



# It's time for Africa – hidden diversity of the *Aphidius colemani* species group (Hymenoptera, Braconidae, Aphidiinae) south of the Sahara

## Research Paper

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## Abstract

*Aphidius colemani* is an important biological control agent, used in greenhouses and open fields against aphid pests. Despite this economical importance, *A. colemani*, along with *A. transcaspicus* and *A. platensis*, has gone through a complex taxonomical history. The three species have only recently gained status as separate species again, comprising the morphologically defined *Aphidius colemani* species group. Other than sporadic records probably as a consequence of escape from greenhouses, the *A. colemani* species group members prefer warmer regions and there are numerous records from South America, Southern Europe and Asia. Based on slide-mounted material collected in the period 1964–2001 in Africa, we describe five new species belonging to this group, and report *A. colemani*, *A. transcaspicus* and *A. platensis* from several African countries. This data opens questions about the origin of the group and presents potential for the diversification of biological control agents against aphid pests.

## Introduction

As an important biocontrol agent against aphids in greenhouses and open fields, *Aphidius colemani* Viereck has been used in biological control since the 1960s (Starý, 1975) and commercially produced in Europe since 1992 (van Lenteren, 2007). However, a complicated taxonomical history has followed this parasitoid until recently (Starý, 1975; Takada, 1998; Kavallieratos and Lykouressis, 1999). A study by Tomanović *et al.* (2014) employing an integrated approach to taxonomy, recognised the *Aphidius colemani* species group, containing *A. colemani*, *A. platensis* Brethes and *A. transcaspicus* Telenga. The three species are easily distinguished from their congeners by the costate anterolateral area of the petiole, and from each other by a combination of morphological characters (number of palpomeres in labial palps, ratio between pterostigma and metacarpus (=R1 vein) length) (Tomanović *et al.*, 2014). Additionally, the costate anterolateral area of petiole can be found in *A. avenae* Haliday, *A. bertrandi* Benoit and *A. pseudopicipes* Starý.

Efforts to uncover aphidiin and braconid diversity in Africa go back to 1949 and the work on braconids of Madagascar by Granger (1949). Most of the subsequent studies also concentrated on a small area or specific countries. Starting in the 1970s, numerous studies were conducted concerning Sub-Saharan Africa (Starý and van Harten, 1972, 1992; Starý and Schmutterer, 1973; Starý *et al.*, 1985, 1994; Starý, 2005; Sæthre *et al.*, 2011; Muller *et al.*, 2014), while in recent years, more attention is given to North Africa (Ghelamallah *et al.*, 2018; Rakhshani *et al.*, 2019; Hemidi and Laamari, 2020). So far, only 22 species of Aphidiinae have been recorded from Sub-Saharan Africa (Petrović, 2022). In contrast, the latest checklist shows 108 species of Aphidiinae in North Africa and Middle East (Rakhshani *et al.*, 2019). Although research has been somewhat consistent during the years, there are still large areas of the continent without any data on Aphidiinae.

Based on specimens collected in Africa, we describe five new species of Aphidiinae belonging to the *A. colemani* species group. Four out of those are described from the Sub-Saharan part of the continent. We also discuss the implications of these findings for biocontrol purposes and the proposed origin of the group.

## Material and methods

Specimens belonging to the *A. colemani* species group were collected in several African countries (Angola, Burundi, Cabo Verde, Egypt, Ethiopia, Kenya, Réunion Island, South Africa,

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and Tristan da Cunha) during the period 1964–2001, by sweeping or collecting plants infested with aphid colonies. Aphid colonies were kept under laboratory conditions for 3–4 weeks or until parasitoid emergence. Adult parasitoids were dissected and slide mounted. Photographs of relevant morphological characters were acquired using a Leica DM LS phase contrast microscope (Leica Microsystems GmbH, Wetzlar, Germany), while measurements were taken with ImageJ software (Schneider *et al.*, 2012) (fig. 1). Morphological terminology follows Sharkey and Wharton (1997).

## Results

In total, we examined 133 specimens belonging to *Aphidius colemani* species group collected in Africa. We uncovered five species

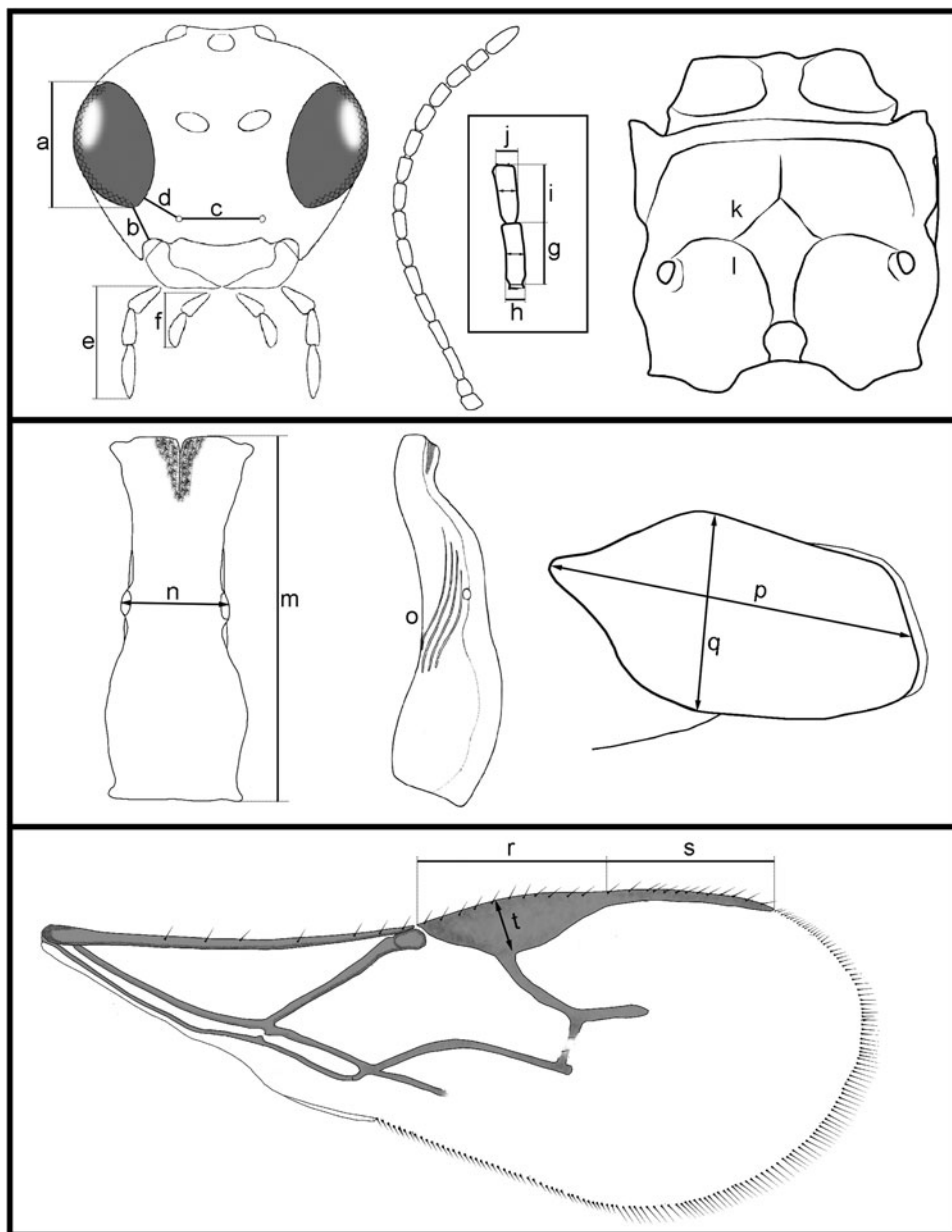
clearly belonging to the *A. colemani* species group, but not fitting descriptions of currently known species.

