN 19030, 19032–19033, 19035–19036, 19038, 19040–19042 (CNC). **MOROCCO**: 5 males, 1 sex unknown, 15 females. TAMU-ENTO X0856308–X0856311, X0856313–X0856318, X0856320, X0856323–X0856324, X0856326, X0856329, X0856331–X0856332, X0856334–X0856336 (TAMU). **NEPAL**: 1 female. BMNH(E) 1039267 (BMNH). **PAKISTAN**: 20 males, 3 sex unknowns, 8 females. TAMU-ENTO X0852974–X0853002, X0854532, X0854632, X0854732 (TAMU). **SOUTH AFRICA**: 9 males, 5 females. ANIC 65020–65021, 65023–65029, 65032–65034 (ANIC); USNM ENT 1119565, 1119573 (USNM). **SPAIN**: 6 males, 12 females. BMNH(E) 1039559, 1039561, 1039565–1039566, 1039568–1039569; TAMU-ENTO X0616389, X0616411, X0852950, X0856305, X0856346–X0856350, X0856352, X0856781 (TAMU); USNM ENT 1212437 (USNM). **SWEDEN**: 4 males, 6 females. BMNH(E) 1039571–1039573, 1039578, 1039581–1039586 (BMNH). **TURKEY**: 2 females. BMNH(E) 1039563–1039564 (BMNH). **UNITED KINGDOM**: 2 males, 6 females. BMNH(E) 1038770–1038773, 1039560, 1039636–1039637 (BMNH); USNM ENT 1212436 (USNM). **USA:California**: 10 females, 2 males, 1 unknown. UCRC ENT 75429, 75431 (UCRC), EMEC 749077–749079, 749081, 749083–749087, 749089, 749732 (EMEC). **USA:Colorado**: 3 males, 6 females. USNM ENT 1119605–1119608, 1119612–1119614, USNM ENT 1119578–1119579 (USNM).

USA:Florida: 2 females. CNC HYMEN 122771, 122813 (CNC). **USA:Hawaii:** 3 females. USNM ENT 1212218–1212220 (USNM). **USA:Kansas:** 2 females. USNM ENT 1119500, 1119580 (USNM). **USA:Maine:** 1 female. USNM ENT 1119576 (USNM). **USA:Maryland:** 2 females. USNM ENT 1119577, USNM ENT 1119599 (USNM). **USA:Minnesota:** 1 sex unknown, 1 female. USNM ENT 1212238–1212239 (no date) (USNM). **USA:Missouri:** 1 unknown, 23 females. CNC HYMEN 122780–122782, 122783–122801, 122804, 122809–122811 (CNC). **USA:Ohio:** 5 females. USNM ENT 1119610–1119611, 1119617–1119619 (USNM). **USA:Oklahoma:** 6 males, 7 mixed series, 19 females. EMEC 749510, 749578–749582, 749589, 749617, 749619, 749621–749635, 749664 (EMEC); TAMU-ENTO X0616388 (TAMU); USNM ENT 1119550–1119553, 1212245, 1212438 (USNM). **USA:Texas:** 7 males, 1 sex unknown, 2 females. TAMU-ENTO X0852918–X0852925, X0853732, X0852938, (TAMU). **Country not specified:** 8 males, 9 females. UCRC ENT 13848, 13996 (UCR); ANIC 64766–64771, 64780–64781, 65065–65067 (ANIC); EMEC 749618, 749620, 749636 (EMEC); USNM ENT 1119589 (USNM).

Hosts. *Acyrtosiphon kondoi* Shinji, 1938, *Acyrtosiphon pisum* (Harris, 1776), *Aphis gossypii* (Glover, 1877), *Aphis umbrellae* (Börner, 1950), *Brevicoryne brassicae* (Linnaeus, 1758), *Chaetosiphon fragaefolii* (Cockerell, 1901), *Diuraphis noxia*, *Hyperomyzus lactucae* (Linnaeus, 1758), *Myzus persicae*, *Rhopalosiphum maidis* (Fitch, 1856), *Schizaphis graminum*, *Therioaphis trifolii*, and *Toxoptera* Koch, 1856 sp.

Distribution. Old World and some New World populations, discussed below.

Discussion. The collections from France, Italy, Morocco, and Spain correspond to those discussed in Kazmer et al. (1996). The leg coloration of *A. asychis* specimens as described in the diagnosis is unique among species in the *asychis* group. We are treating collections from Spain, Morocco, and Italy as conspecific, noting that the metafemora are dark brown [not yellow]. We are also treating the collection from England, Sussex, as conspecific, noting that the profemora and mesofemora are yellow [not dark brown with apex yellow or pale]. We are treating the population from Hoda, Hawaii, and Bangalore, India, as conspecific, noting that the protibia are brown [not yellow]. Although the male antennal club in *asychis* is usually longer than in other species, we note that it is of comparable length (4.0–4.5 L/W) in the series from Montpellier and Antibes, France.

Numerous populations of *A. asychis* are present in North America. The population from Randall Co., Texas, is presumed to have originated from biological control program releases of *A. asychis* against the Russian wheat aphid in that area. The population from Wayne Co., Missouri, was collected from a Malaise trap, and one specimen from Florida was collected by a flight interception trap, both in the late 1980's. The populations from Stillwater, Oklahoma, originated from a lab culture of *A. asychis* for *Schizaphis graminum* biological control. The two specimens collected from Manhattan, Kansas, from spotted alfalfa aphid in a greenhouse probably result from agricultural research at Kansas State University. The series from Alameda Co., California, 1962, is from the former UC Insectary, Oxford Tract, and was possibly being researched as a candidate for biological control of yellow clover aphid or other pest aphids.

However, in a few cases, *A. asychis* was found in North America before any documented biological control releases. An *A. asychis* specimen was collected in Florida in 1952, which does not have any associated host data. Two specimens from Maryland, one from *Myzus persicae* and one from strawberry aphids were collected in 1962 and 1950, respectively. One specimen from Maine in 1958 was collected from a *Capitophorus* aphid mummy. Two specimens from Colorado were collected from *Myzus persicae* mummies, one in 1940 and the other in 1988. These records are especially interesting because they are geographically close to the type locality and host of *A. semiflavus*. The specimens from Minnesota, Ohio, and California (UCRC ENT 75429 and 75431) did not have collecting date or host information.

The lectotype and paralectotype females of *affinis* Förster were examined (NHW, Vienna). They are point-mounted specimens in good condition. We concur with Graham (1976) that *affinis* Förster is a junior synonym of *asychis* Walker. The lectotype of *brachyptera* Kurdjumov (NHW, Vienna) was examined. It is a brachypterous female mounted on a minuten pin through the mesosoma. We concur with Graham (1976) that *brachyptera* Kurdjumov is a junior synonym of *asychis* Walker. The lectotype female of *brevicalcar* Thomson (LUZN, Sweden) was examined. It is a card-mounted female in reasonably good condition. We concur with Graham (1976) that *brevicalcar* Thomson is a junior synonym of *asychis* Walker.

