A review of *Aphidius colemani* (Hymenoptera: Braconidae; Aphidiinae) and closely related species indigenous to Japan

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(Received 23 April 1997; Accepted 16 September 1997)

Abstract

Aphidius colemani and closely related species indigenous to Japan were reviewed. *A. magdae* was newly recorded from Japan. "*A. picipes*" (= *A. avenae*), recorded formerly from Japan, was regarded as *A. uzbekistanicus*. The differences between *A. colemani* and *A. magdae* in morphological characters and esterase banding patterns detected by electrophoresis are presented. Taxonomic status of *A. magdae* is discussed especially in relation to *A. transcaspicus*. *A. magdae* was considered to be a species of Palearctic origin.

Key words: Taxonomy, aphid parasitoid, *Aphidius colemani*, *Aphidius magdae*, *Aphidius transcaspicus*

INTRODUCTION

Aphidius colemani Viereck, a pan-tropical and subtropical aphid parasitoid, is going to be introduced to Japan as a biological control agent against *Aphis gossypii* Glover and *Myzus persicae* (Sulzer), pest aphids of horticultural crops. The effect that introduction of this parasitoid has on aphid parasitoid fauna in Japan may become a problem in future. Before its introduction, therefore, it is necessary to review *A. colemani* and its closely related species indigenous to Japan. *A. colemani* is distinguished from most species of the genus *Aphidius* by the petiole which is anterolaterally costate. The other species with this trait are *A. magdae* Mescheloff and Rosen (Mescheloff and Rosen, 1990) and *A. picipes* (Nees) (Stary, 1973; Pennacchio, 1990). In the course of the present study *A. magdae* was found in Japan. This paper focuses on the differentiation between *A. colemani* and *A. magdae* based on morphological and enzymatic characters. In addition, the species recorded from Japan as *A. picipes* (Takada, 1968; Yamauchi and Takada, 1978; Yano et al., 1983) is revised.

MATERIALS AND METHODS

Materials. Cultures of *A. colemani* were obtained from Koppert B. V., the Netherlands, through Tomen Corporation, Japan, from 1993–1996 and from Ciba Bunting, Novartis

BCM LT., England, through Tomono Agrica Co., Ltd., Japan, in 1996. The parasitoid has been reared in the laboratory at 15L–9D, 20°C, using *Myzus persicae* on *Raphanus sativus* or *Aphis gossypii* on *Cucurbita maxima* as hosts. I used original materials for morphological observation and their progeny (15 females, 20 males from Koppert B. V. and 15 females, 14 males from Ciba Bunting) for electrophoretic separation of esterases. *A. magdae* and *A. uzbekistanicus* were collected from various localities in Japan. A detailed description of the collection data for the specimens used for morphological observation is given in the results of identification for each species. Unless otherwise stated the specimens were collected by me. The other 6 female and 6 male specimens of *A. magdae* (4 females, 4 males from Oohito and 2 females, 2 males from Shirakawa) were used for electrophoretic separation of esterases.

Electrophoretic separation of esterases. Individual adults of *A. colemani* and *A. magdae* were analyzed for variability in esterase enzyme banding patterns using the slab polyacrylamide gel electrophoresis method. Adults of *A. gifuensis* Ashmead from a stock culture which had been reared on *M. persicae* (on *R. sativus*) in our laboratory were used for comparison. Individual adult parasitoids were homogenized in a 30 µl mixture of 4 parts 40% sucrose solution and 1 part 0.5% triton. Four microliters homogenates were syringed into each sample pocket of

the 8% acrylamide gel. Gels were run in a tris-glycine buffer (pH 8.3) at constant amperage (50 mA) in a refrigerator at about 4°C. The gels were then stained with fast blue BB salt using 1-naphthyl acetate as the substrate for about 1 h at 20°C.

RESULTS AND DISCUSSION

1. Identification

(1) *Aphidius colemani* Viereck, 1912

Aphidius colemani Viereck, Proc. U. S. Nat. Mus. 42: 141, 1912.

