The Coccoidea on *Quercus* (Fagaceae) in Bulgaria and Greece, with Particular Reference to Their Importance as Honeydew-Producing Insects

Author(s): K. Trencheva, S. Gounari, G. Trenchev, and E. Kapaxidi
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THE COCCOIDEA ON *QUERCUS* (FAGACEAE) IN BULGARIA AND GREECE, WITH PARTICULAR REFERENCE TO THEIR IMPORTANCE AS HONEYDEW-PRODUCING INSECTS[1]

K. Trencheva,[2] S. Gounari,[3] G. Trenchev,[2] and E. Kapaxidi[4]

ABSTRACT: A study of scale insects (Coccoidea) on oak trees (*Quercus* sp., Fagaceae) was undertaken between April and October in 2005 and 2006 in Bulgaria (B) and Greece (G), mainly in regions of beekeeping interest, to determine the sources of honeydew utilized by the bees. A total of 12 species of scale insects were collected: Coccidae: *Eulecanium tiliae* Linnaeus (B and G), *Eulecanium ciliatum* Douglas (B) and *Parthenolecanium rufulum* Cockerell: (B and G); Diaspididae: *Targionia vitis* Signoret (B and G), *Lepidosaphes ulmi* Linnaeus (B), *Diaspidiotus wuenni* Lindinger (G), *Diaspidiotus zonatus* Frauenfeld (G) and *Diaspidiotus lenticularis* Lindinger (G); Kermesidae: *Kermes roboris* Fourcroy (B) and *Kermes gibbosus* Signoret (B); Eriococcidae: *Eriococcus* sp. (B and G), and Asterolecaniidae: *Asterodiaspis repugnans* Russell (B and G). Only 6 of these species are honeydew-producing insects, and only 3 of them (*Eulecanium tilliae*, *Parthenolecanium rufulum* and *Eriococcus* sp.) were found in both Bulgaria and Greece. As *Parthenolecanium rufulum* is the most widespread species, it is most likely to be the main source of honeydew from Coccoidea. Among the species collected, the asterolecaniid *Asterodiaspis repugnans* (Russel) is a new record for Bulgaria, and the diaspidid *Diaspidiotus wuenni* (Lindinger) is a new record for Greece. Biological information, such as, host plant, developmental stage, distribution and some phenological data are given.

KEY WORDS: Scale insects, oak trees, beekeeping in forests, coccids

The first list of Bulgarian scale insects was published by Tschorbadjiew (1938), who mentioned 23 species on 24 host plant species. However, he listed only three species on oaks (*Quercus* sp., Fagaceae): the coccid *Parthenolecanium rufulum* (Cockerell) and the diaspidids *Quadraspidiotus ostreaeformis* (Curtis) and *Lepidosaphes ulmi* (Linnaeus). Since then, 13 additional species have been reported on oaks in Bulgaria (Tzalev, 1964, 1968; Kozár et al., 1979). The first list of Greek scale insects fauna was provided by Bodenheimer (1928), who reported 25 species on 12 host plant species, although only 4 species were found on oaks: the coccid *Eulecanium tiliae* (Linnaeus) and the diaspidids *Aspidiotus nerii* (Bouché), *Chrysomphalus dictyospermi* (Morgan) and *Diaspidiotus zonatus* (Frauenfeld). Since then, a further 21 scale insect species have been reported on oak trees in Greece (Koroneos**,** 1934, Kozár, et al.**,** 1991). According to Kosztarab and Kozár (1988), 17 species of scale insects are associated with oaks in Central Europe. In total, 16 species are known on *Quercus* sp. in Bulgaria and 25 have been recorded on oaks in Greece.

Although scale insects are generally considered pests, some species are beneficial to man as producers of shellac [e.g. species of Tachardiidae, like *Tachardia*

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[2] University of Forestry, Plant Protection Department, Sofia, Bulgaria. E-mails: k_trencheva@yahoo.com, g_trenchev@yahoo.com, respectively.

[3] Institute of Veterinary Research, National Agricultural Research Foundation, Greece, 25, Neapoleos str., 15341, Athens, Hellas, (Greece). E-mail: sgounari@nagref.gr. Corresponding author.

[4] Benaki Phytopathological Institute, Athens, Greece. E-mail: e.kapaxidi@bpi.gr.

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lacca, where the lac secreted by both female (oval lac cells) and male (elongate lac cells) nymphs], wax [e.g. the soft scale *Ericerus pela* Signoret, where the wax secreted by the male nymphs is harvested and processed in China to produce China wax (Li, 1985)], and the red dye cochineal (e.g. *Dactylopius coccus* Costa).

