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The scale insects (Hemiptera: Coccoidea) of oak trees (Fagaceae: *Quercus* spp.) in Israel

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ABSTRACT

Scale insects (Hemiptera: Coccoidea) of four species of oaks (Fagaceae: *Quercus*) in Israel namely, *Q. boissieri, Q. calliprinos, Q. ithaburensis,* and *Q. look* were collected and identified from natural forest stands during the period 2010-2013. A total of twenty-seven species were determined from nine scale insect families: Asterolecaniidae (3 species), Coccidae (3), Diaspididae (7), Eriococcidae (3), Kermesidae (6), Kuwaniidae (1), Monophlebidae (1), Pseudococcidae (2), and Putoidae (1). Six of these species represent new records for Israel and five are identified to the genus level. Kuwaniidae is a new family record for Israel. Species that were previously collected or recorded on oaks in Israel are listed and discussed. Information is given about host trees and global distribution. The majority of the species reported here are monophagous or stenophagous and they appear to be non-pestiferous to the oak trees in Israel. General traits that describe each scale insect family in the field are provided, together with an identification key to aid in the determination of slide-mounted specimens into families represented in this study.

KEY WORDS: Scale insect, Coccoidea, oak trees, *Quercus*, forest, survey, monophagous, univoltine, Mediterranean, Israel

INTRODUCTION

The genus *Quercus* (Fagaceae) has a rich and diverse arthropod fauna associated with it (Southwood, 1961; Southwood *et al*., 2005). Many of the insects associated with oak trees are host-specific including species of scale insects (e.g. Bytinski-Salz and Sternlicht, 1967; Kozár and Kosztarab, 1982; Southwood *et al*., 2004). In a study on the scale insects (Coccoidea) of Central European forests, Kozár and Kosztarab (1982) compared the prevalence of sixty-four scale insect species associated with

fourteen forest tree genera and found that oak had the highest number of scale insects as compared to the other tested genera. Kennedy and Southwood (1984) recorded that the deciduous oak species, *Q. robur* and *Q. petraea*, native to Britain, have the largest number of associated insects of any tree species in Britain. In a similar study on forestry arthropod species richness, Brändle and Brandl (2001) showed that of the twenty-five tree genera native to Germany, the genus *Quercus* had the highest number of Coccoidea species.

World-wide, the total number of scale insects recorded on oak trees (*Quercus* spp.) is six hundred and thirty-two species belonging to fifteen families (Ben-Dov *et al*., 2013). Host specificity within the Fagaceae and predominantly the genus *Quercus* spp. is known for scale insect species belonging to several families and genera. The Kermesidae (Bullington and Kosztarab, 1985; Ben-Dov *et al*., 2013), and Kuwaniidae (Ben-Dov *et al*., 2013; Wu *et al*., 2013) are examples of two such scale insect families. The species of the genus, *Asterodiaspis*, belonging to the pit scale family, Asterolecaniidae, are also exclusively known to feed on oaks (Russell, 1941; Stumpf and Lambdin, 2006). The family Eriococcidae includes forty-four species that develop on Fagaceae, with three species that are only known on *Quercus* spp. (Hodgson and Trencheva, 2008; Ben-Dov *et al*., 2013).

Oak trees, deciduous and evergreen, are dominant flora in Israel's mountainous regions, and they represent an important element of the woodlands, chaparrals and sclerophyllous maquis of the Mediterranean region. There are five native oak tree species that compose either pure stands or mixed forests in Israel. The most common deciduous species are *Quercus boissieri* Reuter (Boissier oak) and *Q. ithaburensis* Dec. (Mt. Tabor oak). Two deciduous species, exclusively found in the Golan, on Mt. Hermon, are *Q. look* Kotschy and *Q. cerris* Linnaeus (Turkish oak). The latter is a rare species in Israel, found only in one location on Mt. Hermon. *Quercus calliprinos* (Webb.) (Kermes oak) is the only evergreen oak species in Israel and it is the most common oak (Zohary, 1973).

Historically, large areas of Israel were naturally covered with forests dominated by oaks, mainly *Q. calliprinos* (Naveh and Dan, 1973; Liphschitz and Biger, 1990). The original landscape and vegetation was exploited by humans during the last 15,000 years and the natural arboreal vegetation which existed in this region was almost completely destroyed (Eig, 1933; Zohary, 1962, 1973; Aloni and Orshan, 1972; Karschon, 1982). Despite substantial land-use changes in Israel throughout the last century, the oak forests remain an integral component of the country's natural landscape (Liphschitz and Biger, 1990). Today, the majority of Israel's oak forests grow in the Golan Heights, Galilee regions, Judean mountains and on Mt Carmel; small pockets of old trees are found along the central Coastal Plain (e.g. Zohary, 1973).

The first major survey of oak entomofauna conducted in Israel was nearly fifty years ago in 1967 (Bytinski-Salz and Sternlicht, 1967). It revealed three hundred and seventy species of different insect orders that occur on three main oak species, *Q. boissieri, Q. calliprinos* and *Q. ithaburensis*. Scale insects were surveyed in their study and they list twenty-nine species belonging to six families, with an additional

three insects identified to the genus level. However, no slide-material of the scale insect species collected by Bytinski-Salz and Sternlicht (1967) is available for examination and collection data for their specimens was not disclosed.

The objectives of this study are (1) to update the list of scale insects known on four oak trees in Israel namely; *Q. boissieri*, *Q. calliprinos, Q. ithaburensis* and *Q. look*; (2) to discuss the natural geographical area of all the species by bringing information about global distribution and host plants; (3) to provide information on general traits that distinguish between Coccoidea families in the field and (4) to provide an identification key to distinguish between slide-mounted specimens of adult females at the family level.