Aphidius colemani: Mescheloff and Rosen, Israel J. Entomol. 24: 61–65, 1990.

Aphidius platensis Brethes: Starý, Oriental Insects 6: 359–370, 1972.

Specimens examined. Hundreds of specimens were obtained from Koppert B. V., the Netherlands in June, 1993, October, 1995 and January, 1996, and from Ciba Bunting, England in August and September, 1996.

The specimens examined agreed well with the redescrptions of Starý (1972, *A. platensis*) and Mescheloff and Rosen (1990) of the species, although they exhibited color variation as follows:

Female. Head dark brown; mouthparts yellowish brown; eye black; in some specimens, face, clypeus and gena yellowish brown. Antenna a little paler than head; scape and base of first flagellar segment brown ventrally; in some specimens, pedicel and whole of first flagellar segment yellowish brown ventrally. Thorax dark brown to brown; pronotum and propleuron yellowish brown. Legs yellowish brown to yellow; in some specimens, femora and tibiae dark brown. Wings hyaline, veins yellowish brown. Abdomen dark brown; petiole yellow; in some specimens, suture between second and third tergites broadly yellowish brown.

Male. Differs from female: antenna entirely dark brown to brown. Legs: femora and tibiae dark brown to brown. Petiole brown to yellowish brown; second tergite brown.

Hosts. At least 65 species of aphids have been recorded so far (see Appendix). Of these, 27 species are distributed in Japan.

Distribution. India, Middle East, Africa, South America and Oceania (Starý, 1975; Mescheloff and Rosen, 1990).

(2) *Aphidius magdae* Mescheloff and Rosen, 1990

Aphidius magdae Mescheloff and Rosen, Israel J. Entomol. 26: 83–85, 1990.

Specimens examined. ex *Hyalopterus pruni*: on *Prunus persica*, 16 females, 11 males, Oohito, Tagata-gun, Shizuoka Pref., 20. vi. 1996, T. Abe leg. and 9 females, 4 males, Shirakawa, Oono-gun, Gifu Pref., 26. ix. 1996, on *Phragmites communis* var. *longivalvis*, 9 females, 7 males, Kyoto, 13. vii. 1996; ex *Toxoptera aurantii* on *Camellia japonica*, 6 females, 2 males, Kyoto, 28. iv. 1995, S. Hatanaka leg.; ex *Schizaphis rotundiventris* on *Acorus calamus* var. *angustatus*, 1 female, Okayama, 1. vii. 1995; ex *Aphis* sp. on *Fragaria xananassa*, 1 female, 1 male, Kyoto, 24. iv. 1990. 10 females, 5 males, progeny of 4 females emerging from *T. aurantii*, reared on *Myzus persicae* on radish in the laboratory.

The specimens examined agreed well with the original description and figures of *A. magdae* from Israeli specimens (Mescheloff and Rosen, 1990), although they exhibited color variation as follows:

Female. Head dark brown; face, clypeus, gena and mouthparts yellow; eye black; scape and ventral surface of pedicel yellowish brown to yellow; third flagellar segment variable, usually dark brown and ventrally yellow to some extent, in some specimens, entirely yellow and in others, entirely dark brown. Thorax variable in color pattern: in most specimens, yellowish brown to yellow except for mesoscutum and mesoscutellum dark brown, in some specimens, almost entirely yellow, and in others, dark brown except for pronotum and propleuron yellowish brown. Legs yellow. Wings hyaline, stigma and vein yellowish brown. Abdomen dark brown; petiole yellow; second tergite mesially, suture between second and third tergites broad and apical segments yellowish brown.

Male. Differs from female: face and gena brown to yellowish brown; antenna almost entirely dark brown except for ventral surface of scape yellowish. Apical segments of abdomen dark brown.

Hosts. *Hyalopterus pruni* (Geoffroy), *Schizaphis rotundiventris* (Signoret) (new host record), *Tox-*

optera aurantii (Boyer de Fonscolombe) (new host record).