## Descriptions of new species

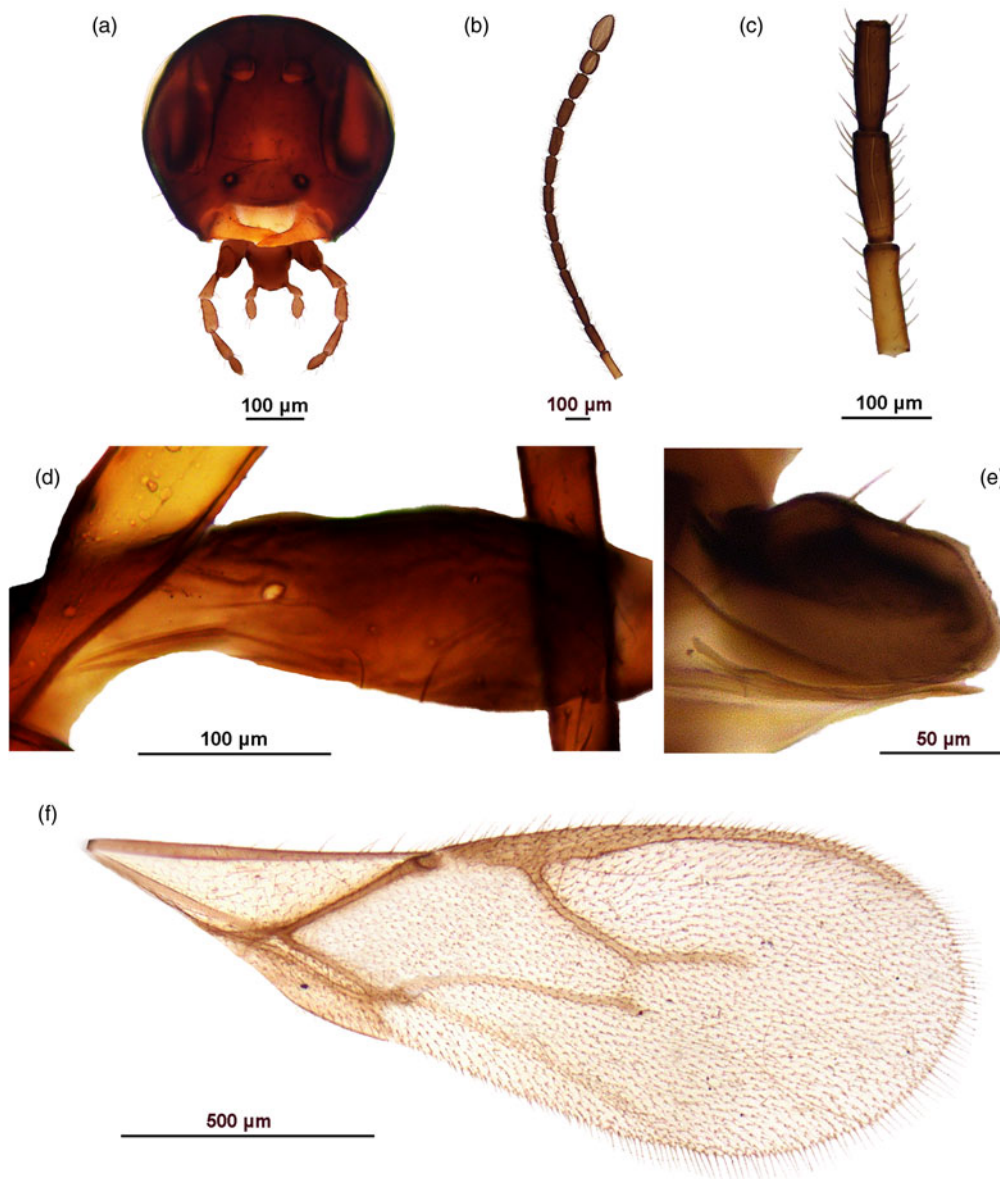
*Aphidius angustastigmatus* sp. n. Črkić & Tomanović  
fig. 2

Material examined: 2♀, slide mounted, South Africa, Johannesburg, Olifantsvlei, 15. XI 1964, caught by sweeping. Holotype ♀ and paratype ♀ deposited in collection of Institute of Entomology, České Budějovice.

Diagnosis: This species is distinguished from other members of the *A. colemani* group and any congeners by a very elongate



**Figure 1.** Characters used in morphological analysis. a – longitudinal eye diameter; b – malar space; c – intertentorial line; d – tentoriocular line; e – maxillary palp; f – labial palp; g – F1 length; h – F1 width; i – F2 length; j – F2 width; k – oblique carina; l – postmedian carina; m – petiole length; n – petiole width; o – costae on anterolateral part of petiole; p – ovipositor sheath length; q – ovipositor sheath width; r – pterostigma length; s – metacarpus length; t – pterostigma width.



**Figure 2.** *Aphidius angustastigmatus* sp. n., female. A. Head. B. Antenna. C. Flagellomeres 1–3. D. Petiole, lateral view. E. Ovipositor sheaths. F. Fore wing.

fore wing pterostigma, which is approx. 7.5 times as long as wide (3.5–4.0 times in *A. colemani* and *A. platensis*) and by irregular pattern of costae on the anterolateral part of the petiole. Additionally, it can easily be differentiated from *A. transcaspicus* by 2-segmented labial palps (3-segmented in *A. transcaspicus*).

#### Description.

Female. Head (fig. 2a). Moderately setose with long setae. Tentorial index (tentoriocular line/intertentorial line) approx. 0.5, malar space approx. 0.3 of longitudinal eye diameter. Clypeus with 1–2 very long setae. Antenna 15-segmented, moderately thickened at apex, with setae subequal to segment diameter (fig. 2b). Flagellar segment 1 (=F1) 3.5–3.6 times as long as wide, without longitudinal placodes. Flagellar segment 2 (=F2) 2.8–3.0 times as long as wide, with 1–2 longitudinal placodes. F1 subequal to F2 (fig. 2c). Maxillary palp with four palpomeres, labial palp with two palpomeres.

Mesosoma. Mesoscutum damaged. Fore wing pterostigma unusually elongated, approx. 7.5 times as long as wide and

subequal to metacarpus (pterostigma length/metacarpus length ratio approx. 0.9) (fig. 2f). Propodeum damaged, with indication of existing central areola.

Metasoma. Petiole slender, with 2–3 irregular costae in the anterolateral area. (fig. 2d) Ovipositor sheath slightly concave at the dorsal margin and short, length/width ratio 1.3–1.4 (fig. 2e).