MATERIALS AND METHODS

Collecting specimens

Twenty-three sites with natural stands of *Quercus* spp. were selected for sampling from different geographic regions in Israel. These sites are either mixed forests or forests with one or more oak species. The geographic regions include: The Golan, Galilee regions, the Judean Mountains, Mt. Carmel and the Coastal Plain. Most of the sampling sites are either designated as nature reserves or protected areas with at least fifty trees of one oak species growing in each location under natural conditions (Table 1). Sampling took place between the years 2010 and 2013 and some sites were visited more frequently than others throughout this period. Adult females are usually stationary or completely immobile on their host plant and therefore sampling leaves and branches was the most efficient way to collect specimens. About 150-200 branches (20-25 cm in length and 12-20 mm diameter) were cut from the upper and lower canopies of 10-20 trees upon each visit. The branches were taken to the laboratory in large plastic bags and examined individually under a stereomicroscope (Nikon, Type 104) for the presence of scale insects. Collection data for each species including; location, date collected and host plant is presented. Species that were collected at earlier dates by others are also included in this survey on the condition that the material was available for examination and its identification was verified by the authors.

Material examined and identifications

All relevant specimens collected were photographed, catalogued, mounted on microscope slides and identified. Specimens were mounted on microscope slides according to the methods outlined by Ben-Dov and Hodgson (1997). Microscope slides that are identified from Israel on *Quercus* spp. from previous collection by others were examined by us and their identifications were confirmed. All the material used in this study is of adult females and was collected by M. Spodek, unless otherwise indicated. All slide material used in this study is deposited at the Coccoidea Collection, Department of Entomology, Agricultural Research Organization, Bet Dagan, Israel (ICVI). Some type material examined are also deposited at The British Museum (Natural

Table 1: List of collection sites by geographical region, including geographic co-ordinates, altitude (m) and *Quercus* spp. found in each location in Israel.

REGION	LOCATION	Latitude (N)	Longitude (E)	Altitude (m)	Oak trees (*Quercus* spp.)
Golan	1. Nebi Hazuri	33°15′09.54″	35°43′53.60″	821	*Q. calliprinos*
	2. Mas'ada	33°13′02.62″	35°45′11.54″	1015	*Q. calliprinos* *Q. boissieri*
	3. Mezar Nature Reserve	32° 44′ 31.15″	35°42′57.35″	317	*Q. ithaburensis*
	4. Mt. Hermon Nature Reserve-ski lift	33°17'31.84"	35°45'40.06"	1500	*Q. look* *Q. boissieri*
	5. Yehudiya Nature Reserve	32°56'32.55"	35°41'59.38"	200	*Q. calliprinos* *Q. ithaburensis*
Galilee	6. Alonei Abba Nature Reserve	32°43'58.67"	35°09'42.20"	166	*Q. calliprinos* *Q. ithaburensis*
	7. Alon Hagalil	32°45'13.76"	35°13'10.71"	188	*Q. ithaburensis*
	8. Bet Keshet	32°43'17.48"	35°23'45.47"	180	*Q. ithaburensis*
	9. Eilon	33°04'08.97"	35°13'19.78"	280	*Q. calliprinos*
	10.Hanita	33°04'41.65"	35°09'33.43"	162	*Q. calliprinos*
	11.Horshat Tal Nature Reserve	33°13'19.18"	35°37'47.96"	120	*Q. ithaburensis*
	12. Mt. Meron	32°59'50.93"	32°24'38.23"	1166	*Q. boissieri* *Q. calliprinos*
	13. Mt. Tabor	32° 41′ 13.61″	35° 23′ 25.38″	575	*Q. calliprinos* *Q. ithaburensis*
	14. Timrat	32°42'25.89"	35°13'44.61"	230	*Q. calliprinos* *Q. ithaburensis*
Mt. Carmel	15.Horshat Haarbaim	32° 45′ 19.33″	35°01'38.10"	438	*Q. calliprinos*
Coastal Plain	16. Park Alona	32°33'55.19"	35°00'53.67"	138	*Q. ithaburensis*
	17. Park Hasharon	32°25'25.75"	34°53'41.90"	11	*Q. ithaburensis*
	18. Hirbat Tsherkes (Tel Alon)	32°27'01.67"	34°57'45.99"	31	*Q. ithaburensis*
Judean Mountains	19. Amatzia	31°31'53.00"	32°53'21.13"	357	*Q. calliprinos*
	20. Mt. Masrek	31°47'58.33"	35°02'37.60"	600	*Q. calliprinos*
	21. Mt. Hatayasim	31°46'25.80"	35°05'23.97"	790	*Q. calliprinos*
	22. Nahal Dolev Nature Reserve	31°42'57.07"	35°02'08.77"	529	*Q. calliprinos*
	23. Mt. Sansan/Zur Hadassa	31°43'23.49"	35°05'27.74"	741	*Q. boissieri* *Q. calliprinos*

History), London, U.K. (BMNH) and Museum National d'Histoire Naturelle, Paris, France (MNHN). The species are classified according to the family they belong to and they are listed alphabetically under each family. Families and species newly recorded from Israel are indicated with an asterisk (*). Undetermined species are indicated by two asterisks (**). Host plants and distribution for each species, are from Ben-Dov *et al*. (2013) unless cited otherwise.

Phytophagous definitions

The host tree(s) for each scale insect collected and identified in Israel is recorded, with additional host tree information from countries outside of Israel. Based on the botanical classification of the genus *Quercus* of Schwartz (1937) and Zohary, (1961), we adapted the following phytophagous definitions to be assigned to each of the scale insect species recovered from this survey: Monophagous-species found on one or more oak species within one of the four *Quercus* subgenera i.e.: *Gallifera*, *Aegilops, Ilex* and *Coccifera*; Stenophagous-species found on two or more subgenera of the genus *Quercus*; Oligophagous-species found on one or more genera of the family Fagaceae, beside the genus *Quercus*; Polyphagous-species found on one or more families, beside the Fagaceae. We consider the scale insect species, *Koroneaspis aegilopos* (Koroneos), to be stenophagous, although it is also recorded once by Bodenheimer (1943) on *Loranthus europaeus* Jacq. (Loranthaceae), a semi-parasitic plant that often parasitizes oak species in Turkey and Europe (Hegi, 1981).

In the following key, we adopted the terms for morphological characters which are currently widely used in the taxonomy of scale insect studies (e.g. Hodgson, 1994; Williams, 1985, 2004). The identification of taxa at the family, genus and species level is based on study of slide-mounted adult females, which is also true for the following key. This key has been modified from Ben-Dov (2012) to include only the scale insect families associated with oak trees in Israel.

