Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2017; 5(1): 692-696

Received: 03-11-2016
Accepted: 04-12-2016

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Aphelinid wasps (Hymenoptera, Aphelinidae) – parasitoids of scale insects (Hemiptera, Diaspididae) in Azerbaijan

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Abstract
A review of aphelinid parasitic wasps (Hymenoptera, Aphelinidae) obtained from their scale hosts in Azerbaijan is provided for the first time. As a result of long-term investigation, 30 species of aphelinids were revealed in the fauna of Azerbaijan. Of these, one species was described as a new for science and six species were reported for the first time for the fauna of Azerbaijan.

Keywords: Pests, scale insects, parasitoids, aphelinids, fauna, trophic relationships

Introduction
In the integrated system of protection of plants against sucking pest insects and diseases distributed by them an important role plays biological control, including use of natural enemies, such as entomophages and parasitoids.
Aphelinids as effective enemies of many harmful sucking insects, such as coccids, aphids, aylerodids are successfully used in biological control. However, despite their high effectiveness, this group of parasitoids is still insufficiently used in the integrated system of protection of plants against pests in Azerbaijan. Therefore, the studying aphelinid fauna of Azerbaijan is actual and important as bases for development of ways of their practical application in plant protection in Republic. The first report on Aphelinidae of Azerbaijan includes 29 species [4]. Later, Mustafayeva recorded 46 species of aphelinids in the fauna of eastern Azerbaijan [1, 2]. In present paper a list of aphelinids (Chalcidoiidea, Aphelinidae) parasiaztng on scales (Hemiptera, Diaspididae) occurring in Azerbaijan is provided.

Materials and Methods
Investigation was carried out in different regions of Azerbaijan from early spring to late autumn 1995 – 2010. Samples were made during complex faunistical expedition organized by Institute of Zoology of Azerbaijan Academy of Sciences and during numerous individual trips. Aphelinids were collected in various wild and agricultural biotopes by net sweeping and many species were obtained after emergency from their hosts in the laboratory [5]. Collected specimens were glued to small triangular pieces of card paper which were then pined with thin entomological pines. For identification of individuals of 3 quite small species microscopical slides of sexual organs were prepared. Collected species were determined using key papers by Nikolskaya & Yasnosh [3] and Yasnosh [6]. The same literature [3, 6] was used for obtaining information about their distribution. A new host records for the studied aphelinids are marked with an asterisk in the text of the paper.

Results and Discussions
A total of 30 species of aphelinids, belonging to 9 genera were found to parasitize the scale insects (Hemiptera, Diaspididae) in Azerbaijan. Trophic relationships of target aphelinid species are established. Below I provide an annotated list of these species.
Subfamily Aphelininae
Genus Aphytis Howard, 1900
Aphytis aonidea Mercet, 1911.
It was breed from *Lepidosaphes granati* Kor.* on the pomegranate, from *Carulaspis minima* Targ.* on thuja and cypress, from *Carulaspis visci* Schr. on cypress. The species is also a parasitoid of *Diaspidiotus perniciosus* Comst., *Chrysomphalus dictyospermi* Morg., *Aonidiella*