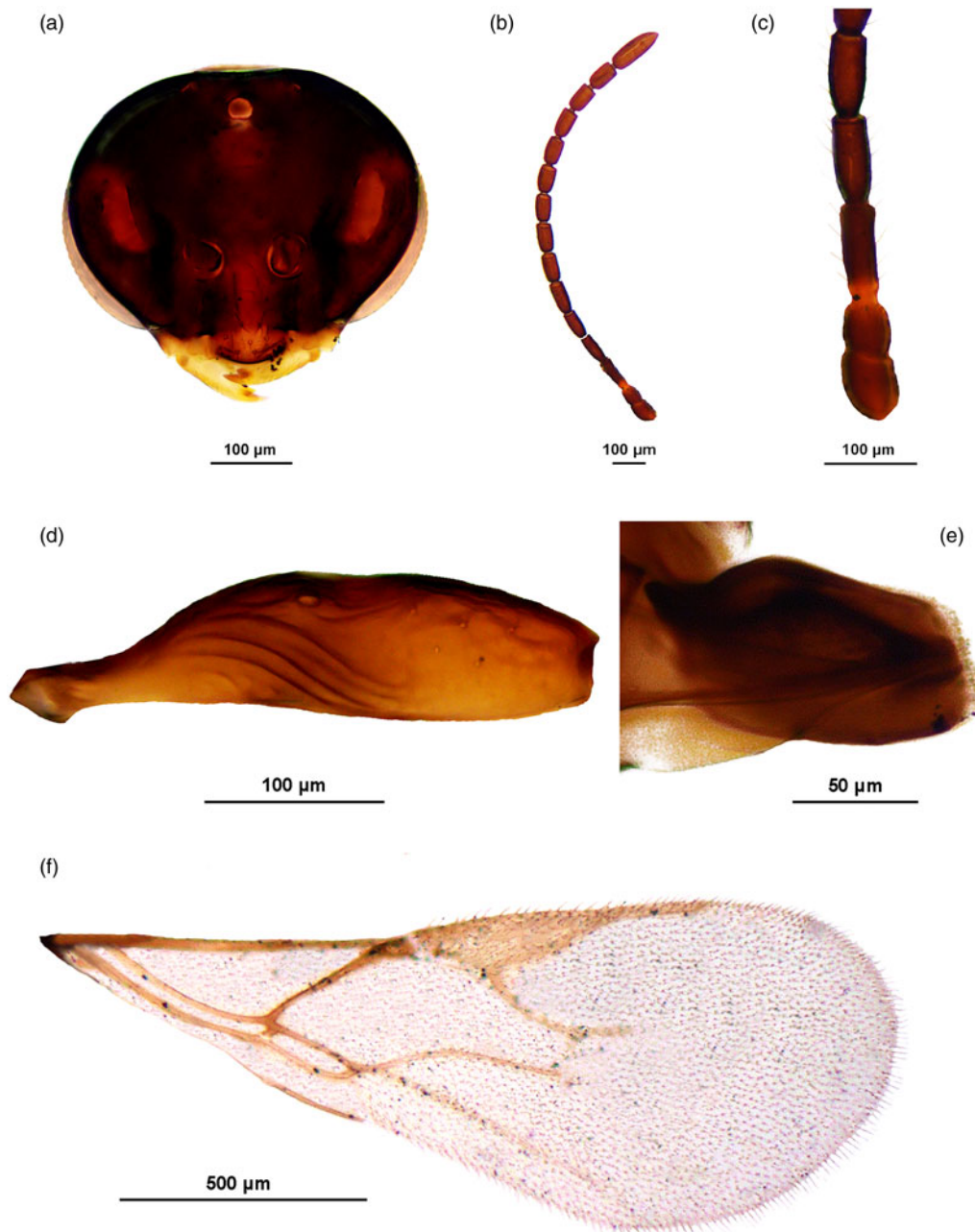
Coloration. Head brown, mouthparts light brown. Scapus, pedicel and F1 yellow, remainder of antenna brown. Mesoscutum and propodeum brown, legs light brown. Wings hyaline with brown venation. Metasoma brown.

Male. Unknown.

Host: unknown.

Etymology: The name of the new species is derived from its unique diagnostic feature, the very long and narrow forewing pterostigma.

*Aphidius brevicarpus* sp. n. Črkić & Tomanović  
fig. 3



**Figure 3.** *Aphidius brevicarpus* sp. n., female. A. Head. B. Antenna. C. Flagellomeres 1–3. D. Petiole, lateral view. E. Ovipositor sheaths. F. Fore wing.

Material examined: 1♀, slide mounted, Ethiopia, Fiche, 2850 m.a.s.l., reared from *Diuraphis noxia* (Kurdjumov) on *Hordeum vulgare*. Holotype ♀ deposited in collection of Institute of Entomology, České Budějovice.

Diagnosis. This species closely resembles *A. colemani*, from which it can be distinguished by a very short metacarpus; pterostigma length/metacarpus length is 1.8–2 in *Aphidius brevicarpus* sp. n., while it is 1.1–1.2 in *A. colemani* and 1.5 in the morphologically similar *A. platensis*. It is easily distinguished from *A. transcaspicus* by 2-segmented labial palps (3-segmented in *A. transcaspicus*).

Description.

Female. Head (fig. 3a). Sparsely setose. Antenna 15-segmented, moderately thickened at apex, with setae subequal to half of

segment diameter (fig. 3b). Terminal segment long and undivided, indicating a possibility of individuals with 16-segmented antennae within this species. F1 2.6–2.7 times as long as wide, without longitudinal placodes. F2 2.1 times as long as wide, with 2–3 longitudinal placodes. F1 subequal to F2 (fig. 3c). Maxillary palp with four palpomeres, labial palp with two palpomeres.

Mesosoma. Mesoscutum damaged. Fore wing pterostigma elongated, 3.7–4.0 times as long as wide and almost double the length of metacarpus (pterostigma length/metacarpus length ratio 1.8–2.0) (fig. 3f). Propodeum damaged.

Metasoma. Petiole slender, with 4–5 costae in the anterolateral area (fig. 3d). Ovipositor sheath slightly concave at the dorsal margin, length/width ratio 1.5 (fig. 3e).

Coloration. Head brown, mouthparts light brown. Antenna brown, except for a yellow annellus at the base of F1. Mesoscutum and propodeum brown, legs light brown. Wings hyaline with brown venation. Metasoma light brown to brown. Male. Unknown.

Host: *Diuraphis noxia*.

Etymology: The name of the new species is derived from its diagnostic feature, the very short fore wing metacarpus.

*Aphidius egypti* sp. n. Čkrkić & Tomanović  
fig. 4

Material examined: 1♀, slide mounted, Egypt, reared from 'aphids on tomatoes'. Holotype ♀ deposited in collection of Institute of Entomology, České Budějovice.

Diagnosis. This species is distinguished from other members of the *A. colemani* group by fore wing pterostigma shape, which is elongated and approx. 5 times as long as wide (3.5–4.0 times in *A. colemani* and *A. platensis*, 7.5 times in *Aphidius angustastigmatus* sp. n.). Additionally, it can easily be differentiated from *A. transcaspicus* by 2-segmented labial palps (3-segmented in *A. transcaspicus*).