RESULTS

Key to the adult females of scale insect families associated with four oak tree species in Israel

1. Abdominal spiracles present **2**
-. Abdominal spiracles absent **3**
2 Mouth parts present ..... **Monophlebidae**
-. Mouth parts absent ..... **Kuwaniidae**
3. Anal opening covered with one or two plates ..... **Coccidae**
-. Anal opening not covered with plates **4**
4. Venter with wide submarginal band of tubular ducts ..... **Kermesidae**
-. Venter without wide submarginal band of tubular ducts **5**
5. Posterior abdominal segments forming a pygidium with a fringe of ducts, plate and lobes . ..... **Diaspididae**
-. Posterior abdominal segments not forming a pygidium **6**

6. Antennae 1-segmented; legs absent; 8-shaped pores present..... **Asterolecaniidae**
-. Antennae with more than 1 segment; legs present; 8-shaped pores absent..... **7**
7. With one or more of the following characters present: ventral circulus or circuli, dorsal ostioles, 1-18 cerarii and trilocular pores **8**
-. Without ventral circulus or circuli, dorsal ostioles, cerarii or trilocular pores. All of these might be lacking from a single scale .....**Eriococcidae**
8. Each coxa with 2 sensory pores on each of ventral and dorsal surfaces of the segment ....**Pseudococcidae**
-. Each coxa with 3 sensory pores on each of ventral and dorsal surfaces of the segment .... **Putoidae**

Asterolecaniidae (pit scales)

Field characters:

Most insects of this family generally produce a tough wax test that covers the exposed part of the body of the female. The cover is often translucent and yellow or green. Insects in this family are usually round, oval, ellipsoidal or oblong. The female body fills the whole test cavity, but as egg-laying begins, the body is compressed to one end of the cover. The body of the insect is set in a depression or pit in the host plant (Russell, 1941; Stumpf and Lambdin, 2006).

***Asterodiaspis minor* (Russell)**
(Plate 1, fig. a.)

Host trees in Israel: *Quercus boissieri, Q. calliprinos* and *Q. ithaburensis*.

Host trees in other countries: Fagaceae: *Quercus agrifolia*, *Q. cerris*, *Q. dilatata*, *Q. douglasii*, *Q. incana*, *Q. infectoria*, *Q. kelloggii*, *Q. lanuginosa*, *Q. lobata*, *Q. montana, Q. pedunculata*, *Q. petreae* and *Q. robur*.

Distribution: Palaearctic: Armenia, Azerbaijan, England, Georgia, Germany, Iran, Iraq, Italy, Poland, Turkey, Ukraine and **Nearctic**: USA.

Remarks: In Israel, there are no known reports of damage by this insect. This insect is known as a pest of oaks in California, USA (Pritchard and Beer, 1950a,b; Hecht-Poinar *et al*., 1989; Gill, 1993).

Material examined: Alonei Abba Nature Reserve, *Quercus ithaburensis*, 9.v.2010, 14.x.2012; Alon Hagalil, *Q. ithaburensis*, 14.ii.2010; Hanita, *Q. calliprinos*, 7.v.2012; Horshat Tal Nature Reserve, *Q. ithaburensis*, 30.v.2010; Ma'aleh Adumim, *Q.* sp., 16.ix.2008, Y. Ben-Dov; Mezar, *Q. ithaburensis*, 10.iii.2013; Mt. Hermon Nature Reserve, *Q. look,* 7.v.2012; Mt. Meron, *Q. boissieri*, 24.i.2011, 17.iii.2013, *Q. calliprinos,*13.iii.2011; Mt. Tabor, *Q. ithaburensis*, 10.xii.2012; Neve Yaar, *Q. ithaburensis*, 25.x.2009; Park Alona, *Q. ithaburensis*, 13.i.2013; Park Hasharon, *Q. ithaburensis*, 13.i.2013; Yehudiya Nature Reserve, *Q. ithaburensis*, 6.ii.2010; Zur Hadassa, *Q. boissieri,* 25.ii.2013.

***Asterodiaspis variolosa* (Ratzenburg)**
(Plate 1, fig. b.)

Host tree in Israel: *Quercus calliprinos*

Host trees in other countries: Fagaceae: *Quercus alba*, *Q. cerris pectinata*, *Q. coccifera*, *Q. concordia*, *Q. ilex*, *Q. kelloggii*, *Q. lusitanica*, *Q. montana*, *Q. palustris*, *Q. pedunculata*, *Q. pedunculata thomasii*, *Q. petreae*, *Q. prinus*, *Q. pubescens*, *Q. robur*, *Q. robur monstrosa cucullata, Q. robur*, *Q. rubra*, *Q. sessiliflora, Q. sessilis mespilifolia* and *Q. sideroxyla*.

Distribution: Palaearctic: widespread in Mediterranean and European countries; also present in **Afrotropical:** South Africa, **Australasian:** Australia and New Zealand; **Nearctic:** Canada and USA; **Neotropical:** Argentina, Brazil and Chile.

Remarks: Bodenheimer (1924) and Bytinski-Salz and Sternlicht (1967) reported *A. variolosum* on *Q. calliprinos* in Israel. Ben-Dov (2012) lists this species on *Q. ithaburenisis*, however since there is no material of this record, we don't consider *Q. ithaburensis* a host tree of *A. variolosa* in Israel.

Material examined: Eilon, *Quercus calliprinos*, 13.iii.2011; Ein Hemed (Aquabella), *Q. calliprinos*, 20.i.2013; Golan: Buqaata Forest, *Q. calliprinos*. 27.iv.1981, Y. Ben-Dov; Hakdoshim, *Q. calliprinos*, 30.iv.1981, Y. Ben-Dov.

****Asterodiaspis* sp. near *repugnans* (Russell)**

Host trees in Israel: *Quercus ithaburensis* and *Q. look*.
Material examined: Horshat Tal Nature Reserve, *Quercus ithaburensis*, 30.v.2010; Mt. Hermon Nature Reserve, *Q. ithaburensis*, 30.v.2010, Y. Ben-Dov, *Q. look*, 21.vii.2011.