lauri Bche.,and *Parlatoria ziziphi* Lucas.
Distribution: Moldova, Caucasus, Western Europe.
Aphytis chilensis Howard, 1900.
It was breed from *Aspidiotus nerii* Bche. on oleander, olive, thuja, laurel and other plants.
Distributtion: Black Sea coast of Caucasus, South of Western Europe, Western Asia, North Africa, North and South America, Australia.
Aphytis maculicornis Masi, 1911.
It was breed from *Aspidiotus nerii* Bche. on laurel, oleander, olive, thuja and other plants.
Distribution: Black Sea coast of Caucasus, South of Western Europe, Western Asia, North Africa, North and South America, Australia.
Aphytis hispanicus Mercet, 1912.
It was breed from scales *Parlatoria oleae* Golvee, *Aspidiotus nerii* Bche., *Chrysomphalus dictyospermi* Morg. on different fruit and decorative plants. New species for the fauna of Azerbaijan.
Distribution: Southern Europe, Transcaucasia, Taiwan, USA.
Aphytis mytilaspidis (Le Baron, 1870).
It was breed from *Lepidosaphes granati* Kor.* on pomegranate, *Parlatoria oleae* Colvee on olive, cherry plum, peach, from *Diaspidiotus caucasicus* Borchs. on willow, poplar, from *Salicicola kermanensis* Lndgr. on poplar, from *Carulaspis minima* Targ. on cypress, thuja, from *Diaspidiotus ostreaformis* Curt. on poplar.
Disribution: Crimea, Caucasus, Russia: Primorsk Area, Sakhalin, South Kuriles (Kunashir), Central Asia, Western Europe, North Africa, Iraq, India, Japan, America.
*Aphytis proclia (*Walker, 1839).
It was breed from *Diaspidiotus perniciosus* Comst. on dogrose, apple-tree, ash-tree, rasttberry, from *Pseudaulacaspis pentagona* Targ. on raspberry, mulberry and the Lankaran acacia, from *Diaspidiotus pyri* Licht. on apple-tree, from *Lepidosaphes ulm*i L. on poplar.
Distribution: Moldova, Ukraine, Crimea, Caucasus, Central Asia, Central and Southern Europe, Russia: European part, Primorsk Area, Sakhalin, Southern Kuriles (Kunashir).
Aphytis testaceus Tshumakova, 1961.
It was breed from *Lepidosaphes granati* Kor.* on pomegranate, from *Carulaspis minima* Targ.*on thuja, from *Diaspidiotus ostreaformis* Curt. on poplar and willow.
Distribution: Moldova, Norhern Caucasus, Primorsk area.
Aphytis chrysomphali (Mercet, 1912).
It is parasitoid of *Chrysomphalus dictyospermi* Morg. on decorative plants. First record for Azerbaijan fauna.
Distribution: Black Sea shore of the Caucasus, Western Europe, North Africa, introduced to China, India, Japan, Australia.
Aphytis moldavicus Yasnosh, 1958.
It was breed from *Lepidosaphes ulmi* L. on poplar and apple tree, from *Diaspidiotus pyri* Licht. on poplar. First record for the fauna of Azerbaijan.
Distribution: Russia.
Subfamily Coccophaginae
Genus Coccobius Ratseburg, 1852 (= *Physcus* Howard, 1895)
Coccobius granati Yasnosh et Mustafayeva, 1992.
It was breed from *Lepidosaphes granati* Kor. on pomegranate. The species was described as new to science.
Distribution: Azerbaijan (Absheron).
Coccobius pistacicolus (Yasnosh, 1958)
It is parasitoid of Lepidosaphes pistaciae Arch.
Distribution: Transcaucasia.
Coccobius mesasiaticus (Yasnosh and Myartsova, 1975).
It was breed from *Diaspidiotus caucasicus* Borchs.* on poplar.
Distribution: Central Asia.
Coccobius testaceus (Masi, 1909).
It was breed from *Lepidosaphes ulmi* L. on poplar and willow, from *Diaspidiotus ostreaforms* Gurt. on poplar and elm, from *Lepidosaphes granati* Kor.* on pomegranate, from *Lepidosaphes ficus* Sign.* on fig tree, from *Lepidosaphes conchiformis* Gmel* on cypress.
Distribution: Crimea, Caucasus, Central Asia, Western Europe, Caliphornia.
Subfamily Azotinae
Genus Ablerus Howard, 1894 (*Azotus* Howard, 1898, Yasnosh, 1995)
Ablerus atomon (Walker, 1847).
It was breed from *Diaspidiotus caucasicus* Borchs. on poplar, from *Lepidosaphes ulmi* L.* on medlar from *Diaspidiotus perniciosus* Comst. On pear-tree and apple-tree, from *Aulacaspis rosae* Bche. on rose, from *Diaspidiotus ostreaformis* Curt. on poplar. It is secondary parasitoid of many species of scales.
Distribution: Ukraine, Moldova, Caucasus, Central Asia, Primorsk area, Western Europe, North America.
Ablerus celsus Walker, 1847.
It was breed from *Lepidosaphes granati* Kor.* on pomegranate. The species is also secondary parasioid of *Diaspidiotus ostreaformis* Curt., *Diaspidiotus gigas* Th et Gern., *Chionaspis salicis* L., *Salicicola kermanensis* Lindgr., *Aulacaspis rosae* Bche.
Distribution: Moldova, Crimea, Caucasus, Central Asia, Central and Western Europe.
Ablerus chrysomphali Ghesguire, 1960.
It was breed from *Diaspidiotus caucasicus* Borchs.* on poplar. Also was observed as parasite of *Chrysomphalus dictuospermi* Morg. and *Parlatoria oleae* Colvee.
Distribution: Georgia, Turkmenistan, North Africa.
Subfamily Prospaltellinae
Genus Pterotrix Westwood, 1833
Pretotrix macropedicellata (Malac, 1947).
It was breed from *Aulacaspis rosae* Bche. on rose.
Distribution: Black Sea shore of the Caucasus, Czech Republic, Slovakia.
Genus Archenomus Howard, 1898
Archonomus bicolor Howard, 1898.
It was breed from *Tecaspis asiatica* Balach. Also parasitize on *Diaspidiotus pyri* Licht., *Diaspidiotus ostreaformis* Curt., *Diaspidiotus perniciosus* Coms., *Diaspidiotus turanicus* Borch., *Aulacaspis rosae* Bche.
Distribution: Crimea, Caucasus, Western Europe, North America, Ceylon, Java.
Archenomus caucasicus Yasnoch, 1955.
It was breed from *Diaspidiotus caucasicus* Borchs. on poplar, willow, from *Diaspidiotus perniciosus* Comst. on Elaeagnus.
Distribution: Georgia, Azerbaijan.
Archenomus longiclavae Giralt. (= *A. longicornis* Nikolskayae, 1959).
It was breed from *Diaspidiotus ostreaformis* Gurt. on poplar, from *Lepidosaphis granati* Kor.* on pomegranate, from *Lepidosaphis ulmi L.* on poplar.
Distribution: European part of Russia, North Caucasus, Crimea, Primorsk area, Central and Primorsk area.
Archenomus maritimus (Nikolskayae, 1952)
It was breed from *Lepidosaphes granati* Kor.* on pomegranate, from *Diaspidiotus perniciosus* Comst. on Elaeagnus.

Distribution: North Caucasus, Primorsk area, Hungary.

Genus Hispaniella Mercet, 1911

Hispaniella lauri Mercet, 1911.

It was breed from *Diaspidiotus caucasicus* Borchs. on willow, poplar, from *Diaspidiotus ostreaformis* Curt. on poplar, from *Diaspidiotus perniciosus* Comst. on ash-tree, poplar, from *Lepidosaphis ulmi* L. on ash-tree.

Distribution: Moldova, Caucasus, Primorsk area, Slovakia, Yugoslavia, Spain, North America.

Genus Aspidiotiphagus Howard, 1894

Aspidiotiphagus citrinus Grav., 1891.

It was breed from *Aspidiotus nerii* Bche. On thuja and oleander, on *Asparagus sprengeri* Regel. and *Asparagus plunosus* Baker, from *Chrysomphalus dictiospermi* Morg. on laurel, from *Parlatoria oleae* Colvee on apple-tree, quince, olive, cherry plum, from *Diaspidiotus perniciosus* Comst. on pear-tree, from *Aulacaspis rosae* Bche. on rose. This polypagous parasioid also parasitize *Diaspidiotus prunorum* Laing., *Carulaspis minima* Targ., *Lepidosaphes ulmi* L.

Distribution: Moldova, Crimea, Caucasus, Primorsk area.