A population from *T. aurantii* was successfully reared on *Myzus persicae* in the laboratory, while populations collected from *H. pruni* at Oohito and Shirakawa could not be reared on *Myzus persicae* and *Aphis gossypii*.

H. pruni was also recorded in Israel as a host of this parasitoid, together with *Melanaphis donacis* (Passerini) and *Brachycaudus amygdalinus* (Schouteden) (Mescheloff and Rosen, 1990).

Distribution. Japan (Honshu) and Israel.

(3) *Aphidius uzbekistanicus* Luzhetzki, 1960
Aphidius (*Aphidius*) *uzbekistanicus* Luzhetzki, in Jachonotov et al. (eds.), Useful and pest insects of Uzbeki.: 22–23, 1960.

Aphidius uzbekistanicus: Starý, Annot. Zool. Bot., 84: 69–72, 1973; Chou, Master's Thesis, Nat. Chung-Hsing Univ., Taiwan: 41–43, 1984; Mescheloff and Rosen, Israel J. Entomol. 24: 77–80, 1990.

Aphidius avenae Haliday: Takada, Insecta Matsum. 30: 96–97, 1968.

Aphidius picipes (Nees): Mochida and Takada, Appl. Entomol. Zool. 13: 125–127, 1978; Yamauchi and Takada, Akitu, New Series 20: 1, 1978; Yano et al., Bull. Entomol. Res. 73: 559, 1983.

Specimens examined. 63 females, 86 males of 91 females, 109 males examined in Takada (1968); 1 female mentioned in Yamauchi and Takada (1978); 21 females of 79 females in Mochida and Takada (1978); 12 females, 14 males of 14 females, 16 males in Yano et al. (1983); ex *Sitobion akebiae* on gramineous plants, 1 male, Nikkou, Tochigi Pref., x. 1966, H. Higuchi leg., 1 female, Hino, Gamou-gun, Shiga Pref., 15. v. 1976, M. Ashitani leg., 3 females, 4 males, Kyoto, 21. x. 1970, 28. v. 1971, 3. vi. 1976 and 7. vi. 1984, and 1 male, Kagoshima, 16. iv. 1972, K. Kusigemati leg.; 21 females, 11 males: Bibai, Hokkaido; Kyoto; Amagasaki, Nishinomiya and Kobe, Hyogo Pref.; Kagoshima; Yaku, Kumage-gun, Kagoshima Pref.

I reexamined most of the specimens previously identified by me with *A. avenae* (Takada, 1968) and *A. picipes* (Mochida and Takada,

1978; Yamauchi and Takada, 1978; Yano et al., 1983). I came to the conclusion that they should be regarded as *A. uzbekistanicus*. These specimens agree well with Starý's (1973) and Mescheloff and Rosen's (1990) redescrptions of *A. uzbekistanicus* in having a petiole (Fig. 13) which is anterolaterally costulate, and in the prime key characters as described by Takada (1968).

Hosts. *Sitobion akebiae* (Shinji) and *S. ibarae* (Matsumura) (Takada, 1968).

In Taiwan *Sitobion miscanthi* (Takahashi) and *Rhopalosiphum padi* (Linnaeus) are known as hosts of this parasitoid (Chou, 1984).

Distribution. Japan (Hokkaido, Honshu, Kyushu), Taiwan, India, Israel and Europe.

2. Differences between *A. colemani* and *A. magdae*

Morphological characters. *A. colemani* and *A. magdae* have some traits in common: petiole (Figs. 8 and 9) 2.6–3.6 times as long as wide at spiracles, anterolaterally with 2–5 distinct costae (Figs. 11 and 12), propodeum (Figs. 5 and 6) completely areolated, maxillary palp with 4 segments and first flagellar segment equal to the second. But these species differ in the venation of the forewing, the segment numbers of antenna and labial palp, the shape and hair pattern of ovipositor sheath, the hair number on propodeum, the relative width of face, and the body coloration as mentioned in the following key.

Forewing (Fig. 1): first abscissa of radius arising at middle of stigma; radius arcuate: first and second abscissa merge smoothly above second intercubitus; wing width to first abscissa of radius: 3.06–3.45; length of stigma to metacarp: 1.14–1.35. Labial palp 2-segmented. Antenna with usually 15, rarely 16 segments in female (15:86, 16:4) and usually 17, rarely 16 or 18 segments in male (16:1, 17:65, 18:17). Ovipositor sheath (Figs. 3 and 7) with 6 long and 2 short hairs on outer surface, its upper margin almost straight. Propodeum (Fig. 5) with 8–14 hairs. Head width to face width: 2.10–2.37 in female and 2.06–2.17 in male. Ocellar triangle right or slightly obtuse. Face usually dark brown; apical segments of abdomen dark brown in

Figs. 1, 3, 5, 7, 8 and 11: *Aphidius colemani* ♀; 2, 4, 6, 9, 10 and 12: *A. magdae* ♀; 13: *A. uzbekistanicus* ♀. 1 and 2: forewing; 3 and 4: genitalia; 5 and 6: propodeum; 7 and 10: ovipositor sheath; 8 and 9: petiole in dorsal view; 11–13: petiole in lateral view.

Fig. 14. Esterase zymograms of 3 *Aphidius* species.

female.....*A. colemani*

Forewing (Fig. 2): first abscissa of radius arising before middle of stigma; radius bent: first and second abscissa meet creating an obtuse angle; wing width to first abscissa of radius: 3.57–4.33; length of stigma to metacarp: 1.54–2.20. Labial palp 3-segmented. Antenna with usually 16, rarely 15 or 17 segments in female (15:1, 16:35, 17:5) and 18 or 19 segments in male (18:11, 19:14). Ovipositor sheath (Figs. 4 and 10) with 5 long and 1 or 2 short hairs on outer surface, its upper margin slightly concave. Propodeum (Fig. 6) with 16–28 hairs. Head width to face width: 2.41–2.58 in female and 2.15–2.23 in male. Ocellar triangle right or slightly acute. Face yellow; apical segments of abdomen yellowish brown in female.

..... *A. magdae*

Esterase pattern. Esterase banding patterns detected by electrophoresis of *A. colemani* and *A. magdae* are shown in Fig. 14, together with *A. gifuensis* for comparison. The three *Aphidius* species were readily distinguished from each other by characteristic banding pat-

terns. *A. gifuensis* gave intense band of the slowest mobility (RM, relative mobility to bromphenol blue (BPB): 22.0–23.6). The banding patterns of *A. colemani* and *A. magdae* comprised two groups of bands, the first of which consisted of two bands (RM: 34.9–48.7) and the second of which consisted of one to three bands (RM: 63.6–75.1). The first group of bands migrated slower in *A. colemani* than in *A. magdae*. In *A. colemani* the first group of bands was more intensely stained than the second, while in *A. magdae* the second group of bands was stained more intensely. In *A. colemani* the first and second groups of bands showed infraspecific mobility variation in the specimens from Koppert B. V. (Fig. 14: 5–8), but the banding pattern was monomorphic in the specimens from Ciba Bunting (Fig. 14: 9). In *A. magdae* the second group of bands showed mobility variation (Fig. 14: 10–13). No sexually related banding pattern differences were observed in these three parasitoids.

3. Taxonomic status of *Aphidius magdae*

Mescheloff and Rosen (1990) recorded

Hyalopterus pruni and two other aphid species as hosts of *A. magdae* from Israel. I observed this parasitoid preferentially attacking *H. pruni* on its primary and secondary host plants in Japan. Starý (1975) noted that the host range of *A. colemani* is very wide in the tropics but much narrower from the Mediterranean to Central Asia, where it parasitizes mainly *H. pruni*. The populations distributed in the latter region had been treated as *A. transcaspicus* Telenga, 1958, but Starý (1975) classified it as a synonym of *A. colemani*. After examining two syntype specimens of *A. transcaspicus*, Mescheloff and Rosen (1990) stated that they are different from their concept of *A. colemani*. They also stated that *A. magdae* could be separated from *A. transcaspicus* mainly by the coloration of the first flagellar segment. Rabasse et al. (1985) showed that populations of *A. colemani* from south France differed from those from Brazil in the number of antennal segments, relative length of the metacarp of the forewing, pubescence and the esterase banding pattern detected by electrophoresis. The former also differed from the latter in host selection (Tardieux and Rabasse, 1986). Interbreeding between populations of *A. colemani* from south France, Brazil and La Reunion was never successful (Tardieux and Rabasse, 1988). Thus, Messing and Rabasse (1995) concluded that populations which were grouped under the name *A. colemani* possibly represented a complex of cryptic, sibling species. Starý (1995) also noted that quite a wide range of interspecific differences might be presumed to develop in such a widely distributed "species."

The taxon treated here as *A. magdae* is similar to the southern French populations of *A. colemani* examined by Rabasse et al. (1985) in the number of antennal segments, relative length of metacarp and pubescence. Although it is difficult to make precise comparisons of the esterase banding patterns of the present taxa with those of south French populations of *A. colemani* (Rabasse et al., 1985) since the methods used are different, these two taxa share the trait of the first group of bands, which migrate relatively faster. Chou (1981, 1984) recorded "*A. colemani*" from Taiwan but this taxon is presumably not *A. colemani*, but that treat-

ed here as *A. magdae*. His figures of forewing (Fig. 82), propodeum (Fig. 355), petiole (Figs. 410 and 463) and ovipositor sheath (Fig. 517) accurately illustrate the traits of *A. magdae* mentioned in the above key. Its association with *Hyalopterus pruni* (Chou, 1981) is notable. Mescheloff and Rosen (1990) stated that *A. magdae* is closely related to *A. transcaspicus*, but, as mentioned above, the former can easily be separated from the latter mainly by the entirely yellow first flagellar segment. In the specimens collected from Japan, however, the coloration of the first flagellar segment is variable, ranging from entirely yellow to entirely dark brown. This suggests that *A. magdae* may be identical to *A. transcaspicus*.

From these results, *A. magdae* (possibly = *A. transcaspicus*), which is mainly specialized to *Hyalopterus pruni*, is considered to be a species of Palearctic origin, in contrast to *A. colemani*, which is of Oriental origin (Starý, 1975).

ACKNOWLEDGEMENTS

I wish to express my sincere thanks to Mr. T. Abe (Oohito), Tomen Corporation (Tokyo) and Tomono Agrica Co. Ltd. (Shizuoka) for providing parasitoid materials.

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Appendix: A host list of *Aphidius colemani*

Aphid species	References			
	1	3	4	6
Aphidinae				
Pterocommatini				
<i>Pterocomma populeum</i> (Kaltenbach)	+			
Aphidini				
<i>Aphis chloris</i> Koch		+		
* <i>Aphis craccivora</i> Koch	+	+		+
<i>Aphis epilobiaria</i> Theobald		+		
* <i>Aphis fabae</i> Scopoli	+	+	+	+
* <i>Aphis gossypii</i> Glover	+	+	+	+
<i>Aphis hederæ</i> Kaltenbach		+		+
<i>Aphis intybi</i> Koch		+		
<i>Aphis marthae</i> Essig				+
* <i>Aphis nerii</i> Boyer de Fonscolombe	+	+		+
<i>Aphis patagonica</i> Blanchard				+
<i>Aphis punicae</i> Passerini	+	+		
<i>Aphis ruborum</i> (Boerner)				+
* <i>Aphis rumicis</i> Linnaeus	+			
<i>Aphis solanella</i> Theobald	+			
* <i>Aphis spiraecola</i> Patch	+	+		+
<i>Aphis umbrella</i> (Boerner)		+		
<i>Aphis verbasci</i> Schrank		+		
<i>Aphis zizyphi</i> Theobald	+	+		
* <i>Hyalopterus pruni</i> (Geoffroy)	(+)?		(+)?	
<i>Melanaphis donacis</i> (Passerini)	(+)?			
<i>Melanaphis meghalayensis</i> RayChaudhuri and C. Banerjee			+	
* <i>Rhopalosiphum maidis</i> (Fitch)	+	+	+	+
* <i>Rhopalosiphum nymphaeae</i> (Linnaeus)	+			+
* <i>Rhopalosiphum padi</i> (Linnaeus)	+	+	+	+
<i>Schizaphis (Paraschizaphis) eastopi</i> Van Harten and Ilharco	+			
<i>Schizaphis (Paraschizaphis) scirpi</i> (Passerini)		+		
* <i>Schizaphis graminum</i> (Rondani)	+	+	+	+
* <i>Schizaphis rotundiventris</i> (Signoret)	+			
* <i>Toxoptera aurantii</i> (Boyer de Fonscolombe)	+			+
* <i>Toxoptera citricida</i> (Kirkaldy)	+			
Macrosiphini				
<i>Aulacorthum dispersum</i> Van der Goot	+			

* <i>Aulacorthum solani</i> (Kaltenbach)	+			+	
* <i>Acyrtosiphon pisum</i> (Harris)					+
<i>Brachycaudus</i> (<i>Thuleaphis</i>) <i>aegyptiaca</i> (Hall)	+				
<i>Brachycaudus</i> (<i>Thuleaphis</i>) <i>amygdalinus</i> (Schouteden)			+		
* <i>Brachycaudus helichrysi</i> (Kaltenbach)	+	+			+
<i>Brachycaudus</i> (<i>Acaudus</i>) <i>persicae</i> (Passerini)	+				+
<i>Brachycaudus</i> (<i>Appelia</i>) <i>schwartzi</i> (Boerner)	+				+
<i>Brachycaudus</i> (<i>Appelia</i>) <i>tragopogonis</i> (Kaltenbach)					+
* <i>Brevicoryne brassicae</i> (Linnaeus)	+				+
* <i>Capitophorus elaeagni</i> (Del Guercio)	+	+			+
<i>Capitophorus hippophaes mitegoni</i> Eastop	+				
* <i>Cavariella aegopodii</i> (Scopoli)					+
<i>Chaetosiphon tetrarhodum</i> (Walker)					+
<i>Diuraphis noxia</i> (Mordvilko)					+
* <i>Dysaphis tulipae</i> (Boyer de Fonscolombe)	+				
<i>Dysaphis apiifolia</i> (Theobald)					+
* <i>Hayhurstia atriplicis</i> (Linnaeus)		+			
<i>Hyadaphis foeniculi</i> (Passerini)	+				
* <i>Hyperomyzus carduellinus</i> (Theobald)	+				
* <i>Hyperomyzus lactucae</i> (Linnaeus)					+
<i>Ipuka dispersum</i> (Van der Goot)	+				
* <i>Macrosiphum euphorbiae</i> (Thomas)	+	+			+
<i>Macrosiphum rosae</i> (Linnaeus)	+	+			+
* <i>Metopolophium dirhodum</i> (Walker)					+
<i>Metopolophium festucae cerealium</i> Stroyan					+
<i>Micromyzus kalimpongensis</i> A. N. Basu			+		
<i>Myzus ornatus</i> Laing	+				+
* <i>Myzus persicae</i> (Sulzer)	+	+	+		+
<i>Nasonovia ribisnigri</i> (Mosley)					+
*# <i>Pentalonia nigronervosa</i> Coquerel					
<i>Sitobion avenae</i> (Fabricius)	+				+
<i>Sitobion fragariae</i> (Walker)		+			+
<i>Sitobion rosaeiformis</i> Das			+		
<i>Uroleucon aeneus</i> (Hille Ris Lambers)					+
Thelaxinae					
<i>Thelaxis confertae</i> Boerner			+		

1: Starý (1975), 2: Aalbersberg, Van der Westhuizen and Hewitt (1988), 3: Meschloff and Rosen (1990), 4: RayChaudhuri (1990), 5: Voelkl, Stechmann and Starý (1990), 6: Starý (1995).

* Distributed in Japan.

Unnatural host.