Coccidae (soft scales)

Field characters:

The appearance of soft scales in the field is highly variable depending on the group. The body shape is frequently round or broadly oval but some are elongate, elliptical or deltoid. With the exception of very old or very convex individuals, most soft scales have two pairs of white, button like wax structures on the body margin. In most species, young adults have a flat profile and at the onset of oviposition, the body expands, forming a cavity under the body where the eggs are protected and incubated. Some soft scales produce white waxen covers or ovisacs over the body. Wax coverings are thin and transparent, filamentous or powdery, thick and opaque, or thin and glassy (Gill, 1988).

****Eulecanium* sp. near *tiliae* (Linnaeus)**

Host trees in Israel: *Quercus boissieri* and *Q. ithaburensis*

Material examined: Alone Abba Nature Reserve, *Quercus ithaburensis*, 11.ii.1987, Y. Ben-Dov; Mezar, *Q. ithaburensis*, 10.iii.2013; Mt. Meron (loop trail), *Q. boissieri*, 13.ii.2011, 31.iii.2011, 10.iv.2013; Timrat, *Q. ithaburensis*, 25.iii.2012.

***Kenima galilit* Ben-Dov**
(Plate 1, fig. c.)

Host trees in Israel: *Quercus calliprinos* and *Q. ithaburensis*.

Host trees in other countries: This species has only been recorded from Israel.

Distribution: This species has only been recorded from Israel.

Remarks: This species was described by Ben-Dov (2001a) and linked to *Eulecanium tivoni* Sternlicht *nomen nudum*. Bytinski-Salz and Sternlicht (1967) listed *E. tivoni* on *Q. ithaburensis*. Males are present and the male test is described in detail by Ben-Dov (2001a).

Material examined: Type material: Holotype adult ♀, P**aratypes** 20 adult ♀♀, Horshat Tal Nature Reserve, on twigs of *Quercus ithaburensis,* 27.ii.2001, Y. Ben-Dov. **Other non-type material:** Alon Hagalil, *Q. ithaburensis*, 14.ii.2010, 25.iii.2010, 18.iv.2010; Horshat Tal Nature Reserve, *Q. ithaburensis*, 21.ii.2010, 27.ii.2011; Nebi Hazuri, *Q. calliprinos*, 18.iv.2012, Y. Ben-Dov; Neve Yaar, *Q. ithaburensis*, 11.v.2000, Y. Ben-Dov, 25.ii.2010; Yehudiya Nature Reserve, *Q. ithaburensis*, 6.iii.2010.

*****Pulvinaria* sp.**

Host tree in Israel: *Quercus calliprinos*

Material examined: Eilon, *Q. calliprinos*, 10.iii.2013.

Diaspididae (armored scales)

Adult females range in size from 1 to 2 mm long or in diameter. Adult females have two basic shapes, circular or elongate (oystershell-shaped). The body is covered by a wax scale that is composed of the skins of previous instars (exuviae). During scale formation, many scales incorporate parts of the plant into the cover or mine beneath loosened plant tissues, making these scales cryptic. They are found on branches and leaves (Gill, 1997).

***Chionaspis lepineyi* Balachowsky**
(Plate 1, fig. d.)

Host trees in Israel: *Quercus calliprinos* and *Q. ithaburensis*.

Host trees in other countries: Fagaceae: *Castanea sativa*, *Q. ilex*, *Q. robur* and *Q. suber*.

Distribution: This species is widely distributed in Europe and the Mediterranean regions.

Remarks: Specimens were collected on branches and females are found on thin branches, surrounded by large numbers of white waxy tests of the males (authors' observations and Kosztarab and Kozár, 1988). This species was recorded by Bytinski-Salz and Sternlicht (1967) on *Q. calliprinos* and *Q. ithaburensis*. Dry material collected in Tivon, Israel by Sternlicht in 1958 was recovered from the National Insect Collections at Tel Aviv University. This specimen was slide mounted and identified as *C. lepineyi*.

Material examined: Alonei Abba Nature Reserve, 22.vi.2011; Amatzia-Givat Gat, *Quercus calliprinos*, 25.ii.2013; Hanita, *Q. calliprinos*, 23.v.2011; Mezar, *Q. ithaburensis*, 10.ii.2013; Mt. Carmel: Horshat Haarbaim, *Q. calliprinos*, 10.12.2012; Nahal Dolev Nature Reserve, *Q. calliprinos*, 27.v.2011; Timrat, *Q. calliprinos*, 24.vii.2011, 22.iv.2012; Tivon, *Q. ithaburensis,* 1.iii.1958, M. Sternlicht.

***Diaspidiotus zonatus* (Frauenfeld)**
(Plate 1, fig. e.)

Host trees in Israel: *Quercus boissieri, Q. calliprinos* and *Q. ithaburensis*.

Host trees in other countries: Mainly **Fagaceae** species including species of the genera *Fagus* and *Quercus*. Other families include **Betulaceae, Ericaceae, Juglandaceae, Loranthaceae, Moraceae, Rhamnaceae, Rosaceae** and **Salicaceae.**

Distribution: This species is widely distributed in the Palaearctic region.

Remarks: Specimens were collected on thin branches in Israel. This species was first recorded as *Aspidiotus zonatus* by F.S Bodenheimer in Israel on *Ceratonia siliqua* near Binyamina and later on *Q. coccifera* (Bodenheimer, 1924). Bytinski-Salz and Sternlicht (1967) record this insect as *Quadraspidiotus zonatus* on *Quercus calliprinos*. Ben-Dov (2012) lists this species on *Q. calliprinos*.

Material examined: Alonei Abba Nature Reserve, *Quercus ithaburensis*, 9.v.2010, 30.v.2010, 30.v.2010, 14.ii.2012, 13.i.2013; Mt. Masrek, *Q. calliprinos,* 20.i.2013; Mt. Meron (peak trail), *Q. boissieri*, 13.iii.2011, 11.iv.2011, 17.iii.2013; Mt. Tabor (peak trail), *Q. ithaburensis*, 10.12.2012; Nebi Hazuri, *Q. calliprinos,* 27.xii.2009; Neve Yaar, *Q. ithaburensis*, 25.x.2009, 9.v.2010; Park Hasharon, *Q. ithaburensis*, 13.1.2013.

***Gonaspidiotus minimus* (Berlese and Leonardi)**
(Plate 1, fig. f.)

Host trees in Israel: *Quercus calliprinos* and *Q. ithaburensis*.