Genus Diaspiniphagus Silvestri, 1927

Diaspiniphagus similis (Masi, 1908) (= *Coccophagoidea similis* Masi).

It was breed from *Diaspidiotus ostreaformis* Curt. on poplar, willow, from *Lepidosaphes ulmi* L. on quince, from *Carulaspis minima* Targ. on thuja. It is also recorded as parasioid of *Diaspidiotus prunorum* Laing., *Diaspidiotus caucasicus* Borchs., *Diaspidiotus gigas* Theim and Gerneck., *Nuculaspis abietis* Schr., *Unaspis evonumi* Comst., *Lecaspis pisulla* Loew. and some other scales.

Distribution: Caucasus, Central Asia, Primorsk area.

Genus Encarsia Foerster, 1878 (= Prospaltella)

Encarsia aurantii (Howard, 1894).

It was breed from *Chrusomphalus dictiospermi* Morg. on laurel, ficus, pea, yucca and some other plants, from *Aspidiotus nerii* Bche. on oleander and yucca.

Distribution: Black Sea coast of Caucasus, Azerbaijan, Iran, China, Australia, North America, Argentina, Chili.

Encarsia gigas Tshum., 1957.

It was breed from *Diaspidiotus ostreaformis* Curt. on poplar, from *Lepidosaphes ulmi* on willow, from *Unaspis evonymi* Comst. on spindle tree. Distribution: Caucasus, Central Asia, Primorsk area, Hungary, former Yugoslavia, Western Europe.

Encarsia fasciata (Malenotti, 1917).

It was breed from *Aonidea lauri* Bouche. on laurel, from *Lepidosaphes ulmi* L. on poplar, from *Aulacaspis rosae* Bouche. on rose, from *Unaspis evonymi* Comst. on spindle tree. It also parasitizes on *Diaspidiotus caucasicus* Borchs, *Diaspidiotus perniciosus* Comst. *Adiscodiaspis tamaricicola* Mal., *Aonidea lauri* Boche.*, *Unaspis evonymi* Comst.*, *Leucaspus pusilla* Loew.*.

Distribution: Eastern Georgia, central and southern parts of Western Europe, Iran, North America.

Encarsia intermedia Ferr, 1961.

It was breed from *Nuculaspis abietis* Schr. on spruce, from *Lopholeucaspis yaponica* Ckll. on subtropical crops. First record for the fauna of Azerbaijan.

Distribution: Black Sea coast of Caucasus, Transcaucasia, Western Europe.

Encarsia perniciosi Tower., 1913.

It was breed from *Diaspidiotus perniciosus* Comst. on apple-tree, quince, poplar and some other trees.

Distribution: Western Europe, Moldova, Caucasus, Central Asia, Primorsk area, China, USA, Canada.

Encarsia leucaspidis Merc., 1912.

It was breed from *Leucaspis pusilla* Loew. on pine. First record for the fauna of Azerbaijan.

Distribution: Western Europe, Caucasus.

Table 1: Trophic relationships of aphelinids (Hymenoptera, Aphelinidae) of Azerbaijan with their scale insect hosts (Hemiptera, Diaspididae)