The type material of *dubia* Kurdjumov (NHW, Vienna) which consists of a female lectotype and five female paralectotypes, mounted together on a small wooden block on minuten pins, and a second pin with a wooden block bearing five additional female paralectotypes, was examined. A red dot next to one pin identifies the lectotype. The specimens are dirty and in poor condition and the minuten pins are rusting. Although we note some color variation in the metasoma of these specimens, we concur with Graham (1976) that *dubia* Kurdjumov is a junior synonym of *asychis* Walker. The lectotype female and paralectotype females of *euthria* Walker (BMNH, London) were examined. The lectotype and one paralectotype are mounted on the same card and are in poor condition (lectotype is missing all of the metasoma). Three additional paralectotypes individually card mounted are in reasonably good condition. We concur with Graham (1976) that *euthria* Walker is a junior synonym of *asychis* Walker.

***Aphelinus kazakhstanensis* Shirley & Woolley, sp. n.**

<http://zoobank.org/4C44C168-CF80-46FA-BDEF-92B52CB810D6>

Figs 5, 6

Diagnosis. *Females and males.* Legs with procoxa brown (Fig. 5d) [not yellow (Fig. 9d)], profemur and mesofemur light brown with apex yellow or pale (Fig. 5d) [not entirely yellow (Figs. 7d, 9d) or dark brown with apex yellow or pale (Fig. 3d)], mesotibia yellow (Fig. 5d) [not dark brown with apex yellow or pale (Fig. 3d)], metatibia light brown with apex yellow (Fig. 5d) [not entirely yellow (Fig. 9d), or dark brown with apex yellow or pale (Fig. 3d)].



Figure 5. *Aphelinus kazakhstanensis*, paratypes in 95% ethanol **5a** male, antennae and face, anterior view (TAMU-ENTO X0856689) **5b** female, antennae and face, anterior view (TAMU-ENTO X0856403) **5c** male, habitus, lateral view (TAMU-ENTO X0856689) **5d** female, habitus, lateral view (TAMU-ENTO X0856400) **5e** male, habitus, ventral view (TAMU-ENTO X0856689); **5f**: female, habitus, ventral view (TAMU-ENTO X0856403).

Description. Female (Figs. 5b, 5d, 5f and 6b, 6d–6g).

Color (Fig. 5b, 5d, 5f). Head and mesosoma dark brown; radicle and basal portion of scape yellow/white, apical portion of scape and pedicel brown, and F1, F2, F3, and club yellow, tip of club dusky; legs with mesocoxa and metacoxa brown, metafemur yellow, protibia yellow; metasoma yellow from base to apex, lateral margins of metasoma darker than mesal area except in basal quarter.

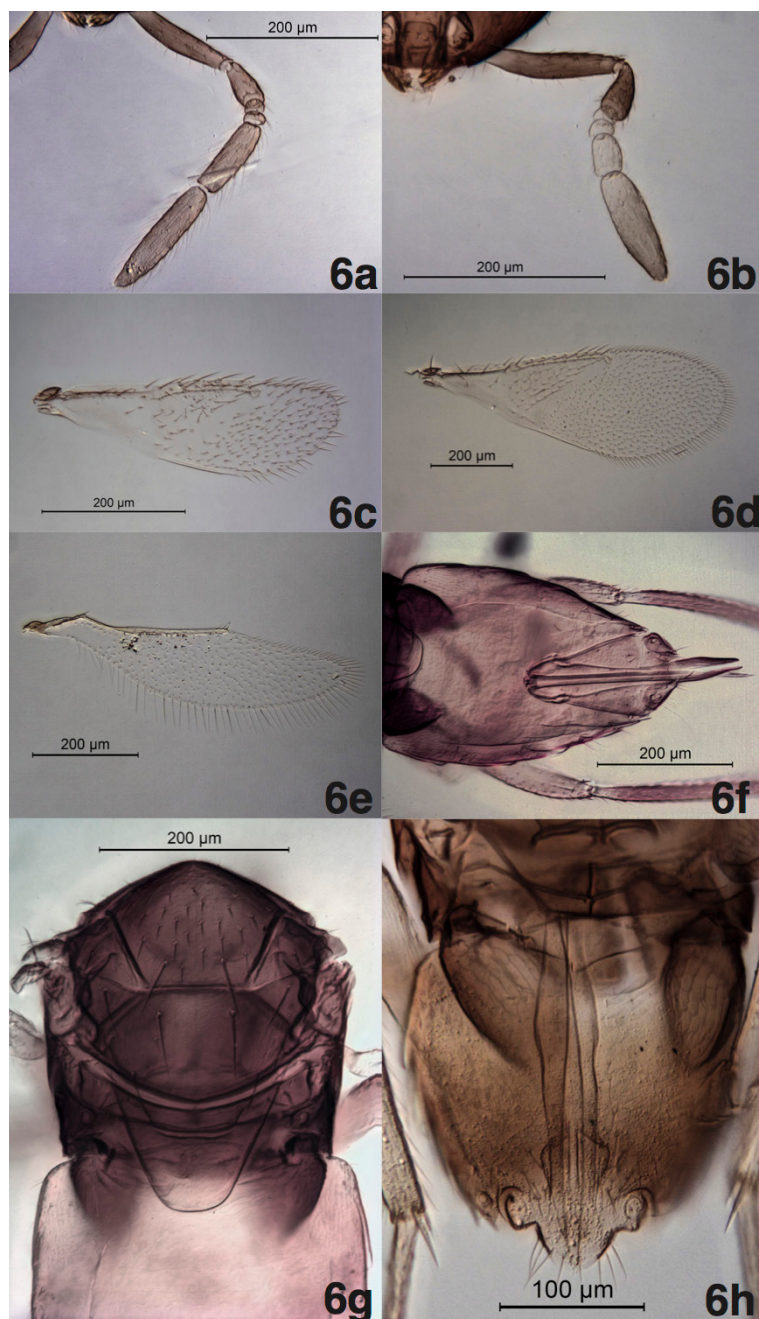


Figure 6. *Aphelinus kazakhstanensis*, slide-mounted paratypes **6a** male, antenna, lateral view (TAMU-ENTO X0856044) **6b** female, antenna, lateral view (TAMU-ENTO X0855782) **6c** male, fore wing, dorsal view (TAMU-ENTO X0856072) **6d** female, fore wing, dorsal view (TAMU-ENTO X0616386) **6e** female, hind wing, dorsal view (TAMU-ENTO X0852956) **6f** female, metasoma, ventral view (TAMU-ENTO X0616386) **6g** female, mesosoma, dorsal view (TAMU-ENTO X0852880) **6h** male, genitalia, ventral view (TAMU-ENTO X0856075).

Body length. 0.7–0.9 mm (n=3; slide mounts) (Holotype 0.7 mm).

Head (Figs. 5b and 6b). Width 1.1–1.2× head length in anterior view; frontovertex width 0.5–0.6× head width and 1.9–2.6× frontovertex length; posterior ocelli diameter 0.6–0.8× posterior ocelli to eye margin distance and 1.5× the posterior ocelli to occipital margin distance; antenna as in Figure 6b with scape length 5.8–7.3× scape width, pedicel length 1.8–2.2× pedicel width, F1 and F2 subquadrate, length of both 1.0× width, F3 length 1.4–1.6× F3 width, and club length 2.9–3.7× club width and 2.8–3.1× F3 width, club with 8 longitudinal sensilla.

Mesosoma (Figs. 5d, 5f and 6g). Mid lobe of mesoscutum length 0.8× mid lobe width, and with two pairs of long setae (one pair lateral and one pair posterior) and 34–35 short setae; side lobes of mesoscutum each with one pair of long setae and one pair of short setae; scutellum with two pairs of long setae (one pair anterior and one pair posterior); mesotibial spur length 0.7–0.8× mesobasitarsus length, metatibial spur length 0.4–0.6× metabasitarsus length.

Fore wing (Fig. 6d). Length 2.3–2.4× fore wing width, longest marginal seta 0.1–0.2× fore wing width; costal cell 0.6–0.7× length of marginal vein, with one line of 6–7 setae on ventral surface and 1–2 dorsal setae in apical quarter; marginal vein with two rows of 14–15 large dorsal setae, one row of 7–8 small dorsal setae, and one row of 8–10 ventral setae; interspace between basal cell and linea calva with 30–33 setae arranged in three complete lines and two incomplete lines; linea calva closed with 2–3 setae at its posterior end, setae bordering linea calva proximally arranged uniformly and evenly to posterior margin of wing.

Hind wing (Fig. 6e). Length 4.6× hind wing width, longest marginal seta 0.7× hind wing width.

Metasoma (Figs. 5d, 5f and 6f). Length 1.4× mesosoma length; ovipositor length 1.6× mesotibia length and 1.3× metatibia length; third valvula length 0.3–0.4× ovipositor length.

Description: Male (Figs. 5a, 5c, 5e and 6a, 6c, 6h). Similar to female except:

Color (Fig. 5a, 5c, 5e). All antennal segments yellow/brown; metasoma yellow at base darkening gradually to light brown at apex.

Head (Figs. 5a and 6a). Antenna with scape length 5.2–7.5× scape width with five pores along mid line of single continuous convex ridge on ventral surface, pores small, approximately same diameter as base of adjacent seta, pedicel length 2.0–2.2× pedicel width, F1 length and F2 length both 0.6× width, F3 length 2.8–3.3× F3 width, club length 3.5–4.7× club width and 1.6–1.7× F3 length.

Metasoma (Fig. 5c, 5e and 6h). Length 0.8–0.9× mesosoma length; phallobase length (including digiti) 5.1–6.4× phallobase width; digiti length 4.7–5.0× digiti width.

Holotype (deposited in USNM). Female, card mounted. Label data: “Texas: Brazos Co. | College Station | TAMU Lab Culture | coll. 23.vii.1991 || ex: *Diuraphis* | *noxia* | on wheat: | T91/061 || T91/061 orig. collection: | U.S.S.R. Dmitrievka | 16–17.v.1991 || S. Halbert coll. | ex. *Diuraphis* | *noxia* on grass || TAMU-ENTO X0852959”.

Paratypes (deposited in USNM, TAMU, BMNH, EMEC, CNC). 41 card mounts (38 female, 3 male). 19 card mounts (18 female, 1 male) with the same label data as holotype (TAMU-ENTO accession numbers: females: X0852952 to –58, X0852961 to –64, X0852966 to –72; male: X0852965). 15 card mounts (all female) with label data reading “USSR: Kazakhstan | Dmitrievka | Ex: Russian Wheat Aphid || On: Wheat | 16–17.v.1991 | S. Halbert T91–061” (TAMU-ENTO accession numbers: X0855626 to –39, X0855641). 7 card mounts (5 females, 2 males) of voucher specimens from non-destructive DNA extraction, with label data reading “KAZAKHSTAN | Dmitrievka | 13.v.1991 | Popraski & Halbert | EPL-92-60 || DNA extracted | BIIRL 2014” (TAMU-ENTO accession numbers: females: X0856043, X0856045, X0856074, X0856076, X0856078; males: X0856041, X0856077), and two additional card mounts (1 female, 1 male) with the same label data (TAMU-ENTO accession numbers X0856689 and X0853796). 12 slide mounts (6 female, 6 male) with the same label data as holotype. (females: X0616386, X0852956, X0856782, X0855779, X0855781, X0855772; males: X0856042, X0856044, X0856072, X0856073, X0856075, X0855780)

Other material examined. None.

Hosts. The original material was collected from *Diuraphis noxia* in the field in Dmitrievka, Kazakhstan. In lab culture, *Diuraphis noxia* on wheat was used as the host.

Distribution. The species is known only from type material from Dmitrievka, Kazakhstan.

Discussion. The collections from Kazakhstan, Dmitrievka correspond exactly to those discussed in Kazmer et al. (1996). The most notable distinction between *A. kazakhstanensis* and all other *A. asychis* group species is the yellow mesotibia, combined with the profemur, mesofemur, and metatibia light brown at base and yellow at apex. *Aphelinus asychis* specimens have mesotibia, metatibia, profemur, and mesofemur dark brown at base and yellow at apex. *Aphelinus semiflavus* has mesotibia, profemur, and mesofemur yellow, and metatibia brown at base and yellow at apex. *Aphelinus sinensis* specimens have mesotibia, metatibia, profemur, and mesofemur all yellow.

Aphelinus semiflavus Howard, 1908

Figs 7, 8

Aphelinus semiflavus Howard, 1908.

Aphelinus brevipennis Girault, 1917, synonymy by Gahan (1924).

Diagnosis. *Females and males.* Legs with procoxa brown (Fig. 7d) [not yellow (Fig. 9d)], profemur, mesofemur, mesotibia entirely yellow (Fig. 7d) [not dark or light brown at base and yellow or pale at apex (Figs. 3d, 5d)] and metatibia light brown with apex yellow (Fig. 7d) [not entirely yellow (Fig. 9d) or dark brown with apex yellow or pale (Fig. 3d)].



Figure 7. *Aphelinus semiflavus*, point-mounted specimens **7a** male, antennae and face, lateral view (CNC 00122807) **7b** female, antennae and face, anterior view (CNC 00122818) **7c** male, habitus, lateral view (USNM ENT 2076436) **7d** female, habitus, lateral view (paralectotype) **7e** male, habitus, dorsal view (USNM ENT 2076436) **7f** female, habitus, dorsal view (paralectotype).

Description. Female (Figs. 7b, 7d, 7f and 8b, 8d–8g).

Color (Fig. 7b, 7d, 7f). Head and mesosoma dark brown; radicle and basal portion of scape yellow/white, apical portion of scape and pedicel brown, and F1, F2, F3, and club yellow, tip of club dusky; legs with mesocoxa and metacoxa brown, metafemur and protibia, entirely yellow; metasoma yellow from base to apex, lateral margins of metasoma darker than mesal area except in basal quarter.