In addition, in many countries, honeydew is utilized by bees to make honey. Honeydew-producing insects are mostly phloem feeders that imbibe large quantities of plant fluids in order to obtain soluble nitrogen compounds. The surplus carbohydrate solution is eliminated as honeydew. Honeybees collect the droplets of honeydew and make honey, known as honeydew honey. Not all coccids are phloem feeders. Some, mainly Diaspididae, feed on parenchyma and xylem (Kloft and Kunkel, 1969). These non-phloem feeders take up a much reduced volume of sap and eliminate very little, if any, honeydew. These species are of no importance to honeybees.

In Bulgaria, the honeydew-producing scale insects belong to four families: Coccidae (five species), Kermesidae (four species), Eriococcidae (one species) and Pseudococcidae (one species). In Greece, the honeydew-producing scale insects are: Coccidae (four species) of which *Physokermes hemicryphus* (Dalman) is probably the most important, Kermesidae (one species) and Margarodidae (one species). Other important sources of honeydew are the aphids *Cinara confines* and *C. pectinatae* (Lachnidae) (Santas, 1983) which occur on *Abies* spp. It is estimated that about 50% of the annual honey production in middle Europe (e.g. Austria, Germany, Switzerland) is derived from honeydew (Kunkel, 1997). The honeydew honey in Greece represents 70-80% of the annual honey production. Of this, 60-65% is derived from the honeydew secretions of *Marchalina hellenica* Gennadius (Thrasyvoulou and Manikis, 1996), which occurs on *Pinus*. While the remaining 10-20% is mainly made from the honeydew secretions of other honeydew producers on *Abies* and *Quercus* spp. (Thrasyvoulou and Manikis, 1996).

Although there is some published work on the phenology of honeydew-producing scale insects on pine and fir trees (Nikolopoulos, 1965; Gounari et al., 2004; Gounari, 2006; Hodgson and Gounari, 2006), there is only one record, *Kermes quercus* (Kermesidae), as a honeydew source on oak trees in Greece (Santas 1983). In Bulgaria, there are no data about scale insects as a honeydew source on oak trees.

The aim of this study is to provide information on the distribution, species composition, and some phonological data of scale insects on oak trees, with special reference on honeydew-producing scale insects.

METHODS

The coccid samples were collected between April and October in 2005 and 2006 in Bulgaria and Greece, mainly in regions of beekeeping interest at the following sampling sites: BULGARIA: Rodopi mountains (Panichkovo), Strandja mountains (Izgrev, Fazanovo, Velika), Stara planina mountains (Preslav, Popovo),

Pirin mountains (Predela, Melnik) and Vitosha mountain. GREECE: Rodopi mountains (county of Drama, Paranesti), Kerkini mountain (county of Serres, Nevrokopi), Paiko mountain (county of Pella), Edessa (county of Edessa), Grevena (central Pindos mountains, county of Grevena), "Plastira" lake (county of Karditsa), Pilio, Maurovouni mountain (county of Bolos), Agrinio, south Pindos mountains (countries of Etolias and Akarnanias) Foloi forest (county of Hleia, central Peloponnesus). These regions were selected because of their beekeeping interest after interviewing beekeepers and discussions with Beekeeping Associations.

The collected specimens were preserved in small vials containing ethyl alcohol and glycerin, until identified. The observations were recorded with a digital camera. Voucher specimens have been deposited at University of Forestry, Plant Protection Department, Laboratory of Entomology, Sofia, Bulgaria. In the laboratory, the specimens were mounted on microscope slides following the protocol of Kosztarab and Kozár (1988). Scale insects were identified using keys and illustrations in Kosztarab and Kozár (1988), Danzig (1993), and Gill (1993).

SYSTEMATIC ENTOMOLOGY

During this study, eight species of scale insects were collected in Greece and nine in Bulgaria. *Parthenolecanium rufulum*, *Eulecanium tiliae*, *Targionia vitis,* and *Asterodiaspis repugnans* were found in both Bulgaria and Greece. In Bulgaria, the most speciose family was Coccidae, but in Greece it was Diaspididae. The dominant honeydew-producing scale insect on oak trees in regions of beekeeping interest in Bulgaria and Greece was *P. rufulum*, which was observed in all sampling sites in Bulgaria and in the most sites with oak forests in Greece.

All Coccoidea species collected on oaks during this survey are listed below. BULGARIA: nine species of scale insect associated with the genus *Quercus* were collected, belonging to five families, Diaspididae (2 species), Kermesidae (2 species), Eriococcidae (1 species), Asterolecaniidae (1 species), Coccidae (3 species). GREECE: eight species belonging to four families were collected Diaspididae: (4 species), Coccidae (2 species), Asterolecaniidae (1 species) and Eriococcidae (1 species). *Diaspidiotus wuenni* (Lindinger) (Diaspididae) is new to the Greek fauna; *Asterodiaspis repugnans* (Russell) (Asterolecaniidae) was new to the Bulgarian fauna. Not all of the species collected are honeydew producers.

Honeydew-producing taxa

Family Coccidae

Eulecanium tiliae Linnaeus

Material Examined: BULGARIA, **Panichkovo,** on branches of *Quercus* sp., 18/VI/2005, ovipositing females, eggs; **Izgrev,** on branches of *Quercus polycarpa*, 3/VII/2005, ovipositing females, eggs, crawlers. GREECE, **Foloi forest** on branches of *Quercus frainetto* (syn. *Q. conferta*), 16/VI/2006, female adult.

Remarks: In Bulgaria, *E. tiliae* was previously recorded by Tschorbadjiew (1938) (as *Eulecanium coryli*) on Rosaceae, and by Tzalev (1968) on Tiliaceae

and Hippocastanaceae around Sofia, Varna and Ruse. In Greece, it has been reported on *Ulmus* sp. (Bodenheinmer, 1928) and *Ficus carica* (Moraceae) (Argyriou, 1983).

Biology: According to Tzalev (1968), *E. tiliae* has one generation per year in Bulgaria and overwinters as a second-instar nymph.

Eulecanium ciliatum Douglas

Material Examined: BULGARIA, **Sofia (Vitosha),** on branches of *Quercus* sp., 1/IX/2005, post-reproductive females + second-instar nymphs on underside of leaves.

Remarks: *Eulecanium ciliatum* has been previously reported by Tzalev (1968) on *Quercus* sp., (Fagaceae) from around Sofia and also on *Quercus* sp. in northern Greece by Kozár et al. (1991).

Biology: According to Tzalev (1968), *E. ciliatum* has one generation per year in Bulgaria and overwinters as a second-instar nymph on the woody parts of the host plants. The eggs are laid at the beginning of June and hatch about 3-4 weeks later (Tzalev, 1968).

Parthenolecanium rufulum Cockerell

Material Examined: BULGARIA, **Panichkovo,** on branches of *Quercus* sp., 18/VI/2005, ovipositing females, eggs; **Velika, Izgrev, Fazanovo,** on branches of *Quercus polycarpa* and *Quercus frainetto*, 3/VII/2005, post-reproductive females, eggs + first-instar nymphs on underside of leaves; **Dolno Osenovo,** on branches of *Quercus pubescens*, 27/VII/2005, post-reproductive females + first-instar nymphs on underside of leaves; **Velika,** on branches of *Quercus* sp., 12/VIII/2005, post-reproductive females + first-instar nymphs on underside of leaves; **Popovo, Preslav,** on branches of *Quercus* sp., 25/VIII/2005, post-reproductive females + first-instar nymphs on underside of leaves; **Sofia (Vitosha),** on branches of *Quercus* sp., 8/IX/2005, post-reproductive females + first and second-instar nymphs on underside of leaves; **Velika,** on branches of *Quercus polycarpa*, 23/III/2006, overwintering second stage, and **Melnik,** on branches of *Quercus pubescens*, 29/V/2006, young and ovipositing females. GREECE: **Kerkini mountain, Nevrokopi,** on branches of *Q. frainetto,* 24/VII/2006, first-instar nymphs; **Paiko mountain forest,** on branches of *Q. petraea* (syn. *Q. sessiliflora*), 14/VIII/2006, second-instar nymphs; **Edessa,** on branches of *Q. frainetto*, 24/VII/2006, first-instar nymphs; **Grevena, central Pindos mountains,** on branches of *Q. cerris*, 10/X/2005, second-instar nymphs; **Pilio, Maurovouni mountain,** on branches of *Q. frainetto*, 16/VI/2006 first-instar nymphs; and **Foloi forest,** on branches of *Q. frainetto*, 16/VI/2006 first-instar nymphs.

Remarks: *Parthenolecanium rufulum* has been reported by Tschorbadjiew in (1938) (as *Eulecanium pulchrum*) on *Quercus pedunculata* around Karlovo, and also by Tzalev (1968) on *Quercus* sp., *Castanea vesca* (Fagaceae), *Corylus avellana* (Betulaceae), and *Ulmus* sp. (Ulmaceae). *P. rufulum* is very common on *Quercus* sp. in Bulgaria, but was reported from Greece (Crete) for the first time

by Kozár in 1991 on *Quercus* sp. The above records are therefore the first for mainland Greece.

Biology: *Parthenolecanium rufulum* has one generation a year in Bulgaria and overwinters as a second-instar nymph on the woody parts of the tree. According to Tzalev and Vulcheva (1965), it has one generation per year and overwinters as a second-instar nymph on the woody parts of the host plant. The oviposition period lasts for about 20–25 days (Tzalev and Vulcheva, 1965).

Family Kermesidae

Kermes roboris Fourcroy

Material Examined: BULGARIA, **Velika** on branches of *Quercus* sp., 12/VIII/2005, post-reproductive female; **Fazanovo** on branches of *Quercus polycarpa*, 13/V/2006, young females; **Melnik** on branches of *Quercus* sp. 29/V/2006, young adult females. GREECE: not found during present survey.

Remarks: *K. roboris* has been previously recorded on *Quercus* sp. around Sofia (Tzalev, 1964). It is rare on *Quercus* sp. in Bulgaria. There is no reference for its presence in Greece.

Biology: According to Tzalev (1968), *K. roboris* overwinters as a second-instar nymph on the woody parts of the host plant. The eggs are laid at the beginning of June and hatch at the end of the month (Tzalev, 1968).

Kermes gibbosus Signoret

Material Examined: BULGARIA, **Predela**, on branches of *Quercus* sp., 27/VII/2005, post-reproductive females. GREECE: not found

Remarks: *K. gibbosus* was recorded by Tzalev (1964) on *Quercus* sp. in Sofia and Klisura. There is no reference for its presence in Greece. *K. gibbosus* has been collected only from *Quercus cerris* (Hoy 1963, Kosztarab and Kozár, 1988).

Biology: According to Tzalev (1968), eggs hatch from the beginning of June to the end of June and the species overwinters as a second-instar nymph.

Family Eriococcidae

Eriococcus sp.

Material Examined: BULGARIA: **Melnik**, on branches of *Quercus pubescens*. 29/V/ 2006, young adult females, ovipositing females, crawlers + males. GREECE, **Paiko mountain forest** on branches of *Q. petraea* (syn. *Q. sessiliflora*), 14/VII/2006, crawlers; **Foloi forest** on branches of *Q. frainetto*, 16/VI/2006, crawlers; **Grevena, central Pindos mountains**, on branches of *Q. cerris*, 10/X/2005, second-instar nymphs.

Remarks: There are no previous records of Eriococcidae on *Quercus* sp. in Greece. Eight species from family Eriococcidae have been reported previously from Bulgaria (Tschorbadjiew 1938; Tzalev 1968; Kozár et al.1979), none of them on *Quercus* spp.

Biology: There is no additional information regarding this species in either Greece or Bulgaria.

Non-honeydew-producing taxa recorded during this survey

Family Diaspididae

***Targionia vitis* Signoret**

Material Examined: BULGARIA: **Velika,** on branches of *Quercus* sp., 15/V/2006, adult. GREECE: **Paiko mountain forest,** on branches of *Q. petraea* (syn. *Q. sessiliflora*), 14/VIII/2006, adult female; **Edessa,** on branches of *Q. frainetto*, 24/VII/2006, adult female.

Remarks: In Bulgaria, *T. vitis* has been previously recorded by Tzalev (1968) on *Quercus penduculata* and *Quercus* sp. in Varna, Burgas, Kazanluk, Klisura and by Kozár et al. (1979) on *Quercus pubescens f. polymorpha* in Varna. In Greece, *T. vitis* was recorded for the first time by Koroneos (1934) and later by Ferris (1943) on Ericaceae.

Biology: According to Tzalev (1968), this species overwinters as an adult female in Bulgaria, with the eggs starting to hatch at the beginning of June, and the adults appearing at the end of July and first 10 days of August. There is no information about its biology in Greece.

***Lepidosaphes ulmi* Linnaeus**

Material Examined: BULGARIA: **Velika,** on branches of *Quercus pubescens*., 15/V/2006, adult female. GREECE: not found during the present survey.

Remarks: *L. ulmi* was recorded for the first time by Tschorbadjiew in 1938 on *Fraxinus* sp. (Oleaceae), *Salix* sp. (Salicaceae), *Populus* sp. (Salicaceae), *Ulmus* sp. (Ulmaceae), *Fagus* sp. (Fagaceae), *Quercus* sp. (Fagaceae), *Malus* sp. (Rosaceae), *Pyrus* sp. (Rosaceae) and *Prunus* sp. (Rosaceae). This species was also reported by Tzalev (1968) on *Fraxinus excelsior* (Oleaceae), *Fraxinus* sp. (Oleaceae), *Celtis* sp. (Ulmaceae), *Betula verrucosa* (Betulaceae), *Alnus* sp. (Betulaceae), *Crataegus* sp. (Rosaceae), *Salix* sp. (Salicaceae) and *Cornus* sp. (Cornaceae). In Greece, *L. ulmi* has been recorded by Argyriou (1983) and later by Kozár et al. (1991) on *Cercis siliquastrum* (Fabaceae).

Biology: There are no data on the biology of this species in Greece. In Bulgaria it has been reported to have a variable number of generations per year even on the same host plant (Tzalev, 1968).

***Diaspidiotus wuenni* Lindinger**

Material Examined: GREECE: **Foloi forest**, on branches of *Q. frainetto,* 16/VII/2006, adult female; **Paranesti**, on branches of *Q. frainetto*, 24/VII/2006, adult female; **Paiko**, on branches of *Q. petraea* (syn. *Q. sessiliflora*), 14/VIII/ 2006, adult female. BULGARIA: not collected during the present survey.

Remarks: This is the first record of this species in Greece. In Bulgaria, *D. wuenni* was recorded for the first time by Tzalev (1964) on *Quercus* sp. around Varna.

Biology: There are no additional data on the biology of this species in Bulgaria.

Diaspidiotus zonatus Frauenfeld

Material Examined: GREECE, **Foloi forest**, on branches of *Q. frainetto,* 16/VI/2006, adult female; **Paranesti**, on branches of *Q. frainetto*, 24/VII/2006, adult female. BULGARIA: not found during the present survey.

Remarks: *D. zonatus* was reported for the first time in Greece by Bodenheinmer (1928) on *Quercus* sp. In Bulgaria, *D. zonatus* was recorded for the first time by Tzalev (1964, 1968) on *Quercus penduculata* and *Quercus* sp.

Biology: According to Tzalev (1964, 1968), this species overwinters as an adult female, with the eggs starting to hatch at the beginning of June. There is no information regarding the biology of *D. zonatus* in Greece.

Diaspidiotus lenticularis Lindinger

Material Examined: GREECE, **Edessa,** on twigs of *Q. frainetto*, 24/VII/ 2006, adult female. BULGARIA: not found during the present survey.

Remarks: In Greece, *D. lenticulatus* was recorded for the first time by Koroneos (1934) (as *Aspidiotus ostreaeformis anactenus*) on *Quercus* sp., and by Ferris (1943) as (*Quadraspidiotus lenticularis*) on *Ficus carica* (Moraceae) and *Olea europea* (Oleaceae). In Bulgaria, *D. lenticulatus* has been recorded by Kozár et al. (1979) as (*Quadraspidiotus lenticularis)* on *Fraxinus excelsior* (Oleaceae) in Varna.

Biology: There is no additional information regarding this species in either Greece or Bulgaria.

Family Asterolecaniidae

Asterodiaspis repugnans Russell

Material Examined: BULGARIA: **Velika,** on branches of *Quercus* sp., 15/V/2006, adult female. GREECE: **Foloi forest**, on branches *Q. frainetto*, 29/ VII /2006, ovipositing female, eggs and crawlers, **Paranesti,** on branches of *Q. frainetto*, 24/VII/2006, ovipositing female, eggs and crawlers, **Edessa,** on branches of *Q. frainetto*, 24/VII/2006, ovipositing female, eggs.

Remarks: This is the first record of this species in Bulgaria. Five species of Asterolecaniidae have been reported previously from Bulgaria: *Planchonia arabidis* Signoret (Tzalev, 1968) on *Hedera helix* (Araliaceae); *Asterodiaspis variolosa* (Ratzeburg) (Tzalev, 1968) on *Quercus penduculata*, *Quercus rubra* and *Quercus sesseiliflora*; *A. bella* (Russell) (Kozár et al., 1979) on *Quercus pubescens* f. *Polymorpha; A. quercicola* Bouché (Kozár et al., 1979) on *Quercus pubescens* f. *polymorpha*, and *A. roboris* (Russell) (Kozár et al., 1979) on *Quercus pubescens f. polymorpha*. In Greece, *A. repugnans* was recorded for the first time by Russell (1941) on *Quercus* sp.

Biology: There is no additional data on biology of this species in either Greece or Bulgaria.

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