Family Aphelinidae. **Genera and species of aphelinides**	**Hosts of aphelinides** **Species of scale insects**
Genus *Aphytis* Howard, 1900 1. *Aphytis aonidea* Mercet, 1911	*Diaspidiotus pyri* Lichtenstein, 1881 *Diaspidiotus prunorum* Laing., 1931 *Lepidosaphes granati* Koroneos, 1934* *Carulaspis minima* Targioni-Tozzetti, 1868* *Epidiaspis leperii* Siqnorett, 1869.
2. *Aphytis chilensis* Howard, 1900	*Aspidiotus nerii* Bouche, 1937
3. *Aphytis maculicornis* Masi, 1911	*Parlatoria oleae* Golvee, 1880
4. *Aphytis mytilaspidis* (Le Baron,1870)	*Diaspidiotus caucasicus* Borchsenius, 1935 *Diaspidiotus ostreaformis* Curtis, 1843 *Lepidosaphes granati* Koroneos, 1934* *Lepidosaphes ulmi* Linnaeus, 1758 *Lepidosaphes ficus* Sign., 1870. *Aulacaspis rosae* Bouche, 1833. *Salicicola kermanensis* Lindinger, 1905. *Tecaspis prunorum* Borchsenius, 1939. *Tecaspis asiatica* Balachowsky, 1954.
5. *Aphytis proclia* (Walker, 1839)	*Diaspidiotus perniciosus* Comstok, 1881. *Diaspidiotus pyri* Lichtenstein, 1881 *Pseudaulacaspis pentagona* Targioni-Tozzetti, 1885
6. *Aphytis testaceus* Tschum., 1961	*Lepidosaphes granati* Koroneos, 1934* *Carulaspis minima* Targioni-Tozzetti, 1868* *Epidiaspis leperii* Siqnorett, 1869.
7. *Aphytis hispanicus* Mercet, 1912	*Parlatoria oleae* Colvee, 1880 *Carulaspis visci* Schrank,, 1781 *Aspidiotus nerii* Bouche, 1937 *Chrysomphalus dictyospermi* Morqan, 1889.
8. *Aphytis chrysomphalu* (Merc., 1912)	*Chrysomphalus dictyospermi* Morqan, 1889.
9. *Aphytis moldavicus* Yasnosh, 1958	*Diaspidiotus pyri* Lichtenstein, 1881 *Lepidosaphes ulmi* Linnaeus, 1758.