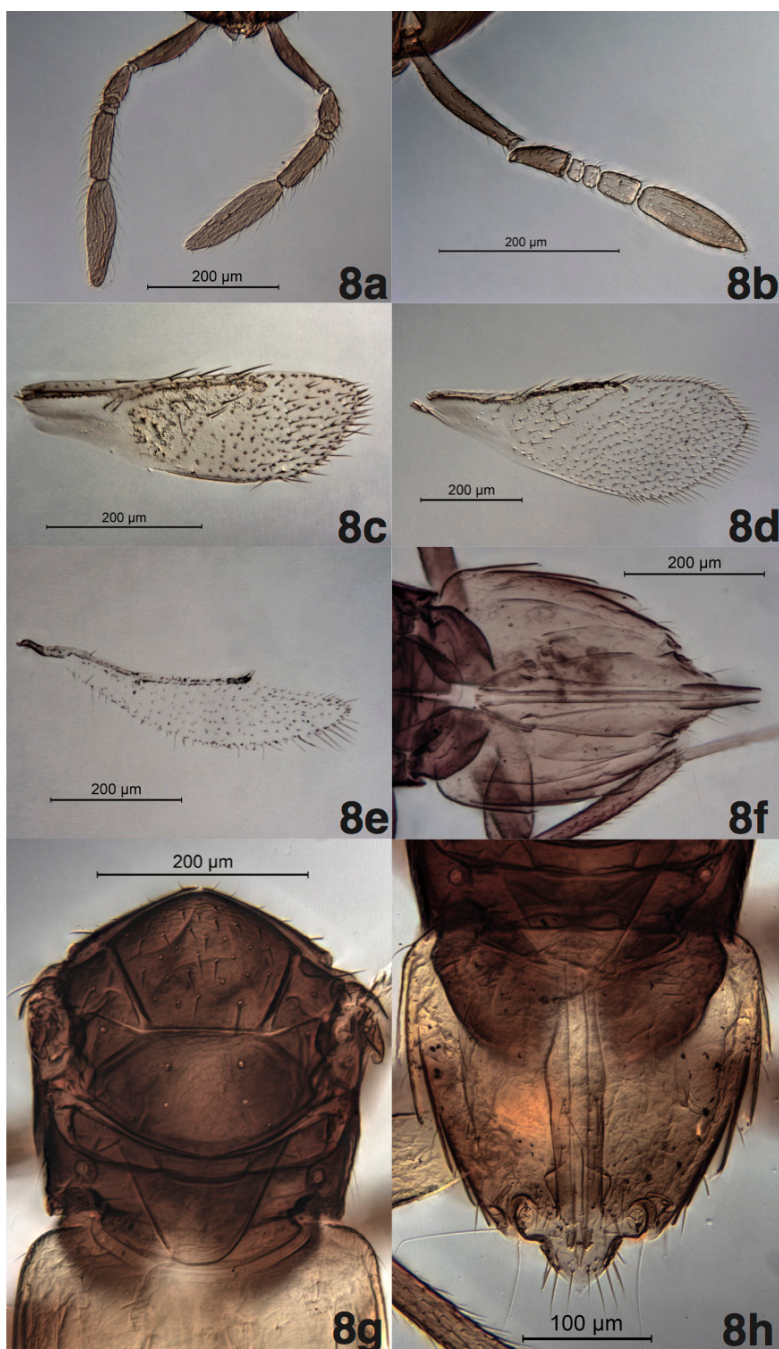


Figure 8. *Aphelinus semiflavus*, slide-mounted specimens **8a** male, antenna, lateral view (paralectotype) **8b** female, antenna, lateral view (paralectotype) **8c** male, fore wing, dorsal view (paralectotype) **8d** female, fore wing, dorsal view (paralectotype) **8e** female, hind wing, dorsal view (paralectotype) **8f** female, metasoma, ventral view (UCRC ENT 326827) **8g** female, mesosoma, dorsal view (paralectotype) **8h** male, genitalia, ventral view (UCRC ENT 326826).

Body length. 0.5–1.0 mm (n=3; slide mounts) (Paralectotypes 0.5–0.6 mm).

Head (Figs. 7b and 8b). Width 1.2–1.3× head length in anterior view; frontovertex width 0.4–0.5× head width and 3.1–3.7× frontovertex length; posterior ocelli diameter 0.5× posterior ocelli to eye margin distance and 1.5× posterior ocelli to occipital margin distance; antenna as in Figure 8b with scape length 6.8–7.0× scape width, pedicel length 2.0–2.3× pedicel width, F1 and F2 subquadrate, length of both 0.9–1.1× width, F3 length 1.5–1.9× F3 width, and club length 3.2–4.4× club width and 2.6–2.3× F3 width, club with 8 longitudinal sensilla.

Mesosoma (Figs. 7d, 7f and 8g). Mid lobe of mesoscutum length 0.7–0.8× mid lobe width with two pairs of long setae (one pair lateral and one pair posterior) and 30–31 short setae; side lobes of mesoscutum each with one pair of long setae and one pair of short setae; scutellum with two pairs of long setae (one pair anterior and one pair posterior); mesotibial spur length 0.6–0.7× mesobasitarsus length, metatibial spur length 0.4–0.5× metabasitarsus length.

Fore wing (Fig. 8d). Length 2.3–2.8× fore wing width, longest marginal seta 0.1× fore wing width; costal cell length 0.6–0.7× length of marginal vein, with one line of 10–12 setae on ventral surface and 1–2 dorsal setae in apical quarter; submarginal vein with two setae; marginal vein with two rows of 14–17 large dorsal setae, one row of 7–13 small dorsal setae, and one row of 7–10 ventral setae; interspace between basal cell and linea calva with 31–40 setae arranged in three complete line and one to two incomplete lines; linea calva closed with 3 setae at its posterior end, setae bordering linea calva proximally are arranged uniformly and evenly to posterior margin of wing.

Hind wing (Fig. 8e). Length 3.5–3.7× hind wing width, longest marginal seta 0.2–0.3× hind wing width.

Metasoma (Figs. 7d, 7f and 8f). Length 2.0× mesosoma length; ovipositor length 0.9× mesotibia length and 1.2× metatibia length; third valvula length 0.3× ovipositor length.

Description. Male (Figs. 7a, 7c, 7e and 8a, 8c, 8h). Similar to female except:

Color (Fig. 7a, 7c, 7e). All antennal segments yellow/brown; metasoma yellow at base darkening gradually to light brown at apex.

Head (Figs. 7a and 8a). Antenna with scape length 6.4× scape width with five pores along mid line of single continuous convex ridge on ventral surface, pores small, approximately same diameter as base of adjacent seta, pedicel length 1.7–2.2× pedicel width, F1 length 0.6× F1 width, F2 length 0.6× F2 width, F3 length 4.2–4.4× F3 width, club length 6.2× club width and 1.5× F3 length.

Metasoma (Fig. 7c, 7e and 8h). Length 1.3× mesosoma length; phallobase length (including digiti) 6.0× phallobase width; digiti length 4.5× digiti width.

Type material examined.

Aphelinus semiflavus Howard 1908, lectotype female (USNM, examined). Label data: “Type | No. 12031 | USNM || *Aphelinus* n.sp. | near mali || *Myzus persicae* | Ft. Collins, Colo. | C.B. Gillette | det. July 15, 1908”. The slide containing the lec-

totype has 3 female and 2 male specimens under one cover slip. The female specimen in the lowest middle portion of the slide is herein designated lectotype, and the slide has been labeled accordingly. Paralectotypes. (USNM, examined). Two females and two males on same slide, data as lectotype. Two females, one male, one sex unknown, on cardmounts with label data reading as “*Myzus persicae* | Fort Collins, CO || C. B. Gillette | Det. July, 15, 08 || Type | No. 12031 | U.S.N.M.”.

Aphelinus brevipennis Girault 1917, lectotype female. (USNM, examined). Slide-mounted parts: “*Aphelinus* | *brevipennis* | Girault | female type || 19801”. Point mount: “Ohio || 1693 || 19801”. The female lectotype designated herein is mounted on a point, and parts consisting of an antenna, a fore wing, a hind wing, a mid leg and a hind leg were dissected by Girault and mounted on a slide. Paralectotype male (USNM). Point-mounted. Label data: “Ohio || 1704 || 19801”.

Other material examined. CANADA: 2 sex unknowns, 18 females, 8 males. CNC HYMEN 18213–18219, 122831, 122834, 122842, 122844–122847, 122850–122860, 122867, 122894–122895 (CNC). **CANADA:Nova Scotia:** 5 males. CNC HYMEN 122822–122824, 122826–122827 (CNC). **FRANCE:** 1 male. UCRC ENT 326865 (UCRC). **INDIA:** 1 unknown, 2 sex unknowns. USNM 1119632, 1119636, 1119638 (USNM). **KOREA:** 5 females, 16 males. TAMU-ENTO X0856593–X0856613 (TAMU). **MEXICO:** 3 males. TAMU-ENTO 616387, X0853003, X0853005 (TAMU). **SPAIN:** 1 male. CNC HYMEN 19028 (CNC). **USA:California:** 2 unknown, 7 sex unknowns, 94 females, 47 males, 3 mixed series. UCRC ENT 13843–13845, 13994, 13995, 14057, 326787, 326798, 326803, 326822–326835, 326837–326840, 326842–326843, 326845–326850, 326853, 326855, 326860–326861, 326863, 326864, 326866, 326869, 326871, 326874–326877, 326879, 326881–326883, 326886, 326887 (UCRC); EMEC 749022–749049, 749080, 749088, 749090–749092, 749511–749514, 749517, 749560–749563, 749567–749568, 749572, 749574–749577, 749583–749588, 749590–749597, 749600–749605, 749607–749616, 749637, 749082, 749011–749021 (EMEC); ANIC 64521 (ANIC); USNM 1119584, 1212283–1212284 (USNM); CNC HYMEN 122848 (CNC); BMNH(E) 1039253 (BMNH). **USA:Colorado:** 2 sex unknowns, 1 female, 11 males, 1 mixed series. UCRC ENT 13847 (UCRC); USNM 1119635, 1119643, 1212226–1212236 (USNM). **USA:Florida:** 1 female, 1 male. CNC HYMEN 122814 (CNC); USNM 1119593 (USNM). **USA:Georgia:** 2 females, 5 males. CNC HYMEN 122803, 122806–122808, 122819–122821 (CNC). **USA:Kansas:** 2 females, 1 male, 1 mixed series. USNM 763852, 1119509, 1119581, 1119601 (USNM). **USA:Maine:** 2 females. USNM 1119572, 1119575 (USNM). **USA:Maine:** 2 mixed series. USNM 763837, 763862 (USNM). **USA:Maryland:** 1 female. CNC HYMEN 122802 (CNC). **USA:Massachusetts:** 4 females, 1 male. USNM 1212210–1212211, 1212215–1212217 (USNM). **USA:Minnesota:** 1 mixed series. USNM 763857 (USNM). **USA:Montana:** 1 females. TAMU-ENTO X0616383 (TAMU). **USA:New Jersey:** 2 females, 1 male. EMEC 749569, 749571, 749570 (EMEC). **USA:New Mexico:** 2 females, 2

males. USNM 1212244, 1212222–1212224 (USNM). **USA:New York:** 7 females, 2 males, 1 sex unknown. USNM 1119570, USNM 763827, 1119595–1119598, 1119602–1119604 (USNM); UCRC ENT 13846 (UCRC). **USA:North Carolina:** 2 females. CNC HYMEN 122816–122817 (CNC). **USA:Ohio:** 2 unknowns, 3 females, 4 males. USNM 763832, 1119582–1119583, 1119587–1119588, 1119590–1119592, 1119616 (USNM). **USA:Oregon:** female. USNM 1212237 (USNM). **USA:Pennsylvania:** 1 female. USNM 1119571 (USNM). **USA:South Carolina:** 1 male. UCRC ENT 13992 (UCRC). **USA:Texas:** 5 females. TAMU-ENTO X0852937, X0852939, X0852940, X0852928–X0852929 (TAMU). **USA:Virginia:** 3 females. TAMU-ENTO X0852934, X0852936 (TAMU); CNC HYMEN 122818 (CNC). **Country not specified:** 5 females, 1 male, 1 mixed series. USNM 763817, 763822, 763842, 763847, 763867 (USNM); UCRC ENT 326685 (UCR); EMEC 398444 (EMEC).

Hosts. *Acyrtosiphon malvae* (Mosley, 1841), *Acyrtosiphon pisum*, *Aphis eugeniae* van der Goot, 1917, *Brachycaudus helichrysi* (Kaltenbach, 1843), *Coloradoa rufomaculata* (Wilson, 1908), *Capitophorus xanthii* (Oestlund, 1886), *Diuraphis noxia*, *Illinoia liriodendra* (Monell, 1879), *Macrosiphoniella ludoviciana* (Oestlund, 1886), *Myzus persicae*, *Myzaphis rosarum* (Kaltenbach, 1843), *Neomyzus circumflexus* (Buckton, 1876), *Rhopalosiphum maidis*, *Rhopalosiphum nymphaeae* (Linnaeus, 1761), *Schizaphis graminum*, *Therioaphis trifolii*, and *Toxoptera* sp.

Distribution. New World, with few populations in Old World (from France, Korea and Spain).

Discussion. There has been confusion in the past about whether or not *A. asychis* and *A. semiflavus* are separate species. Based on the material examined, leg coloration patterns clearly differ between them. Regarding the New World populations examined, we are treating most North American populations as *semiflavus*, noting that in the Mexico and Winnipeg, Canada, populations, the metatibia are yellow/brown [not dark brown at base with apex pale].

We consider the Bangalore, India, and Dezful, Iran populations as sp. nr. *semiflavus*, noting that the India population has mid tibia and mid femora with brown [not yellow] and the Dezful, Iran, population has legs like *semiflavus* except one female with brown [not yellow] on mid tibia and mid femora. There is one specimen from Virginia that we are treating as possibly *semiflavus*, noting that the fore femora and fore tibia are brown [not yellow].

We have examined the lectotype female and paralectotype male of *brevipennis* Girault and agree with the conclusion of Gahan (1924) that it is a junior synonym of *semiflavus* Howard. Although Ferrière (1965), Nikol'skaya and Yasnosh (1966), and Yasnosh (1978) treated *semiflavus* as a junior synonym of *asychis* Walker, for reasons discussed above we consider it to be a distinct and valid species.

Future work should use reciprocal crosses and perhaps molecular data to determine whether populations of *A. semiflavus* in Old World vs. New World are in fact one species, are races of one species with different host ranges, or are two distinct cryptic species.

***Aphelinus sinensis* Shirley & Woolley, sp. n.**

<http://zoobank.org/1601A3C9-0589-4F20-82AD-8B4282488336>

Figs 2, 9, 10

Diagnosis. *Females and males.* Legs with procoxa yellow (Fig. 9d) [not brown (Figs. 3d, 5d, 7d)], profemur, mesofemur, mesotibia, and metatibia yellow (Fig. 9d) [not brown at base with apex yellow or pale (Figs. 3d, 5d, 7d)].

Description. *Female* (Figs. 9b, 9d, 9f and 10b, 10d–10g).

Color (Figs. 9b, 9d, 9f). Head and mesosoma dark brown; radicle and basal portion of scape yellow/white; apical portion of scape and pedicel brown; F1, F2, F3, and club yellow; tip of club dusky; legs with mesocoxa and metacoxa brown, metafemur and protibia yellow; metasoma yellow from base to apex, lateral margins of metasoma darker than mesal area except in basal quarter.

Body length. 0.6–0.9 mm (n=3; slide mounts) (Holotype 0.8 mm).

Head (Figs. 9b and 10b). Width 1.2–1.3× head length in anterior view; frontoververtex width 0.4× head width and 1.0–1.4× frontoververtex length; posterior ocelli diameter 0.6× posterior ocelli to eye margin distance and 1.5× posterior ocelli to occipital margin distance; antenna as in Fig. 4b with scape length 5.0–5.9× scape width; pedicel length 1.5–1.9× pedicel width; F1 and F2 subquadrate, length of both 0.9–1.0× width; F3 length 1.4–1.8× F3 width; club length 3.1–3.3× club width and 2.5–3.0× F3 width, club with 8 longitudinal sensilla.

Mesosoma (Figs. 9d, 9f and 10g). Mid lobe of mesoscutum length 0.7× mid lobe width, with two pairs of long setae (one pair lateral and one pair posterior) and 31–33 short setae; side lobes of mesoscutum each with one pair of long setae and one pair of short setae; scutellum with two pairs of long setae (one pair anterior and one pair posterior); mesotibial spur length 0.7–0.80× mesobasitarsus length; metatibial spur length 0.5× metabasitarsus length.

Fore wing (Fig. 10d). Length 2.5–2.8× fore wing width, longest marginal seta 0.1–0.2× fore wing width; costal cell 0.8× length of marginal vein, with one line of 6–7 setae on ventral surface and 1–2 dorsal setae in apical quarter; submarginal vein with two setae; marginal vein with two rows of 12–18 large dorsal setae, one row of 7–11 small dorsal setae, and one row of 7–10 ventral setae; interspace between basal cell and lineal calva with 18–33 setae arranged in two complete lines and two incomplete lines; lineal calva closed with 2–3 setae at its posterior end, setae bordering lineal calva proximally are arranged uniformly and evenly to posterior margin of wing.

Hind wing (Fig. 10e). Length 3.7–4.5× hind wing width; longest marginal seta 0.3–0.5× hind wing width.

Metasoma (Figs. 9d, 9f, and 10f). Length 1.1× mesosoma length; ovipositor length 1.3× mesotibia length and 1.2× metatibia length; third valvula length 0.4× ovipositor length.

Description. *Male* (Figs. 9a, 9c, 9e and 10a, 10c, 10h). Similar to female except:

Color (Fig. 9a, 9c, 9e). All antennal segments yellow/brown; metasoma yellow at base darkening gradually to light brown at apex.

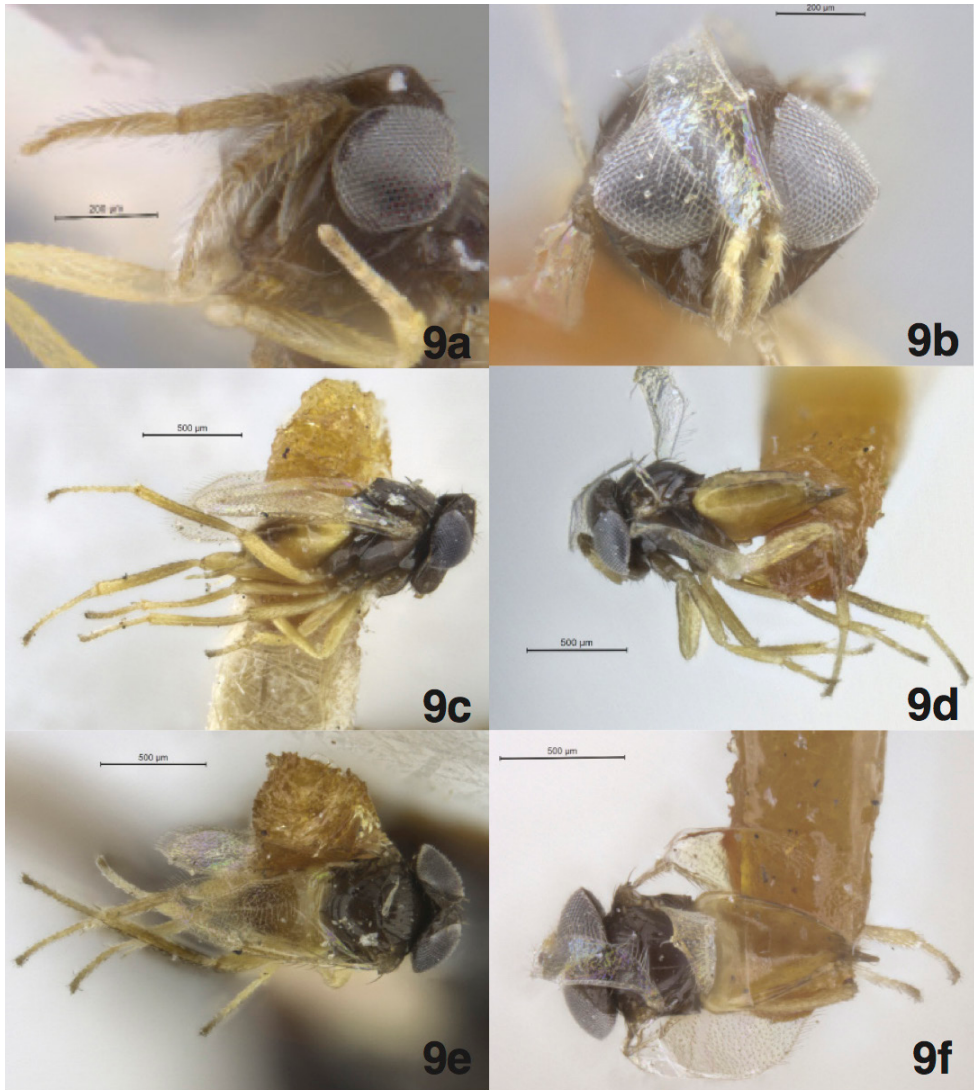


Figure 9. *Aphelinus sinensis* n.sp., paratypes in 95% ethanol **9a** male, antennae and face, anterior view (TAMU-ENTO X0856562) **9b** female, antennae and face, anterior view (TAMU-ENTO X0856563) **9c** male, habitus, lateral view (TAMU-ENTO X0856562) **9d** female, habitus, lateral view (TAMU-ENTO X0856563) **9e** male, habitus, ventral view (TAMU-ENTO X0856562) **9f** female, habitus, ventral view (TAMU-ENTO X0856563).

Head (Figs. 9a and 10a). Antenna with scape length $4.9\times$ scape width, with five pores along mid line of single continuous convex ridge on ventral surface (Fig. 2); pores small, approximately same diameter as base of adjacent setae, pedicel length $1.7\times$ pedicel width; length of F1 and F2 both $0.5\times$ their width; F3 length $4.4\times$ F3 width; club length $4.6\times$ club width and $1.4\times$ F3 length.

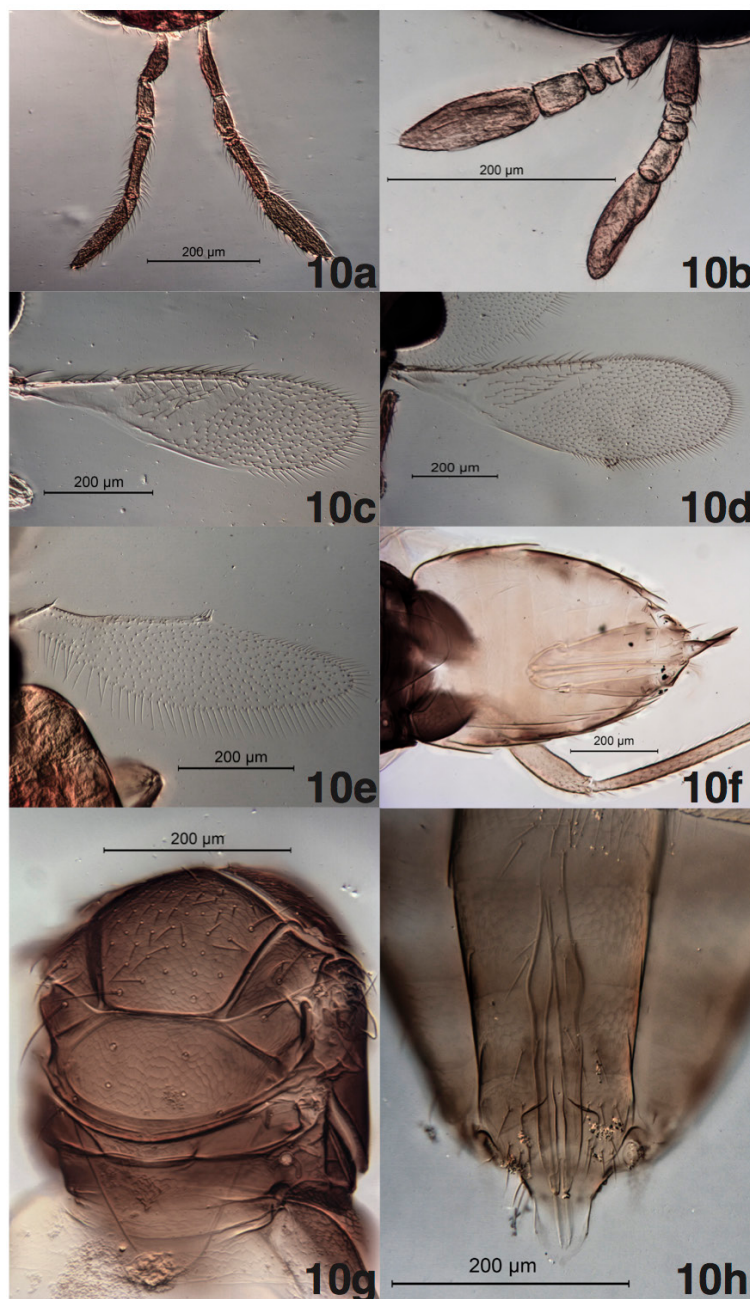


Figure 10. *Aphelinus sinensis* n.sp., slide-mounted paratypes **10a** male, antenna, lateral view (TAMU-ENTO X0852885) **10b** female, antenna, lateral view (TAMU-ENTO X0852877) **10c** male, fore wing, dorsal view (TAMU-ENTO X0852885) **10d** female, fore wing, dorsal view (TAMU-ENTO X0852875) **10e** female, hind wing, dorsal view (TAMU-ENTO X0852869) **10f** female, metasoma, ventral view (TAMU-ENTO X0852880) **10g** female, mesosoma, dorsal view (TAMU-ENTO X0852880) **10h** male, genitalia, ventral view (TAMU-ENTO X0852885).

Metasoma (Fig. 9c, 9e and 10h). Length 1.0× mesosoma length; phallobase length (including digiti) 6.0× phallobase width; digiti length 5.1× digiti width.

Holotype (deposited in USNM). Female, card mounted. Label data: “Texas: Brazos Co. | College Station | TAMU Lab Culture | 15.xii.1992 T92/051 | ex: *Diuraphis noxia* | on wheat || T92/051 orig. collection | P.R. of China | Ningxia | 21.vi.1992 | Keith Hopper coll. | ex. *Diuraphis* | *agropyronophaga* || TAMU-ENTO X0852864”.

Paratypes (deposited in USNM, TAMU, BMNH, EMEC, CNC). 30 card mounts (9 female, 21 male). 10 card mounts (2 female, 8 male) from original material with label data reading “P.R. China: Pingluo | Ningxia 19.xi.1992 | T92/051 orig. mat. | Keith Hopper | ex. *Diuraphis*” (TAMU-ENTO accession numbers: females: X0852882, X0852886; males: X0852878 to –79, X0852883, X0852887, X0852889 to –92). 10 card mounts (7 female, 3 male) from F1 progeny with the same label data as holotype (TAMU-ENTO accession numbers: females: X0852864 to –67, X0852870, X0852873, X0852876; males: X0852874, X0852871, X0852863). 10 (all male) card mounts, voucher specimens from non-destructive DNA extraction, with same label data as original material (TAMU-ENTO accession numbers: X0856046 to –55). 7 slide mounts (5 female, 2 male). 3 slide mounts from original material with same label data as above (females: X0852880, X0852888; male: X0852885). 4 slide mounts from F1 progeny, same label data as above (females: X0852869, X0852875, X0852877; male: X0852868).

Other material examined. CHINA: Harbin: 3 males, 5 females. TAMU-ENTO X0853040–47 (TAMU). JAPAN: Honshu: 2 females. CNC HYMEN 019042 and CNC HYMEN 019033 (CNC).

Hosts. The original material was collected from *Diuraphis tritici* (Gillette 1911) (the junior synonym *Diuraphis agropyronophaga* is given on the holotype label) in the field in China. In lab culture, *Diuraphis noxia* on wheat was used as the host.

Distribution. Northern China and Japan.

Discussion. The collections from China, Pingluo, Ningxia correspond exactly to those discussed in Kazmer et al. (1996). The most notable traits of the type specimens of *A. sinensis* from Pingluo, China, that distinguish them from other *A. asychis* group specimens examined, are the presence of yellow procoxae, yellow femora, and yellow tibiae. In all other *asychis* group species, all coxae are brown, and femora and tibiae are patterned with brown. The series from Harbin, China, exhibits the same leg-pattern coloration as the type series. We are treating the Harbin series as conspecific, noting that the head and metasoma are much darker, almost black, and the antennal club is darker at the apex than in material from Pingluo. There is one specimen from the Honshu, Japan, series that has the same leg coloration patterns as the type series from Pingluo, however, the other specimens in this series resemble *A. asychis*.

Other Potential New Species

There are two additional potential new species, but there is not enough material to describe them. One potential new species is from Harrow, Canada, and has leg coloration

tion like *asychis*, but includes a brown metafemur [not yellow]. There are two other Canadian series with one specimen in each series that also has this leg coloration. The other potential new species is from Dorking, England, and is represented by a single specimen that has leg coloration with all segments very dark brown.

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Appendix

Table 1A. Morphological terms used, their definitions, and URI locations on the Hymenoptera Anatomy Ontology web site (Yoder et al. 2010).