Description.

Female. Head (fig. 4a). Moderately setose. Tentorial index approx. 0.4, malar space approx. 0.2 of longitudinal eye diameter. Clypeus oval with 4–5 setae. Antennae missing. Maxillary palp with four palpomeres, labial palp with two palpomeres.

Mesosoma. Mesoscutum with notaulices only in anterior part, dorsal surface sparsely setose (fig. 4B). Fore wing pterostigma elongated, about 5 times as long as wide; pterostigma length/metacarpus length ratio 1.5 (fig. 4F). Propodeum with a central pentagonal areola (fig. 4C).

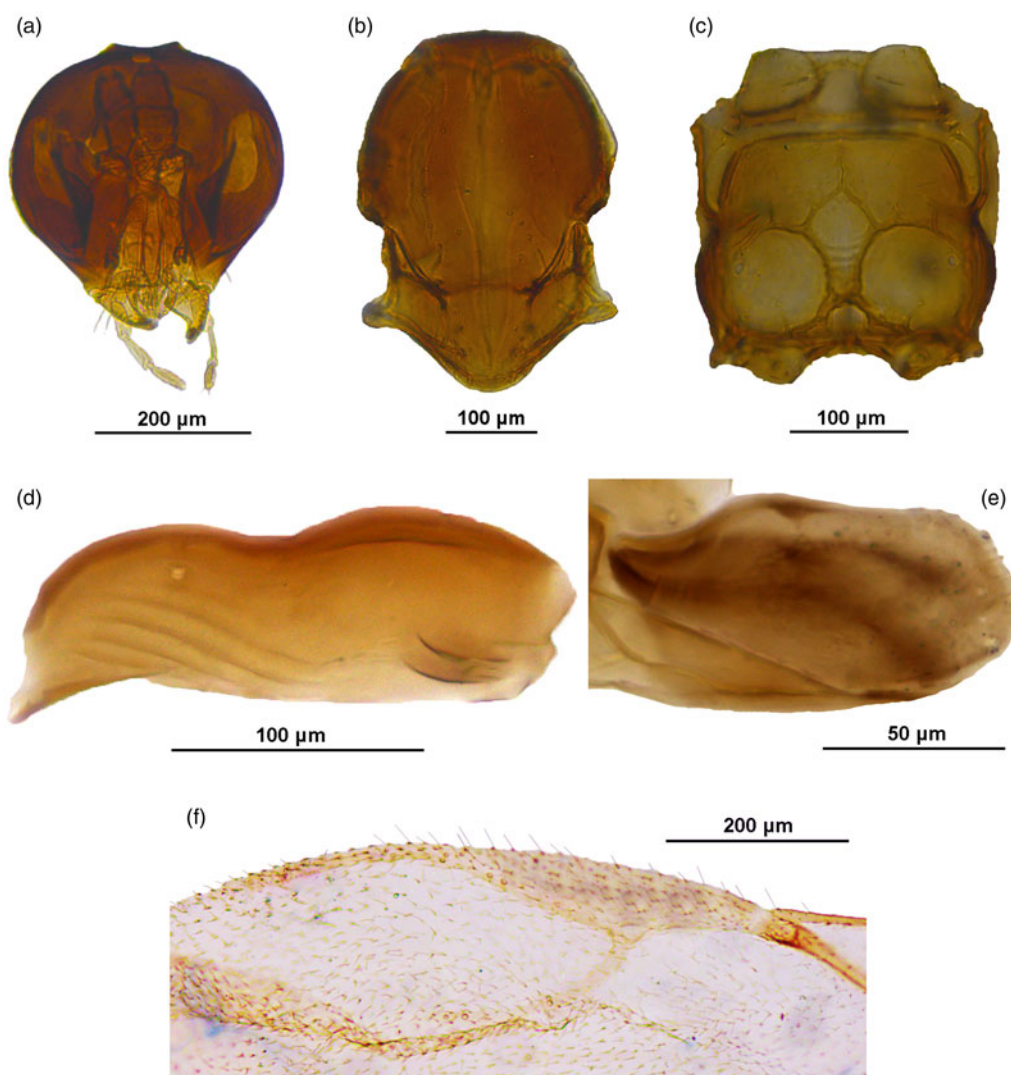
Metasoma. Petiole slender, with 4 costae in the anterolateral area (fig. 4D). Ovipositor sheath slightly concave at the dorsal margin, length/width ratio 1.67 (fig. 4E).

Coloration. Head light brown, mouthparts yellow. Mesoscutum light brown, propodeum yellow. Wings hyaline with light brown venation. Metasoma yellow.

Male. Unknown.

Host: unknown aphids on tomatoes.

Etymology: The name of the new species is derived from its known country distribution.



**Figure 4.** *Aphidius egypti* sp. n., female. A. Head. B. Mesoscutum. C. Propodeum. D. Petiole, lateral view. E. Ovipositor sheaths. F. Detail of fore wing – pterostigma and metacarpus.

*Aphidius remaudierei* sp. n. Črkić & Tomanović  
fig. 5

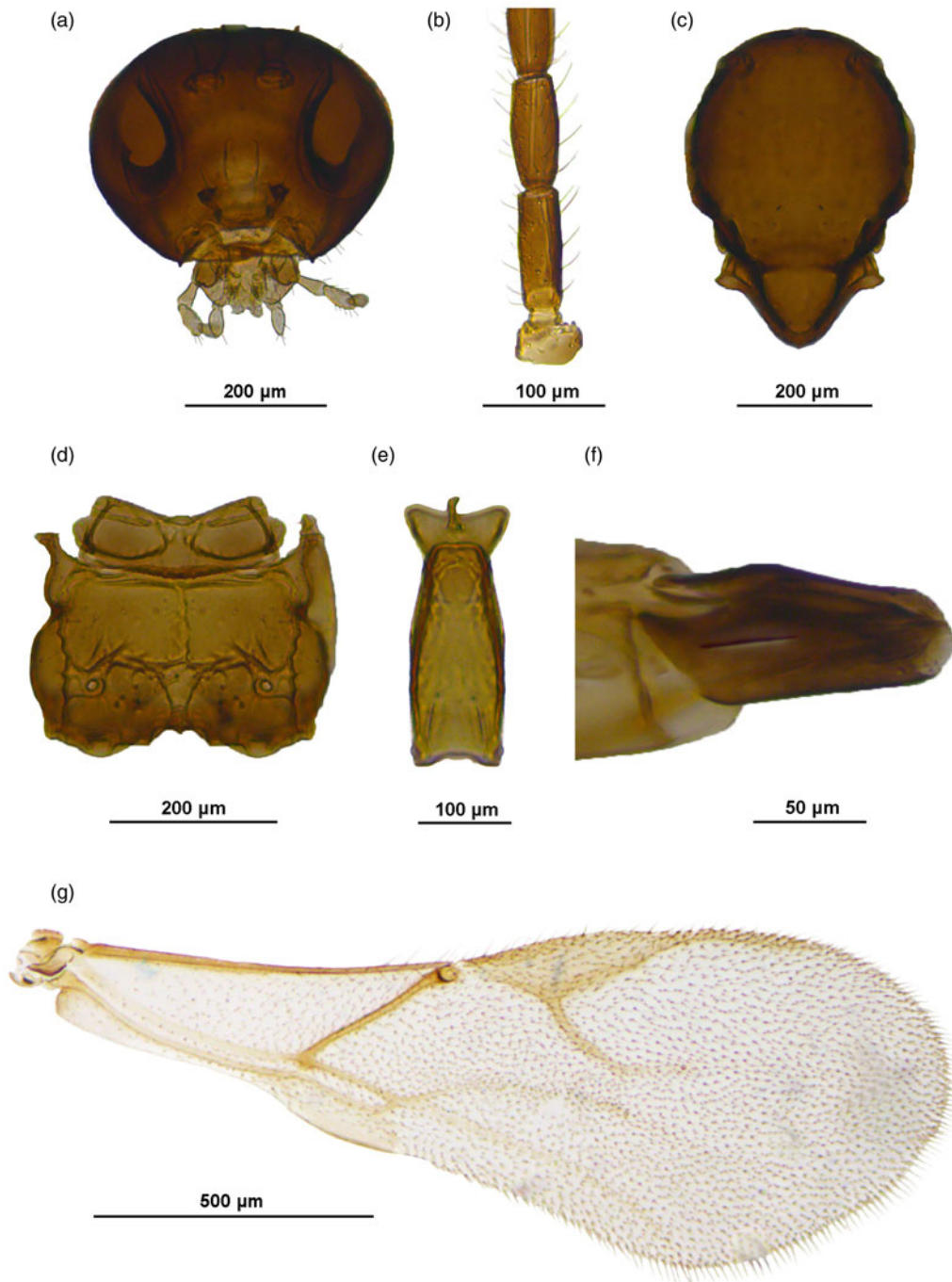
Material examined: 1♀, slide mounted, Burundi, reared from *Sitobion autriquei* Remaudière. Holotype ♀ deposited in collection of Institute of Entomology, České Budějovice.