Host trees in other countries: Fagaceae: *Quercus coccifera*, *Q. ilex*, *Q. ilex fragilis*, *Q. ilicis*, *Q. incana* and *Q. suber*, but also known on **Arecaceae**: *Chamerops humilis*.

Distribution: This species is distributed in the Mediterranean region.

Remarks: This species is commonly found on the underside of leaves (authors' observations). Bodenheimer (1935) and Bytinski-Salz and Sternlicht (1967) report this species on *Q. calliprinos* and *Q. ithaburensis*.

Material examined: Alonei Abba Nature Reserve, *Quercus calliprinos,* 13.1.2013; Amatzia:Givat Gat, *Q. calliprinos*, 25.ii.2013; Buqata Forest, *Q. ithaburensis*, 27.iv.1981, Y. Ben-Dov; Mt. Carmel: Horshat Haarbaim, *Q. calliprinos*, 10.12.2012; Mt. Hatayasim, *Q. calliprinos*, 20.i.2013; Mt. Masrek, *Q. calliprinos*, 20.i.2013; Nebi Hazuri, *Q. calliprinos,* 6.v.2009, Y. Ben-Dov, 20.iii.2011; Neve Zuf*, Q. calliprinos*, 15.vi.2003, Z. Amar; Rosh Hanikra, *Q. calliprinos*, 14.ii.2010.

Hemiberlesia lataniae **(Signoret)**
(Plate 1, fig. g.)

Host trees in Israel: *Quercus calliprinos* and *Q. ithaburensis*.

Host plants in other countries: This species is known from over 100 botanical families, including Fagaceae.

Distribution: This species is widespread in Afrotropical, Australasisan, Nearctic, Neotropical, Oriental and Palaearctic regions of the world.

Remarks: Bytinski-Salz and Sternlicht (1967) observed this species in Israel on *Q. calliprinos* and *Q. ithaburensis*. It is known as a pest in avocado orchards in Israel (Gerson and Zor, 1973).

Material examined: Alone Abba Nature Reserve, 12.xii.2010, 11.i.2012; Hanita, *Quercus calliprinos*, 14.ii.2010; Mt. Carmel: Horshat Haarbaim, *Q. calliprinos*, 10.12.2012; Neve Yaar, *Q. ithaburensis*, 25.x.2009, 25.x.2009.

****Koroneaspis aegilopos*** **(Koroneos)**
(Plate 1, fig. h.)

Host trees in Israel: *Quercus calliprinos* and *Q. ithaburensis*.

Host trees in other countries: Fagaceae: *Q. aegilops*, *Q. coccifera*, *Q. persica*; **Loranthaceae**: *Loranthus europaeus*.

Distribution: The current distribution is restricted to several countries in the Palaearctic region including: Crete, Greece, Iran and Iraq.

Material examined: Alonei Abba Nature Reserve, *Quercus ithaburensis*, 20.iii.2011; Horshat Tal Nature Reserve, *Q. ithaburensis*, 7.xi.2010; Eilon, *Q. calliprinos,* 29.x.2010, 13.iii.2011; Nebi Hazuri, *Q. calliprinos*, 20.ii.2011,1.vi.2011, 26.vi.2011; Yehudiya Nature Reserve, *Q. ithaburensis*, 3.xi.2010; 20.vi.2012.

***Melanaspis louristanus* Balachowsky and Kaussari**
(Plate 1, fig. i.)

Host trees in Israel: *Quercus ithaburensis* and *Q. look*.

Host trees in other countries: Fagaceae: *Quercus persica* (Balachowsky and Kaussari, 1953).

Distribution: This species is recorded only from Iran (Balachowsky and Kaussari, 1953).

Remarks: This species was first recovered by the second author in 2001 on *Q. ithaburensis* from Horshat Tal Nature Reserve (see material examined), however this is the first report of this species in Israel.

Material examined: Alonei Abba Nature Reserve, *Quercus ithaburensis*, 7.xi.2010, 13.iii.2011, 13.1.2013; Alon Hagalil, *Q. ithaburensis*, 18.iv.2010; Horshat Tal Nature Reserve, *Q. ithaburensis*, 2001, Y. Ben-Dov, 27.xii.2009, 21.ii.2010, 20.iii.2011; Mt. Hermon, *Q. look*, 21.viii.2011, 7.v.2012; Neve Yaar, *Q. ithaburensis*, 25.x.2009, 25.ii.2010; Park Alona, *Q. ithaburensis*, 13.1.2013; Yehudiya Nature Reserve, *Q. ithaburensis*, 6.iii.2010, 3.xii.2010, 13.1.2013.

***Targionia vitis* (Signoret)**
(Plate 1, fig. j.)

Host trees in Israel: *Quercus boissieri*, *Q. calliprinos* and *Q. ithaburensis*.

Hosts trees in other countries: Ericaceae: *Arbutus unedo*; **Fagaceae**: *Castanea crenata*, *C. sativa*, *Fagus sylvatica*, *Q. cerris*, *Q. coccifera*, *Q. dentata*, *Q. ilex*, *Q. lanuginosa*, *Q. pedunculata*, *Q. petraea*, *Q. pubescens*, *Q. sessiliflora*, *Q. suber*; **Platanaceae**: *Platanus orientalis*; **Salicaceae**: *Salix* spp.; **Vitaceae**: *Vitis vinifera*.

Distribution: Europe, Mediterranean and eastern Palaearctic**.**

Remarks This species was first reported in Israel on *Quercus ithaburensis* by Bodenheimer (1927a) and later recorded by Bytinski-Salz and Sternlicht (1967) on the same host. In Italy (Dalla Montá *et al*., 2002) and France (Galet, 1982) it is an occasional pest in vineyards.