Term	Definition	URI
antenna	The anatomical cluster that is composed of the scape, pedicel and flagellum.	http://purl.obolibrary.org/obo/HAO_0000101
base	The tergum that is located on abdominal segment 2 AND The tergum that is located on the abdominal segment 3.	http://purl.obolibrary.org/obo/HAO_0000053 and http://purl.obolibrary.org/obo/HAO_0000056
body	The anatomical cluster that is composed of the whole organism but which excludes the antennae, legs and wings.	http://purl.obolibrary.org/obo/HAO_0000182
club	The anatomical cluster composed of the apical flagellomeres that are differentiated by size from the basal flagellomeres.	http://purl.obolibrary.org/obo/HAO_0001185
compound eye	The compound organ that is composed of ommatidia.	http://purl.obolibrary.org/obo/HAO_0000217
costal cell	The membranous region of the fore wing anterior to the submarginal vein, measured from the basal constriction that delimits the apex of the humeral plate of the wing to the point at which the submarginal vein touches the leading edge of the wing.	http://purl.obolibrary.org/obo/HAO_0000226
coxa	The leg segment that is connected to the body and to the trochanter via conjunctivae and muscles.	http://purl.obolibrary.org/obo/HAO_0000228
digitus	The sclerite that is located distally on the parossiculus.	http://purl.obolibrary.org/obo/HAO_0000385
edge	The margin that extends along the border of two areas that are oriented differently.	http://purl.obolibrary.org/obo/HAO_0000285
eye margin	The margin of the compound eye.	http://purl.obolibrary.org/obo/HAO_0000672
F1	The flagellomere that is proximally attached to the pedicel.	http://purl.obolibrary.org/obo/HAO_0001148
F2	The flagellomere that is located distal to the first flagellomere.	http://purl.obolibrary.org/obo/HAO_0001883
F3	The flagellomere that is located immediately distal to the second flagellomere.	http://purl.obolibrary.org/obo/HAO_0001895
femur	The leg segment that is distal to the trochanter and proximal to the tibia.	http://purl.obolibrary.org/obo/HAO_0000327
Fore wing	The wing that is located on the mesothorax.	http://purl.obolibrary.org/obo/HAO_0000351
frontovertex	The anatomical cluster that is composed of the vertex and the dorsal area of the upper face dorsal to the frontofacial ridge.	http://purl.obolibrary.org/obo/HAO_0001823
genitalia	The anatomical cluster that is composed of the cupula, gonostyle, volsella and the aedeagus	http://purl.obolibrary.org/obo/HAO_0000312
head	The tagma that is located anterior to the thorax.	http://purl.obolibrary.org/obo/HAO_0000397
hind wing	The wing that is located on the metathorax.	http://purl.obolibrary.org/obo/HAO_0000400

Term	Definition	URI
leg	The anatomical cluster that is composed of the coxa and all distal leg segments and is connected to the pectus.	http://purl.obolibrary.org/obo/HAO_0000494
longitudinal sensillum	The multiporous plate sensillum that is elongate.	http://purl.obolibrary.org/obo/HAO_0001936
margin	The line that delimits the periphery of an area.	http://purl.obolibrary.org/obo/HAO_0001133
marginal vein	The abscissa that is located along the anterior margin of the fore wing and is thought to correspond to the anterior abscissa of the radius (R1).	http://purl.obolibrary.org/obo/HAO_0000635
mesobasitarsus	The basitarsus that is located in the mid leg.	http://purl.obolibrary.org/obo/HAO_0001131
mesocoxa	The coxa that is located on the mid leg.	http://purl.obolibrary.org/obo/HAO_0001490
mesofemur	The femur that is located on the mid leg.	http://purl.obolibrary.org/obo/HAO_0000576
mesoscutum	The area that is located anterior to the transscutal articulation.	http://purl.obolibrary.org/obo/HAO_0001351
mesosoma	The anatomical cluster that is composed of the prothorax, mesothorax and the metapetal-propodeal complex.	http://purl.obolibrary.org/obo/HAO_0001120
mesotibia	The tibia that is located on the mid leg.	http://purl.obolibrary.org/obo/HAO_0001142
mesotibial spur	The tibial spur that is located on the mesotibia.	http://purl.obolibrary.org/obo/HAO_0001142
metabasitarsus	The basitarsus that is located on the hind leg.	http://purl.obolibrary.org/obo/HAO_0000587
metacoxa	The coxa that is located on the hind leg.	http://purl.obolibrary.org/obo/HAO_0000631
metasoma	The tagma that is connected anteriorly to the metapetal-propodeal complex at the pro-podeal foramen and consists of abdominal segments.	http://purl.obolibrary.org/obo/HAO_0001121
metatibia	The tibia that is located on the hind leg.	http://purl.obolibrary.org/obo/HAO_0000679
metatibial spur	The tibial spur that is located on the metatibia.	http://purl.obolibrary.org/obo/HAO_0000706
mid lobe of mesoscutum	The area that is located between the notauli.	http://purl.obolibrary.org/obo/HAO_0000520
occipital margin	The edge that separates the occiput from the vertex.	http://purl.obolibrary.org/obo/HAO_0001963
ocellus	The multi-tissue structure that is located on the top of the head, composed of the corneal lens, pigment cell, rhabdoms and synaptic plexus.	http://purl.obolibrary.org/obo/HAO_0000661
ovipositor	The anatomical cluster that is composed of the first valvulae, second valvulae, third valvulae, first valvifers and second valvifers.	http://purl.obolibrary.org/obo/HAO_0000510

Term	Definition	URI
pedicel	The antennal segment that is the second segment of the antenna and is connected proximally with the scape and distally with the flagellum.	http://purl.obolibrary.org/obo/HAO_0000512
phallobase	The anatomical cluster that is composed of the cupulae, gonostipites and volsellae.	http://purl.obolibrary.org/obo/HAO_0000713
posterior ocellus	The ocellus that is paired.	http://purl.obolibrary.org/obo/HAO_0000481
procoxa	The coxa that is located on the fore leg.	http://purl.obolibrary.org/obo/HAO_0001122
profemur	The femur that is located on the fore leg.	http://purl.obolibrary.org/obo/HAO_0001124
protibia	The tibia that is located on the fore leg.	http://purl.obolibrary.org/obo/HAO_0000350
radicle	The area that is located proximally on the scape, is limited distally by a constriction and bears proximally the basal knob.	http://purl.obolibrary.org/obo/HAO_0000889
row	The anatomical cluster that is composed of repeated units of anatomical structures.	http://purl.obolibrary.org/obo/HAO_0000901
scape	The antennal segment that is proximal to the pedicel and is connected with the head via the radicle.	http://purl.obolibrary.org/obo/HAO_0000908
scutellum	The area that is located posteriorly of the transscutal line and is composed of the axillae and the mesoscutellum.	http://purl.obolibrary.org/obo/HAO_0000572
secretory pore	The anatomical space that corresponds to the distal end of an exocrine gland.	http://purl.obolibrary.org/obo/HAO_0001966
seta	The sensillum that is multicellular and consists of trichogen, tormogen, and sense cells. The area that is located between the notaulus and the parascutal carina.	http://purl.obolibrary.org/obo/HAO_0000935
side lobe of mesoscutum	The area that is located between the notaulus and the parascutal carina.	http://purl.obolibrary.org/obo/HAO_0000466
stigma	The patch on the wing that is sclerotized and is located on the anterior margin of the fore wing.	http://purl.obolibrary.org/obo/HAO_0000957
submarginal vein	Basal-most portion of the fore wing vein complex that occurs behind the costal cell; measured from the constriction that delimits the humeral plate to the point at which the vein touches the leading edge of the wing apically.	http://purl.obolibrary.org/obo/HAO_0000972
tarsus	The leg segment that is apical to the tibia.	http://purl.obolibrary.org/obo/HAO_0000992
third valvula	The sclerite that is located posterior to the second valvifer and is connected to the second valvifer via conjuntiva.	http://purl.obolibrary.org/obo/HAO_0001012
wing	The appendage that is between the notum and the pectus and is connected to the body by the axillary sclerite muscles.	http://purl.obolibrary.org/obo/HAO_0001089