Diagnosis. This species is distinguished from other members of the *A. colemani* group by 3-segmented maxillary palps (4-segmented in all other species). Additionally, it differs from *A. colemani* in having a relatively shorter metacarpus (pterostigma length/metacarpus length ratio is 1.4, while 1.1–1.2 in *A. colemani*).

Description.

Female. Head (fig. 5a). Moderately setose. Tentorial index 0.4, malar space 0.3 of longitudinal eye diameter. Clypeus with 4–5 setae. Antennae damaged, first 9 flagellomeres of one antenna and last 9 flagellomeres of the other antenna remaining. F1 2.5 times as long as wide, with 2 longitudinal placodes. F2 2.2 times as long as wide, with 3 longitudinal placodes. F1 equal to F2 (fig. 5b). Maxillary palp with three palpomeres, labial palp with two palpomeres.

Mesosoma. Mesoscutum with incomplete notaulices visible in anterior part, dorsal surface sparsely setose (fig. 5c). Fore wing



**Figure 5.** *Aphidius remaudierei* sp. n., female. A. Head. B. Flagellomeres 1–2. C. Mesoscutum. D. Propodeum. E. Petiole, dorsal view. F. Ovipositor sheaths. G. Fore wing.

pterostigma elongated, 3.8–4.0 times as long as wide; pterostigma length/metacarpus length ratio 1.4 (fig. 5g). Propodeum with a central pentagonal areola, oblique carinae almost horizontal (fig. 5d). Metasoma. Petiole slender (fig. 5e). Ovipositor sheath slender and slightly concave at the dorsal margin (fig. 5f).

Coloration. Head light brown, mouthparts yellow. Mesoscutum light brown, propodeum yellow. Wings hyaline with light brown venation. Petiole and metasoma light brown, ovipositor sheath brown.

Male. Unknown.

Host: *Sitobion austrucae*.

Etymology: The name of the new species is derived in honour of the famous French aphidologist Georges Remaudière who described many aphid species from Africa.

*Aphidius petrstaryi* sp. n. Črkić & Tomanović

fig. 6

Material examined: Holotype: 1♀, slide mounted, Angola, Chianga, 12. II 1971, reared from *Hyperomyzus carduelinus* (Theob.) on *Sonchus* sp.; Paratypes: 3♀, slide mounted, Ethiopia, Fiche, 2850 m.a.s.l., reared from *D. noxia* on *Hordeum vulgare*. Holotype and paratypes deposited in collection of Institute of Entomology, České Budějovice.

Diagnosis. This species differs from *A. transcaspicus* in F1 length/width ratio (2.6–3.0 in *A. petrstaryi* sp. n., while 3.5–4.0 in *A. transcaspicus*) and narrower pterostigma (pterostigma length/width is 3.7–4.0 in *A. petrstaryi* sp. n., while 3.6 in *A. transcaspicus*). Its host range is also different from that of *A. transcaspicus* – while *A. transcaspicus* has been reliably recorded on *Hyalopterus* spp. and *Melanaphis donacis* (Passer.), *A. petrstaryi* sp. n. is found on *D. noxia* and *H. carduelinus*.

Description.

Female. Head (fig. 6a). Moderately setose. Tentorial index 0.3–0.5, malar space 0.3 of longitudinal eye diameter. Clypeus with 2–5 setae. Antenna 16-segmented, slightly thickened at apex, with setae subequal to half of segment diameter (fig. 6b). F1 2.6–3.2 times as long as wide, without longitudinal placodes. F2 2.4–3.2 times as long as wide, with 1–2 longitudinal placodes. F1 equal to F2 (fig. 6c). Maxillary palp with four palpomeres, labial palp with three palpomeres.

Mesosoma. Mesoscutum with incomplete notaulices visible in anterior part, dorsal surface sparsely setose (fig. 6d). Fore wing pterostigma elongated, 3.7–4.0 times as long as wide; proportion between pterostigma length and metacarpus length 1.3–1.7 (fig. 6i). Propodeum with a central pentagonal areola (fig. 6e).

Metasoma. Petiole slender, 3.8 times as long as wide at spiracles, with 4–5 costae in the anterolateral area (fig. 6f, g). Ovipositor sheath slender and concave at the dorsal margin, length/width ratio 1.5 (fig. 6h).

Coloration. Head brown, mouthparts light brown. Scapus and pedicel light brown, F1 with a yellow ring at the base, remainder of antenna brown. Mesoscutum brown, propodeum light brown. Wings hyaline with brown venation. Petiole and metasoma light brown, ovipositor sheath brown.

Male: Unknown.

Etymology: The name of the new species is derived in honour of the late Petr Starý, Czech braconologist and his extraordinary contributions to aphidiinae taxonomy.

### Uncertain taxa

In addition to the specimens clearly different from currently known species of the *A. colemani* species group and described

here as new species, there were some individuals with somewhat unclear morphological characters and their combinations. These specimens do not warrant new species designations yet, most of them showing slight deviations from ranges of variation currently established for known species. Some examples are described below.

*Aphidius* sp. 1

Material examined: 1♀, slide mounted, Egypt, Beni Suef, I 1975, reared from *Rhopalosiphum padi* on *Triticum* sp. Deposited in collection of Institute of Entomology, České Budějovice.

Female. Head. Moderately setose. Tentorial index 0.4, malar space 0.3 of longitudinal eye diameter. Clypeus with 3–4 setae. Antenna 16-segmented, with setae subequal to half of segment diameter. Flagellar segment 1 (=F1) 3.3 times as long as wide, without longitudinal placodes. F2 2.8 times as long as wide, with 0–1 longitudinal placodes. F1 equal to F2 (fig. 7a). Maxillary palp with four palpomeres, labial palp with three palpomeres.

Mesosoma. Mesoscutum damaged. Fore wing pterostigma elongated, 4 times as long as wide; proportion between pterostigma length and metacarpus length 1.6 (fig. 7b). Propodeum with a central pentagonal areola.

Metasoma. Petiole slender, with 4 costae in the anterolateral area. Ovipositor sheath slender and slightly concave at the dorsal margin, length/width ratio 1.9.

Coloration. Head light brown, mouthparts yellow. Scapus and pedicel light brown, F1 yellow, remainder of antenna brown. Mesoscutum brown, propodeum light brown. Wings hyaline with brown venation. Petiole, metasoma and ovipositor sheath light brown.

Note: this specimen differs slightly from *A. transcaspicus* in having a narrower pterostigma (length/width ratio 4, while 3.6 in *A. transcaspicus*), and from *A. colemani* and *A. platensis* in having 3-segmented labial palps. It was designated as '*A. mediterraneus*' (= *A. petrstaryi* sp. n.) by Dr Petr Starý, although it can be differentiated from those specimens by a slightly more elongated F1, a larger portion of F1 being yellow (almost the entire segment, while only a yellow ring at the base of F1 is present in *A. petrstaryi* sp. n.) and a general lighter/yellow coloration.

*Aphidius* sp. 2

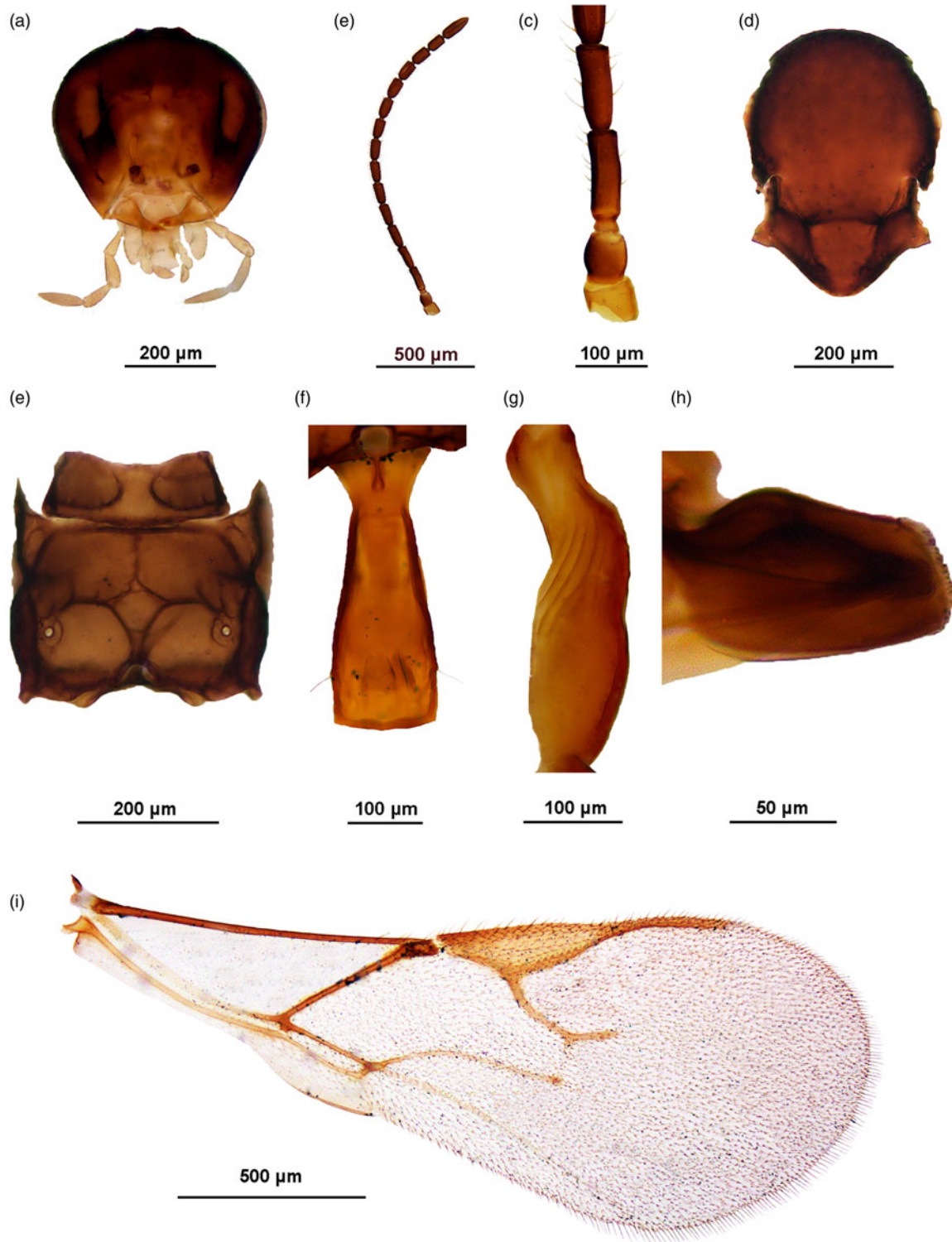
Material examined: 1♀, slide mounted, Ethiopia, Alidoro/Selale, 2820 m.a.s.l., 24. X 2001, reared from *Diuraphis noxia* on *Hordeum vulgare*. Deposited in collection of Institute of Entomology, České Budějovice.

Female. Head. Moderately setose. Tentorial index 0.7, malar space 0.3 of longitudinal eye diameter. Clypeus with 4–5 setae. Antenna 17-segmented, with setae subequal to half of segment diameter. Flagellar segment 1 (=F1) 3.2–3.3 times as long as wide, without longitudinal placodes. F2 2.8–3.3 times as long as wide, with 2–4 longitudinal placodes. F1 equal to F2 (fig. 7c). Maxillary palp with four palpomeres, labial palp with three palpomeres.

Mesosoma. Mesoscutum with incomplete notaulices visible in anterior part, dorsal surface sparsely setose. Fore wing pterostigma elongated, 3.3–3.6 times as long as wide; metacarpus slightly longer than pterostigma (pterostigma length/metacarpus length ratio 0.9) (fig. 7d). Propodeum missing.

Metasoma. Petiole missing. Ovipositor sheath slender and slightly concave at the dorsal margin, length/width ratio 1.8.

Coloration. Head light brown, mouthparts yellow. F1 with a yellow ring at the base, remainder of antenna light brown.



**Figure 6.** *Aphidius petrstaryi* sp. n., female. A. Head. B. Antenna. C. Flagellomeres 1–2. D. Mesoscutum. E. Propodeum. F. Petiole, dorsal view. G. Petiole, lateral view. H. Ovipositor sheaths. I. Fore wing.

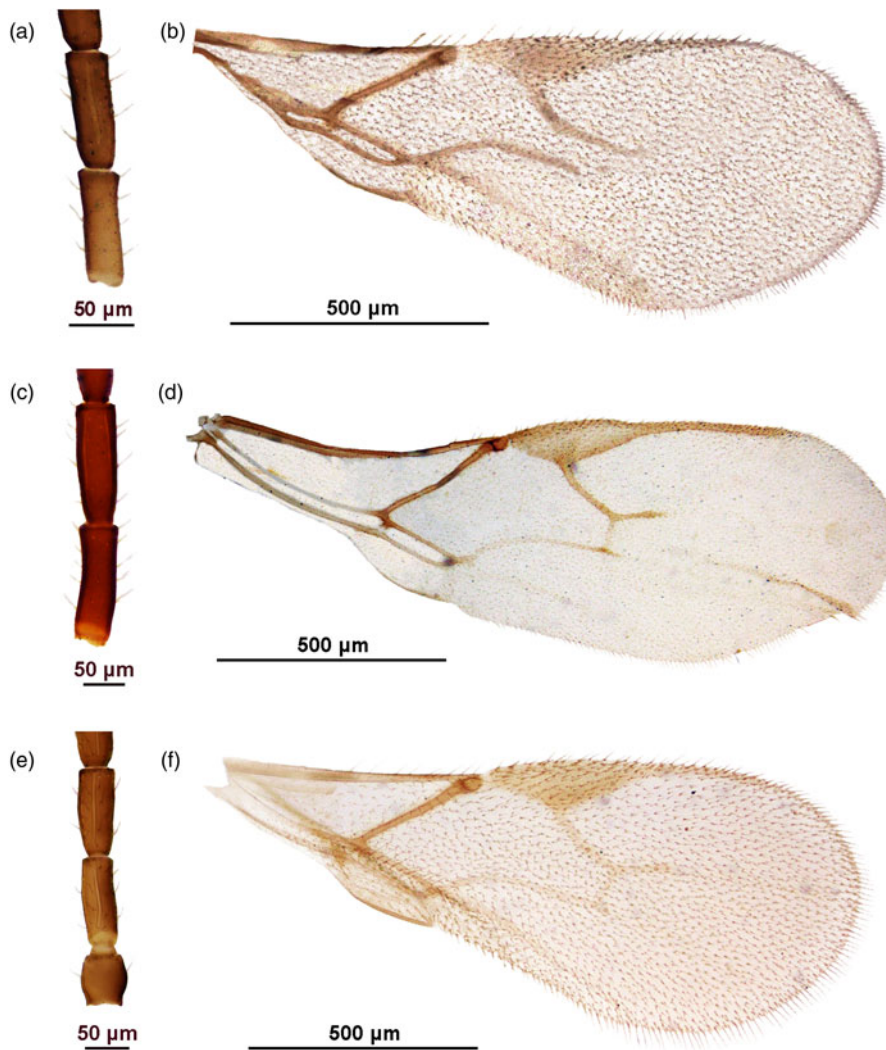
Mesoscutum light brown. Wings hyaline with brown venation. Metasoma and ovipositor sheath light brown.

Note: this specimen was designated as '*A. mediterraneus*' (= *A. petrstaryi* sp. n.) by Dr Petr Starý, but it can be differentiated clearly from other '*A. mediterraneus*' specimens by its very long metacarpus (pterostigma length/metacarpus length ratio is 0.9,

while 1.6 in *A. petrstaryi*), 17-segmented antenna (16-segmented in '*A. mediterraneus*') and a general yellow/light brown coloration. F1 length/width ratio of 3.2 differentiates it from *A. transcaspicus* (3.5–4.0), while the 3-segmented labial palps separate it from *A. colemani* and *A. platensis*.

*Aphidius* sp. 3





**Figure 7.** Uncertain taxa. *Aphidius* sp. 1: A. F1 and F2; B. Fore wing. *Aphidius* sp. 2: C. F1 and F2; D. Fore wing. *Aphidius* sp. 3: E. F1 and F2; F. Fore wing.

Material examined: 1♀, slide mounted, Burundi, reared from *Aphis fabae* on *Phaseolus* sp.

Deposited in collection of Institute of Entomology, České Budějovice.

Description.

Female. Head. Densely setose with short setae. Tentorial index 0.75, malar space approx. 0.3 of longitudinal eye diameter. Clypeus with 3–4 setae. Antenna 15-segmented, slightly thickened at apex, with setae subequal to half of segment diameter. Flagellar segment 1 (=F1) 2.5–2.7 times as long as wide, with 1–2 longitudinal placodes. F2 2.2–2.4 times as long as wide, with 3–4 longitudinal placodes. F2 equal to F1 (fig. 7e). Maxillary palp with four palpomeres, labial palp with three palpomeres.

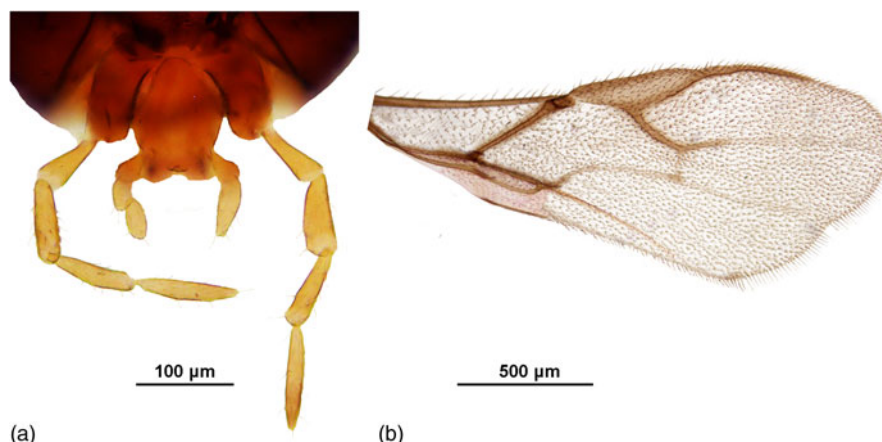
Mesosoma. Mesoscutum damaged. Fore wing pterostigma elongated, 3.4 times as long as wide; pterostigma length/R1 length ratio 1.4 (fig. 7f). Propodeum damaged.

Metasoma. Petiole slender, with 4 costae in the anterolateral area. Ovipositor sheath concave at the dorsal margin, length/width ratio 1.4. Coloration. Head brown, mouthparts light brown, antenna light brown. Mesonotum and propodeum brown, legs light brown. Wings hyaline with brown venation. Metasoma light brown.

Host: *Aphis fabae*.

Note: this specimen was identified as *A. colemani*. It differs from it in having 3-segmented labial palp and a shorter metacarpus. The 3-segmented labial palps are a shared trait with *A. transcaspicus*, but there is some slight variation in this specimen – F1 and F2 are less slender in *Aphidius* sp. 3 (F1 length/width ratio 2.5–2.7, while 3.5–4 in *A. transcaspicus*; F2 length/width ratio 2.2–2.4, while 2.9 in *A. transcaspicus*), and the metacarpus is just slightly longer than what has been recorded for *A. transcaspicus* so far (pterostigma length/metacarpus length 1.4 in *Aphidius* sp. 3, 1.6–2.0 in *A. transcaspicus*).

Additionally, there are a number of specimens that could be placed between *A. colemani* and *A. platensis* based on metacarpus length. Some specimens have one 2-segmented and one 3-segmented labial palp (fig. 8a). Usually, this would be a consequence of the palp segment not splitting fully, and the specimens in question would normally have 3-segmented labial palps. However, a few specimens with 2- and 3-segmented labial palps were collected in the same sample as specimens with 2-segmented labial palps. A detailed comparison of these individuals does not show clear separation based on relevant morphological characters. As another peculiarity, wing shape in a couple of specimens is distinctly different from the general wing shape of Aphidiinae. The



**Figure 8.** A. Specimen with one 2-segmented and one 3-segmented labial palp. Collected in Burundi, reared from *A. fabae*; B. Unusual fore wing shape. Specimen collected in Burundi, reared from *A. gossypii* on *Solanum nigrum*.

wings are clearly much wider, with a constriction at the distal margin (fig. 8b).

#### Additional examined material

##### *Aphidius colemani*

reared from *Aphis craccivora*: 2 females, Cabo Verde, 1 female, Egypt, Giza, 1 female, Angola, San Jorge; reared from *A. gossypii* on *Solanum nigrum*: 7 females, Burundi; on *Phaseolus* sp.: 1 male, Burundi; on unknown plant: 6 females, 2 males, Burundi; 13 females, Reunion Island; reared from *A. fabae*: 12 females, Burundi; reared from *Brachycaudus helichrysi*: 3 females, 1 male, Burundi; reared from *B. schwartzi*: 2 females, Burundi; reared from *Diuraphis noxia*: 1 female, Ethiopia; reared from *Melanaphis sacchari* on *Sorghum* sp.: 3 females, Burundi; reared from *Rhopalosiphum maidis*: 2 females, 1 male, Angola, 1 female, Reunion Island; reared from *R. padi*: 2 females, Angola, 6 females, 2 males, Burundi; reared from *Schizaphis rotundiventris*: 3 males, Angola, 1 female, Burundi; reared from unknown aphid on *Cucurbita* sp.: 1 female, Egypt, Oman, 1995; collected by Malaise trap: 1 female, Tristan da Cunha, Gough Island.

##### *Aphidius platensis*

reared from *B. helichrysi*: 2 females, Burundi; reared from 'cereal aphids' on 'spring barley': 19 females, Ethiopia, Fiche, 2850 m.a.s.l.; on unknown plant: reared from *Hyalopterus pruni* on *Phragmites* sp.: 1 female, Burundi, 1983; reared from unknown aphid on *Solanum lycopersicum*: 2 females, Egypt, Oman, 1995; on *Zea mays*: 3 females, Egypt, Oman, 1995.

##### *Aphidius transcaspicus*

reared from *B. helichrysi*: 1 female, Burundi; reared from *H. pruni* on *Phragmites* sp.: 1 female, Burundi, 1983; on *Prunus persica*: 2 females, Egypt; on unknown plant: 3 females, Burundi; reared from *Hyperomyzus carduelinus*: 2 females, Burundi; reared from *Macrosiphum euphorbiae*: 2 females, Burundi; reared from *R. maidis* on *Z. mays*: 1 male, Kenya, Chiromo; collected by sweeping: 3 females, South Africa, Mondeor, Johannesburg, 26 XI 1964; 2 females, South Africa.

## Discussion

*Aphidius colemani* group has long been puzzling researchers, despite including a small number of species. The three species included in it were considered valid species, then synonymised (Starý, 1975), then restored as separate species again (Tomanović *et al.*, 2014). As a consequence, earlier literature data about their distribution and hosts can lead to erroneous conclusions if not examined thoroughly. This problem is

compounded with the shared host range between *A. colemani* and *A. platensis*. One such example is the Biological Control Program of Wheat Aphids (BCPWA) undertaken in Brazil in the 1970s and 1980s, where *A. colemani* was introduced from France and Israel. Santos *et al.* (2019) re-examined specimens collected during the introduction and the monitoring period, thought at the time to be *A. colemani*, and found that they, in fact, all belong to *A. platensis*. A similar problem probably still exists in the light of commercially produced *A. colemani*, and it is likely that what is distributed as *A. colemani* actually contains a combination of two or more species from this group (Tomanović *et al.*, 2014).

As well as identification, finding a potential origin area and actual distribution of species from the *A. colemani* species group is complicated by its taxonomic history. So far, different origin areas have been proposed by different authors and with different taxonomic treatments of species. Starý (1972) proposed India as area of origin for *A. platensis*, as opposed to it being a member of the Neotropical faunistic complex, since it was described from South America. After synonymising the three species under *A. colemani*, Starý (1975) merged their distribution data and again postulated the Oriental region as the place of origin of this species. Takada (1998) confirmed Oriental origin for *A. colemani*, but assigned Palaearctic origin to *A. magdae* (= *A. transcaspicus*). Finally, Tomanović *et al.* (2014) postulated a Mediterranean origin for all three species.

Regarding the species described in this study, we can assume Afrotropical origin based on the current data. These findings may imply an area of origin for *A. colemani* species complex different from what has been considered in literature so far. With nine species, Africa currently holds the greatest diversity of the group. This might suggest that the group originated there and subsequently spread mainly through the tropical and subtropical regions. The findings of Woolley *et al.* (2021) support this hypothesis with a high haplotype diversity found in *A. colemani* species group in East Africa. Unfortunately, specimens from that study were destroyed during DNA extraction and no photographs or morphological analyses are given in the study, so a comparison with our specimens is impossible. Interestingly, none of the specimens examined in our study belong to *A. bertrandi*, a species from the *A. colemani* group reported to be the most common aphidiid in East Africa. *Aphidius bertrandi* is easily distinguished from other members of the *colemani* group by 18–19-segmented antenna (Starý *et al.*, 1985).

In contrast to the diversity of *A. colemani* group in Africa, reported Aphidiinae diversity in this region is very low. With

occasional studies conducted since the 1970s, the current number of Aphidiinae in Sub-Saharan Africa (until this study) stands at only 22 (Starý and van Harten, 1972, 1992; Starý and Schmutterer, 1973; Starý *et al.*, 1985, 1994; Sæthre *et al.*, 2011; Muller *et al.*, 2014). The question arises whether this is a consequence of fewer research efforts, or the actual state of aphidiine diversity. On one hand, the diversity of aphids is greater in the Northern hemisphere, so it would make sense to expect a greater diversity of their parasitoids. On the other hand, there is an apparent shortage of Aphidiinae taxonomists in the Southern hemisphere, as shown in a recent review by Petrović (2022), although this could actually be a shortage of funding opportunities for researchers in the global south.

The five newly described species from *A. colemani* species group have great potential for the biocontrol market. Since these species share the same host range pattern as the nominal species, and probably similar biological and ecological traits, we can assume that existing production technologies for *A. colemani* could work for them too. The increasing pressure of aphid pests affected by climate changes necessitates use of a greater diversity of Aphidiinae biocontrol agents in open fields and glasshouses. Further research of *A. colemani* species group from Sub-Saharan Africa could lead to their taxonomical clarification and confirmation of the high diversity. Hopefully this could lead to a more diverse Aphidiinae presence in the biocontrol market.

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