Material examined: Alonei Abba Nature Reserve, *Quercus ithaburensis*, 17.x.2010, 13.iii.2011, 11.i.2012; Alon Hagalil, *Q. ithaburensis,* 14.ii.2010; Amatzia:Givat Gad, *Q. calliprinos*,25.ii.2013; Bet Keshet, *Q. ithaburensis,* 1.iii.2002, Y. Ben-Dov; Dovev, *Q. calliprinos,* 25,vi.2003, Z. Tamari; Ein Hemed (Aquabella), *Q. calliprinos,* 20.i.2013; Horshat Tal Nature Reserve, *Q. ithaburensis,* 7.xi.201; Mt. Carmel-:Horshat Haarbaim, *Q. calliprinos*, 10.12.2012; Mezar, *Q. ithaburensis*, 10.iii.2013; Hirbat Tsherkes:Tal Alon, *Q. ithaburensis*, 10.ii.2013; Mt. Hatayasim, *Q. calliprinos,* 20.i.2013; Mt. Meron, *Q. boissieri,* 24.xii.2010, Y. Ben-Dov, 24.x.2010, 17.iii.2013;

Q. calliprinos, 13.iii.2011; Mt. Tabor (peak trail), *Q. ithaburensis*, 10.12.2012; Nebi Hazuri, *Q. calliprinos*, 27.xii.2009; Park Hasharon, *Q. ithaburensis*, 13.1.2013; Park Alona, *Q. ithaburensis*, 13.1.2013; Shimron, *Q. ithaburensis*,11.ii.1987, Y. Ben-Dov; Timrat, *Q. calliprinos*, 31.vii.2011,18.xi.2012, *Q. ithaburensis*, 24.iii.2012; Yehudiya Nature Reserve, *Q. ithaburensis*, 3.xii.2010, 13.1.2013; Yodfat, *Q. calliprinos,* 14.ii.2010; Zur Hadassa, *Q. calliprinos*, 25.ii.2013.

Eriococcidae (felt scales)

Felt scales are very diverse and they are comprised of a number of unrelated groups. Adults are small to moderate in size (1 to 3 mm), oval or oblong. Adults and early stages are usually not covered by mealy wax, as in mealybugs, but they otherwise resemble them. In the genera, *Acanthococcus* and *Eriococcus*, all females stages possess enlarged spine-like setae on the dorsum. Some adult females produce a white, gray or yellowish ovisac that encloses its entire body. The posterior end of the sac has a small opening that allows the first-instars to emerge. Others occur under the bark of the host, produce little or no ovisac (Gill, 1993).

**** Acanthococcus melnikensis*** (Hodgson and Trencheva)
(Plate 1, fig. k.)

Host trees in Israel: *Quercus calliprinos* and *Q. ithaburensis*.

Host tree in other countries: *Quercus pubescens*

Distribution: **Palaearctic**: Bulgaria (Hodgson and Trencheva, 2008).

Remarks: Gavrilov (2010) suggests that *A. melnikensis* is a synonym of *A. aceris* Signoret. However, after close examination of the specimens from Israel and of specimens of *A. aceris* (from Greece and Hungary) we conclude that they are different species (personal communication with B. Kaydan). Female *A. melnikensis* produce a white felt-sac that encloses their body in preparation for oviposition (authors' observations).

Material examined: Alonei Abba Nature Reserve, *Quercus ithaburensis*, 7.x.2010, 27.ii.2011; Golan: Odem Forest, *Q. calliprinos,* 7.vi.2001, Y. Ben-Dov; Eilon, *Q. calliprinos,* 27.iv.1987, Y. Ben-Dov, 29.iv.2000, Z. Tamari, 21.iv.2011; Hanita, *Q. calliprinos,*15.vi.2001, Y. Ben-Dov; Horshat Tal Nature Reserve, *Q. ithaburensis*, 18.iii.1981, Y. Ben-Dov; Mt. Meron, *Q. ithaburensis*, 1.vi.1988, Y. Ben-Dov; Mt. Tabor, *Q. ithaburensis*, 10.xii.2012; Nebi Hazuri, *Q. calliprinos,* 21.iii.2010, 18.iv.2010; Timrat, *Q. calliprinos*, 24.iv.2012.

****Acanthococcus roboris*** **(Goux)**
(Plate 1, fig. l.)

Host tree in Israel: *Quercus boissieri* and *Q. calliprinos*.

Hosts in other countries: Fagaceae: *Castanea sativa*, *Q. imeretina*, *Q. petraea*, *Q. pubescens*, *Q. robur*. **Hippocastanaceae**: *Aesculus hippocastanum*. **Pterocaryaceae**: *Pterocarya pterocarpa*.

Distribution: Mediterranean, European and eastern Palaearctic.

Material examined: Mt. Meron, *Quercus boissieri*, 13.iii.2011; Nebi Hazuri, *Q. calliprinos*, 18.iv.2010.

*****Acanthococcus* sp. near *melnikensis*** (Hodgson and Trencheva)

Host tree in Israel: *Quercus ithaburensis*

Material examined: Alonei Abba Nature Reserve, *Quercus ithaburensis*, 14.ii.2012; Horshat Tal Nature Reserve, *Q. ithaburensis*, 23.iii.2000, Z. Tamari, 21.ii.2010, 7.x.2010, 27.ii.2011, 20.iii.2011; Mezar, *Q. ithaburensis*, 10.iii.2013; Yehudiya Nature Reserve, *Q. ithaburensis*, 6.iii.2010.

Kermesidae (gall-like scales)

Kermesidae are host specific to trees belonging to Fagaceae and are mainly found on oak trees. Most females are circular in shape and flat just after the last molt. After molting the female expands to usually a globular or near spherical shape. Eggs are protected and incubated inside the female's body. Once egg laying is complete, the females die and the dead, sclerotized scales (post-reproductive females) may adhere to the host tree for up to a year or more. It is usually this stage that is noticed by collectors (Bullington and Kosztarab, 1985).

***Kermes echinatus* Balachowsky**
(Plate 2, fig. m.)

Host tree: *Quercus calliprinos*

Distribution: This species is only known from Israel.

Remarks: Crimson dye was extracted from both adult females and eggs and chemically analyzed by Amar et al. (2005). This species is linked with the "Tolaat Shani" (scarlet worm in Hebrew), an animal mentioned in the Bible used for dye extraction during the period of the second Temple Period (70 A.D.) in Israel (Amar et al., 2005). This species is bi-parental and univoltine (authors' observations).

Material examined: Type material: Syntype 2 first-instar nymphs, Nahalal Forest, Israel, *Quercus coccifera* 10.v.1950, Bytinski-Salz (ICVI C:3691, MNHN 1065-8). **Non-type material:** Alonei Abba Nature Reserve, 19.vi.2011, 26.vi.2011, 3.vi.2012; Eilon, 19.vi.2011, 22.vi.2011, 26.vi.2011, 3.vi.2012; Nahal Dolev Nature Reserve, 17.vi.2010, 15.vi.2012, 17.vi.2011, 8.vi.2012, 22.vi.2012; Hanita, 6.vi.2010; Nebi Hazuri, 6.vii.2011.

***Kermes greeni* Bodenheimer**
(Plate 2, fig. n.)

Host tree in Israel: *Quercus calliprinos*

Host tree in other countries: *Quercus coccifera*

Distribution: Crete (Greece) (Pellizzari *et al*., 2011) and Turkey (Japoshvili and Karaca, 2003).

Remarks: Bytinski-Salz and Sternlicht (1967) erroneously listed this species as a synonym to *Kermes echinatus*. Spodek *et al*. (2012a) establish *Kermes palestiniensis* Balachowsky, 1953 as a junior synonym. This species is bi-parental and univoltine (authors' observations).

Material examined: Type material: Lectotype adult ♀ of *K. greeni*, on *Quercus coccifera*, Israel, Nahalal, 2.ii.1926, F.S. Bodenheimer. **Paralectotypes**: 7 adult ♀♀ (6 in ICVI, 1 in BMNH), same data as lectotype. Also: 5 first-instar nymphs in 2 of the **paralectotype** adult ♀♀, Israel: Nahalal, *K. greeni*, 2.ii.1926, F.S. Bodenheimer. Also: **Syntype** first-instar nymphs *Kermes palestiniensis* Balachowsky Ras-el Nakurah [=current name Rosh Hanikra], *Q. coccifera*, 12.vii.1950, S. Neumark (MNHN). **Non-type material:** Eilon, 13.iii.2011, Y. Ben-Dov; Hanita, 5.vi.2001, Z. Tamari; 6.vi.2010, 8.v.2011, 8.v.2011, 17.v.2011, 7.v.2012; Timrat, 24.vi.2011, 31.vii.2011, 22.iv.2012, 7.v.2012.

***Kermes nahalali* Bodenheimer**
(Plate 2, fig. o.)

Host tree in Israel: *Quercus ithaburensis*

Distribution: This species is only known from Israel.

Remarks: Bytinski-Salz and Sternlicht (1967) record this species on *Q. calliprinos*. *Kermes bytinskii* Sternlicht, 1969 is a junior synonym (Spodek and Ben-Dov, in press). This species is bi-parental and univoltine (authors' observations).

Material examined: Type material: Lectotype adult ♀ and 4 adult ♀♀; **Paralectotypes** collected on *Quercus coccifera* in Nahalal, Israel, v.1920 by F.S. Bodenheimer; **Paratype** adult ♀ *Kermes bytinskii* Sternlicht, Tivon, Israel, *Q. ithaburensis*, iii.1957, M. Sternlicht (BMNH, 1969-627); **Paratype** 5 first-instar nymphs *Kermes bytinskii* Sternlicht, Tivon, *Q. ithaburensis*, iii.1957, M. Sternlicht (BMNH, 1969-627). **Non-type material:** Alon Hagalil, 25.iv.2010; Alonei Abba Nature Reserve, 25.iv.2010, 27.ii.2011, 13.iii.2011, 14.ii.2012, 4.iii.2012, 24.iii.2012; Horshat Tal Nature Reserve, 20.ii.1968, M. Sternlicht, 6.ii.2011, 21.ii.2010, 27.ii.2011, 14.ii.2012, 29.ii.2012; Tivon, 15.vi.1955, M. Sternlicht.

***Kermes spatulatus* Balachowsky**
(Plate 2, fig. p.)

Host trees in Israel: *Quercus ithaburensis* and *Q. look*.

Distribution: This species is only known from Israel.

Remarks: Bytinski-Salz and Sternlicht (1967) recorded this species on *Quercus ithaburensis*. The first-instar nymph and post-reproductive female are morphologically similar to *K. bacciformis* Leonardi, a Mediterranean and European kermesid (Balachowsky, 1953 and authors' observations). This species is bi-parental and univoltine (authors' observations).

Material examined: Type material: Syntype 3 first-instar nymphs, Daphne Oaks (=Horshat Tal Nature Reserve), Israel, *Quercus ithaburensis*, 12.v.1952, H. Bytinski-Salz (ICVI, MNHN 1058-5). **Non-type material:** Horshat Tal Nature Reserve, v.1958, 10.vi.1964, 26.iv.1967, M. Sternlicht, 18.iv.2010, 3.iv.2011, 8.iv.2012; Mt. Hermon Nature Reserve, *Q. look,* 24.v.2012, 20.vi.2012, 21.viii.2011.

***Nidularia balachowskii* Bodenheimer**
(Plate 2, fig. q.)

Host tree in Israel: *Quercus ithaburensis*

Host trees in other countries: *Quercus* spp. (Bodenheimer, 1941, 1944).

Distribution: Turkey (Bodenheimer, 1941) and Iran (Bodenheimer, 1944).

Remarks: Bytinski-Salz and Sternlicht (1967) listed this species on *Q. ithaburensis*, however they classified it erroneously under the Pseudococcidae. Spodek *et al*. (2012b) confirm family placement of this species in Kermesidae by morphological and molecular analyses. *Nidularia pulvinata* (Planchon) is also listed by Bytinski-Salz and Sternlicht (1967), however there are no material records of this species and therefore we conclude that this species is not present in Israel (Spodek *et al*., 2012b). *Nidularia balachowskii* is bi-parental and univoltine (authors' observations).

Material examined: Type material: Lectotype adult ♀ (ICVI), and **paralectotype** adult ♀ (MNHN-14802-4), 21 km at road from Mardin to Diyarbakir, Turkey, on branches and twigs of *Quercus* sp. (Fagaceae), 13.ii.1939, F.S. Bodenheimer. Bodenheimer (1941) did not select a holotype, and we regard the above-mentioned specimens as the original material studied by him as indicated on the slide labels. **Non-type material:** Daphne Oaks (= current name Horshat Tal Nature Reserve), on *Quercus* sp., 1.v.1939, F.S. Bodenheimer, (C:4805/1 adult ♀). This was the first record of this species from Israel. Alonei Abba Nature Reserve, 11.1.2011; Horshat Tal Nature Reserve, 30.v.2010, 14.ii.2012, 27.ii.2011, 13.iii. 2012; Yehudiya Nature Reserve, 6.iii.2010, 10.x.2010, 7.xi.2010, 11.i.2011, 6.ii.2011, 16.x.2011, 6.xi.2011, 3.vi.2012, 20.ix.2012, 20.v.2013.

***Kermes* sp. near *echinatus* Balachowsky**

Host trees in Israel: *Quercus ithaburensis* and *Q. look*

Material examined: Mt. Hermon Nature Reserve, *Quercus look*, 20.vi.2012, 20.vi.2012, 4.xi.2012; Mezar, *Q. ithaburensis*, 4.xi.2012.

***Kuwaniidae**

The body of these scale insects is elongate; cyst stage without legs, occurring in cracks on trunk or under bark; often brightly colored. Species are often red and very mobile on trunks and branches. Adult females produce a white waxy ovisac that covers the body and they oviposit under the bark of trees. Species are only known only from oak trees (Gill, 1993).

***Kuwania rubra* Goux**
(Plate 2, fig. r.)

Host tree in Israel: *Quercus calliprinos*

Host trees in other countries: *Quercus ilex*, *Q. robur* (Silvestri, 1939) and *Castanea* spp. (Marotta and Tranfaglia, 1990).

Distribution: Mediterranean (France, Italy and Portugal)

Remarks: This is the first report of a species in this family from Israel. Bytinski-Salz and Sternlicht (1967) report *Kuwania* sp. near *quercus* on *Quercus ithaburensis*. It is reported as a rare species from a survey of scale insects on oaks in Italy (Pellizzari and Camporese, 1991). Adult females observed by authors walking on trunks of trees in late May and June in Israel.

Material examined: Nahal Dolev Nature Reserve, *Q. calliprinos*, 1.vi.2012; Timrat, 24.v.2012, 16.vi.2013.

Monophlebidae (giant scales)

These are large scales that have an elongated oval body; many species grow to a length of one centimeter long. The adult females have dark colored legs and conspicuous antennae. Most genera have a waxy coating but some do not and various species have some form of ovisac (Foldi, 2009)

***Gueriniella serratulae* (Fabricius)**
(Plate 2, fig. s.)

Host tree in Israel: *Quercus calliprinos*

Host trees in other countries: 12 botanical families including species of **Aizoaceae, Asteraceae, Chenopodiaceae, Cistaceae, Fabaceae, Lamiaceae, Myrtaceae, Oleaceae, Pinaceae, Rosaceae, Umbelliferae** and **Vitaceae**.

Distribution: Mediterranean and eastern Palaearctic.

Remarks: Bodenheimer (1927b) was the first to record this species on oaks. Bytinski-Salz and Sternlicht (1967) later found this species on *Q. calliprinos* and *Q. ithaburnensis*. Bodenheimer (1953) observed oviposition in June and September in Israel.

Material examined: Nebi Hazuri, *Q. calliprinos*, 9.v.2010, Y. Ben-Dov, 24.vii.2011, Y. Ben-Dov.

Pseudococcidae (mealybugs)

Adult females are often characterized by a white, mealy or powdery secretion that covers the body. A filamentous secretion often is produced that encloses the eggs and at least part of the body (McKenzie, 1967).

Eurycoccus sternlichti Williams
(Plate 2, fig. t.)

Host tree in Israel: *Quercus ithaburensis*

Distribution: To date, this species is only recorded in Israel.

Remarks: Bytinski-Salz and Sternlicht (1967) report this species on *Q. ithaburensis*. Williams (1958) noted that in Israel this species occurs in colonies of two to five in the hollows of branches and induces galls. Galling by this species was not observed in the present study. Adult females are found in association with developing acorns, between November and December (authors' observations).

Material examined: Horshat Tal Nature Reserve, *Quercus ithaburensis*, 1.x.1956, M. Sternlicht, 7.xi.2010.

Phenacoccus alonim Ben-Dov
(Plate 2, fig. u.)

Host tree in Israel: *Quercus ithaburensis*

Distribution: To date, this species has only been recorded in Israel.

Remarks: Bytinski-Salz and Sternlicht (1967) report *Phenacoccus* sp. near *quercus* on *Q. ithaburensis*.

Material examine: Type material: Holotype adult ♀ and **paratype** 9 adult ♀♀ from Alonei Abba Nature Reserve, *Quercus ithaburensis*, 11.ii.1987, Y. Ben-Dov. **Non-type material:** Alonei Abba Nature Reserve, *Q. ithaburensis*, 12.xii.2010; Alonim, *Q. ithaburensis*, 11.ii.1987, Y. Ben-Dov.

Putoidae (giant mealybugs)

The adult female is oval and up to five millimeters long and concealed by tufts of powdery white wax. If the wax is removed, two longitudinal black stripes can be seen on the upper surface of the body and the wax glands are large and conspicuous. The legs and antennae are well-developed and a dark color (Williams *et al*., 2011).

***Puto israelensis* Ben-Dov**
(Plate 2, fig. v.)

Host tree in Israel: *Quercus calliprinos*

Host tree in other countries: *Quercus alnifolia* (Ben-Dov, 2001b)

Distribution: Outside of Israel, this species is only known from Cyprus (Ben-Dov, 2001b).

Remarks: This is the only species of the genus *Puto* known from Israel. Adult females and males were collected in May. It is speculated that this species develops one annual generation in Israel (Ben-Dov, 2001b).

Material examined: Type material: Holotype adult ♀ and **paratype** 5 adult ♀♀ Mas'ada forest, *Quercus calliprinos*, 11.v.1981, Y. Ben-Dov. **Non-type material:** Mas'ada forest, *Q. calliprinos*, 27.iv.1981, Y. Ben-Dov; Golan:Odem Forest, *Q. calliprinos*, 25.ii.2008, Y. Ben-Dov; 27.iv.2010; Mt. Carmel, *Q. calliprinos*, 30.iii.1989, Y. Ben-Dov; Nebi Hazuri, *Q. calliprinos*, 10.ii.2003, Z. Tamari, 21.ii.2010, Y. