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ADVANCES IN THE STUDY OF APHELINIDAE (HYMENOPTERA: CHALCIDIOIDEA) OF MEXICO

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Introduction

The family Aphelinidae belongs to the superfamily Chalcidoidea in the Order Hymenoptera, it is a family of moderate size within Chalcidoidea, containing about 1170 species in 33 genera (Noyes, 2006). About 140 described species are known from the Neartic region (Woolley, 1997), 72 species have been recorded for Argentina (De Sanis, 1998), 74 species are known to occur in Mexico (Myartseva & Ruiz-Cancino, 2000).

Aphelinids are primary parasitoids, rarely hyperparasitoids of Insecta, mainly Homoptera, especially Coccoidea and Aleyrodidea, although some species are known as egg parasitoids (Polaszek, 1991; Gibson et al., 1997). The genera with higher number of species are Encarsia Foerster, Coccophagus Westwood, Aphytis Howard and Eremocerus Haldeman. All have a cosmopolitan distribution. Among Chalcidoidea, Aphelinidae is rivalled only by Encyrtidae in the number of species that have been effective parasitoids of Homoptera (Greathead, 1986). The objective of this paper is to show the advances in the study of fauna, composition, host-relationships and geographical range of the Mexican Aphelinidae.

Material and methods

The special study of the family Aphelinidae was began in Mexico in 1998 and continues until the present time. Specimens were collected using three common methods (Noyes, 1982). Collections with a sweep net, yellow pan-traps and Malaise traps were used very rarely because these methods usually yielded few specimens. The main method used to collect aphelinids was rearing them from their hosts. Collected leaves and twigs on different plants infested with whiteflies and scale insects were cut from trees, shrubs and grasses, the samples were transported to the laboratory and kept in plastic and glass containers of different size, depending on number of host specimens. for emergence of parasitoids. Emerged parasitoids were collected with aspirator and transferred to vials with
75% ethanol and refrigerated for preserving. Later part of specimens were dissected and mounted on glass-slides in Canada balsam for study of morphology, drawing and identification. All material was fully labeled. Specimens on slides and in 75% ethanol are preserved in the Entomological Museum of the University of Tamaulipas, Mexico. The author examined also collections of that Museum (Ciudad Victoria, Tamaulipas, Mexico) and the Research Entomological Museum of the University of California (Riverside, California, U.S.A.). For species identification were used morphological criteria, based principally on some parts of head and body (configuration and relative proportions of antennal segments, setation of mesosoma, setation and length to width ratios of fore and hind wings, relative length of midtibial spur, middle tibia and ovipositor etc.).

Results and discussion

Previously, seventy four species in 9 genera were recorded for Mexico (Myartseva & Ruiz-Cancino, 2000). Then, 95 identified species in 12 genera were recorded in 2004 (Myartseva et al., 2004). In 2009, the list of aphelinids includes 179 species from 12 genera (Table 1).

Table 1. Aphelinidae of Mexico (2000-2009).

<table>
<thead>
<tr>
<th></th>
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<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Encarsia</td>
<td>31</td>
<td>41</td>
<td>94</td>
<td>51</td>
<td>+</td>
</tr>
<tr>
<td>Coccophagus</td>
<td>9</td>
<td>10</td>
<td>27</td>
<td>17</td>
<td>+</td>
</tr>
<tr>
<td>Eretmocerus</td>
<td>6</td>
<td>9</td>
<td>20</td>
<td>6</td>
<td>+</td>
</tr>
<tr>
<td>Aphytis</td>
<td>18</td>
<td>19</td>
<td>20</td>
<td>2</td>
<td>+</td>
</tr>
<tr>
<td>Pteroptrix</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>+</td>
</tr>
<tr>
<td>Marietta</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>+</td>
</tr>
<tr>
<td>Coccobius</td>
<td>-</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>+</td>
</tr>
<tr>
<td>Aphelinus</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Dirphys</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cales</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ablerus</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Centrodora</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>74</td>
<td>93</td>
<td>179</td>
<td>81</td>
<td>7</td>
</tr>
</tbody>
</table>

During this period were described 81 species in 7 genera as new for science. Studied materials from different authors about parasitoids of Homoptera in Mexico were published
in 116 publications, including 88 on Aphelinidae. For the six more important genera were composed keys to species.

**Genus Encarsia Foerster**

Contains more than 320 described species, making this cosmopolitan genus the largest in the family Aphelinidae (Table 2). Eighty-eight species of Mexican fauna, including 47 new species, were revised in 2008 (Myartseva & Evans, 2008). This fauna can be characterized geographically as typical New World fauna, and in zoogeographical aspect, according to predominance of species with southern distribution, as Neotropical fauna (81.8%).

<table>
<thead>
<tr>
<th>Country</th>
<th>Total species</th>
<th>Aleyrodidae</th>
<th>Diaspididae</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>57</td>
<td>38</td>
<td>17</td>
<td>Huang &amp; Polaszek, 1998</td>
</tr>
<tr>
<td>India</td>
<td>49</td>
<td>34</td>
<td>11</td>
<td>Hayat, 1989</td>
</tr>
<tr>
<td>Russia</td>
<td>30</td>
<td>21</td>
<td>9</td>
<td>Triapitzin et al., 1996</td>
</tr>
<tr>
<td>Italy</td>
<td>28</td>
<td>18</td>
<td>10</td>
<td>Viggiani, 1987</td>
</tr>
<tr>
<td>Egypt</td>
<td>14</td>
<td>10</td>
<td>4</td>
<td>Polaszek et al., 1999</td>
</tr>
<tr>
<td>Australia</td>
<td>59</td>
<td>50</td>
<td>6</td>
<td>Schmidt &amp; Polaszek, 2007</td>
</tr>
<tr>
<td>Mexico</td>
<td>65</td>
<td>51</td>
<td>14</td>
<td>Myartseva &amp; Evans, 2008</td>
</tr>
<tr>
<td>World</td>
<td>185</td>
<td>132</td>
<td>49</td>
<td>Heraty &amp; Woolley, 1999</td>
</tr>
</tbody>
</table>

Eight species of *Encarsia* were introduced into Mexico against diaspidids and aleyrids, generally on citrus (Myartseva & Ruiz-Cancino, 2000). *Encarsia perplexa* Huang & Polaszek, one species of Oriental origin, was released in Mexico successfully and now in citrus growing areas is recorded reliably as an effective parasitoid of citrus blackfly, *Aleurocanthus woglumi* Ashby. We reared from this pest one new species, *E. colima* Myartseva (Myartseva, 2005). *E. dominicana* Evans was introduced to Mexico against woolly whitefly, *Aleurothrixus floccosus* (Maskell) and successfully established. *E. inaron* (Walker) was introduced to California against pomegranate whitefly, *Siphoninus phillyreae* (Haliday) and later penetrated to Mexico by ecesis (Myartseva, 2006 a). Two *Encarsia* species were introduced to Mexico for biological control of armored scale insects: *E. aurantii* (Howard) to combat the Florida red scale *Chrysomphalus aonidum* (L.), and *E. perniciosi* (Tower) against California red scale *Aonidiella aurantii* (Maskell) (Garcia-
Martell, 1973). Numerous species of this genus have important role as parasitoids for natural control of phytophagous insects in several landscapes.

**Genus Coccophagus Westwood**

*Coccophagus* Westwood also is one of the largest genera. It comprises 248 recognized species and has a cosmopolitan distribution (Noyes, 2003). In the New World, 59 species of this genus are known, including 39 species distributed in the Neotropical and 32 species distributed in the Nearctic region (Woolley, 1997; Noyes, 2002). Nine species were known to occur in Mexico until our studies (Myartseva & Ruiz-Cancino, 2000; Myartseva & Coronado-Blanco, 2003; Myartseva *et al.*, 2004). Now for Mexico are registered 27 species, including 17 new described by author (Myartseva, 2006 b, 2009).

The females of *Coccophagus* are endoparasitoids of homopteran insects, mainly soft scales (Coccidae) and mealybugs (Pseudococcidae) and rarely other Coccoidea (Herting, 1972). The males are generally hyperparasitoids on other primary parasitoids, including conspecific females. *Coccophagus* species prefer attack soft scales. Mexican fauna comprises 63 species of 25 genera of Coccidae (Miller, 1996). Several species of *Coccophagus* are important in agriculture because have been used in the biological control of homopteran pests (Clausen, 1978; Greathed, 1986; Altieri & Nicholls, 1999). For example, the polyphagous black scale of African origin, *Saissetia oleae* (Olivier), an important pest on olives and citrus trees, have been one target for biological control by introduction of their natural enemies in several countries (Myartseva *et al.*, 2004). We found data on 4 species of *Coccophagus* reared in Mexico from black scales *Saissetia* spp.: *Coccophagus mexicanus* (Girault), *C. ochraceus* (Howard), *C. quaestor* (Girault) and *C. rusti* (Compere). All prefer to attack soft scales on ornamentals and fruits. *C. rusti* is one species of African origin. It was introduced into California and later to Peru, where is achieved substantial control of black scale *Saissetia oleae*. In Mexico, *Coccophagus rusti* penetrated by ecesis and now is common parasitoid of soft scales in Mexican fauna.

In Mexico, green soft scale *Coccus hesperidum* Limnacu sometimes is a dangerous pest on citrus and other fruits and ornamental trees. This scale is attacked by many natural enemies, including *Coccophagus* species, and usually they suppress its reproduction (in Africa, for example, 17 species of *Coccophagus* - Annecke & Inshley, 1974).
Genus *Eretmocerus* Haldeman

*Eretmocerus* comprises over 60 described species and has cosmopolitan distribution. In Mexico were known 6 species (Myartseva & Ruiz-Cancino, 2000), nowadays – 20 species, including 6 species described as new for science (Myartseva, 2006; Myartseva & Coronado-Blanco, 2007; Myartseva et al., 2007). Species of *Eretmocerus* develop as primary ecto-endoparasitoids of whiteflies and are important natural enemies for biological control of some pests on several agricultural crops.

Several *Eretmocerus* species were introduced into many countries for biological control of whitefly pests of many vegetable, fruits and ornamental plants. In Mexico, three species are known as parasitoids of one major pest in greenhouses and outdoor, *Bemisia tabaci* (Gennadius): *Eretmocerus emiratus* (Zolnerowich & Rose), *E. eremicus* (Rose & Zolnerowich) and *E. mundus* Mercet. These species were introduced for biological control of this major pest (Hennessey et al., 1995; Cota Gómez et al., 1998). *Eretmocerus serius* Silvestri was introduced into Mexico against citrus blackfly *Aleurocanthus woglumi*. According to our data, *Eretmocerus* species attack in Mexico whiteflies of 8 species from the genera *Aleurocanthus, Aleurodixus, Bemisia, Siphoninus, Tetraleurodes* and *Trialeurodes*, which include important plant pests (Myartseva et al., 2007).

Genus *Aphytis* Howard

*Aphytis* Howard currently includes about 130 species and is distributed in all zoogeographical regions (Hayat, 1998). Eighteen described species are known in the Nearctic region (Woolley, 1997). From the 18 species known to occur in Mexico, 10 are worldwide in distribution. Two species have been described earlier from Mexico and distributed only in this country: *A. punctaticorpus* Girault and *A. simmondsiae* DeBach (Rosen & DeBach, 1979; DeBach, 1984). Last years we described another two new species from Mexico (Myartseva, 2004). The genus *Aphytis* is well-known, because many of the species used for the biological control of armored scale insects (Diaspididae).

*Aphytis* species develop exclusively as primary ectoparasitoids and are the most important genus of natural enemies on dangerous diaspidids. Several species have been employed successfully in biological control programs, directed against economically important scale pests. Six species of *Aphytis, A. chilensis* Howard, *A. chrysomphali*
(Mercel), *A. holoxanthus* DeBach, *A. lepidosaphes* Compere and *A. lingnanensis* Compere were introduced into Mexico against several serious pests of citrus, such as Florida red scale *Chrysomphalus aonidum* L., California red scale *Aonidiella aurantii* (Maskell), purple scale *Lepidosaphes beckii* (Newman), oleander scale *Aspidiotus nerii* Bouchè and chaff scale *Parlatoria pergandii* Comstock (Myartseva, 2004). The species of *Aphytis* currently appear to be by far the most promising agents for the biological control of armored scale insect pests. Identification of species of the genus *Aphytis* is more difficult than other genera: special optical devices are required to study of the morphological structure found in the genus – crenulae. Posterior margin of propodeum rarely always with these crenulae in nesad third, the latter slightly triangularly or roundly produced or with two submedian lobes.

In conclusion, utilization of natural enemies – parasitoids from the family Aphelinidae, for the biological control of homopteran pests - has been highly successful to date but we have hardly made a beginning yet on several crops. There is an enormous potential of natural enemies that still await discovery, and further research is likely to yield many additional successes.

Acknowledgements

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Literature cited