	Epidiaspis leperii Siqnorett, 1869.
Genus Coccobius Ratseburg, 1852 10. *Coccobius granati* Yasnosh and Mustafayeva, 1992	*Lepidosaphes granati* Koroneos, 1934.
11.*Coccobius pistasicolus* (Yasnosh, 1958)	*Lepidosaphes pistaciae* Arch., 1918
12. *Coccobius mesasiaticus* (Yasnosh and Myartsova, 1975)	*Diaspidiotus caucasicus* Borch., 1935 * *Diaspidiotus ostreaformis* Curtis, 1843
13. *Coccobius testaceus* (Masi, 1909)	*Lepidosaphes ulmi* Linnaeus, 1758 *Lepidosaphes granati* Koroneos, 1934* *Lepidosaphes conchiformis* Gmel., 1790* *Lepidosaphes ficus* Sign., 1870*
Genus *Ablerus* Howard, 1894 14. *Ablerus atomon* (Walker, 1847)	*Lepidosaphes ulmi* Linnaeus, 1758* *Diaspidiotus ostreaformis* Curtis, 1843. *Diaspidiotus caucasicus* Borchs., 1935 *Diaspidiotus perniciosus* Comst., 1881 *Aulacaspis rosae* Bouche, 1833.
15. *Ablerus celsus* Walker, 1847	*Lepidosaphes ulmi* (Linnaeus, 1758) *Lepidosaphes granati* Koroneos, 1934*
16.*Ablerus chrysomphali* Ghesguire, 1960	*Diaspidiotus caucasicus* Borchsenius, 1935* *Chrysomphalus dictuospermi* Morqan, 1889 *Parlatoria oleae* Colvee, 1880.
Genus *Pteroptrix* Westwood, 1833 17. *Pteroptrix macropedicellata* (Malac, 1947)	*Aulacaspis rosae* Bouche, 1833.
Genus *Archenomus* Howard, 1898 18. *Archenomus bicolor* Howard,1898	*Diaspidiotus pyri* Lichtenstein, 1881 *Aspidiotus nerii* Bouche, 1937 *Tecaspis asiatica* Balachowsky, 1954
19. *Archenomus caucasicus* Yasnosh, 1955	*Diaspidiotus caucasicus* Borchs., 1935. *Diaspidiotus perniciosus* Comst., 1881. *Diaspidiotus prunorum* Laing., 1931
20. *Archenomus longiclavae* Giralt., 1959	*Diaspidiotus ostreaformis* Curtis, 1843 *Lepidosaphes granati* Koroneos, 1934* *Lepidosaphes ulmi* Linnaeus, 1758.
21. *Archenomus maritimus* (Nikolskayae, 1952)	*Diaspidiotus perniciosus* Comstok, 1881 *Diaspidiotus pyri* Lichtenstein, 1881 *Lepidosaphes granati* Koroneos, 1934*
Genus *Hispaniella* Mercet, 1911 22. *Hispaniella lauri* Mercet,1911	*Diaspidiotus caucasicus* Borchsenius, 1935 *Diaspidiotus perniciosus* Comstok, 1881. *Diaspidiotus ostreaformis* Curtis, 1843 *Lepidosaphes ulmi* Linnaeus, 1758. *Salicicola kermanensis* Lindinger, 1905
Genus *Aspidiotiphagus* Howard, 1894 23. *Aspidiotiphagus citrinus* Graw.1891	*Parlatoria oleae* Colve, 1880. *Aspidiotus nerii* Bouche, 1937. *Diaspidiotus perniciosus* Comstok, 1881 *Diaspidiotus prunorum* Laing., 1931. *Lepidosaphes ulmi* Linnaeus, 1758. *Lepidosaphes gloverii* Packard, 1869. *Pseudaulacaspis pentagona* Targioni – Tozzetti,1885. *Chrysomphalus dictyospermi* Morqan, 1889. *Diaspis echinocacti* Bouche, 1933. *Carulaspis minima* Targioni-Tozzetti, 1868 *Aulacaspis rosae* Bouche, 1833 *Tecaspis prunorum* Borchsenius, 1939. *Tecaspis asiatica* Balachow., 1954
Genus *Diaspiniphagus* Silvestri, 1927 24. *Diaspiniphagus similis* (Masi, 1908)	*Diaspidiotus ostreaformis* Curtis, 1843.
Genus *Encarsia* Foerster, 1878 25. *Encarsia aurantii* (Howard, 1894)	*Lepidosaphes ulmi* Linnaeus, 1758. *Lepidosaphes gloverii* Packard, 1869. *Pseudaulacaspis pentagona* Targioni-Tozzetti, 1885.
26. *Encarsia gigas* Tshum., 1957	*Diaspidiotus ostreaformis* Curtis, 1843.
27. *Encarsia fasciata* (Malenotti, 1917)	*Lepidosaphes ulmi* Linnaeus, 1758. *Lecaspis pusilla* Loew. 1883* *Unaspis evonymi* Comstok, 1881 * *Adiscodiaspis tamaricicola* Malenotti, 1916 *Aulacaspis rosae* Bouche, 1833. *Aonidea lauri* Bouche, 1833 *
28. *Encarsia intermedia* Ferr, 1961	*Nuculaspis abietis* (Schrank, 1776) *Lopholeucaspis yaponica* Balach., 1953
29. *Encarsia perniciosi* Tower., 1913	*Diaspidiotus perniciosus* Comstok, 1881
30. *Encarsia leucaspidis* Merc., 1912	*Leucaspis pusilla* Loew., 1883

Conclusions

1. A total of 30 species of aphelinid parasitic wasps belonging to 9 genera were recorded in the fauna of Azerbaijan. Of these the most diverse genus was *Aphytis*, including 9 species, followed by Encarsia (6 species), Coccobius (4), Archenomus (4) and Ablerus (3). Each of the rest four genera were represented by single species only.
2. Among found species 5 species (*Aphytis moldavicus*, *Aphytis chrysomphali*, *Aphytis hispanicus, Encarsia intermedia, Encarsia leucaspidis*) are recorded in the fauna of Azerbaijan for the first time. And one species *Coccobius granati* Yasnosh and Mustafayeva was described as new for science.
3. Seventeen species of scale insects were reported as new hosts for aphelinids. These species are marked with an asterisk.

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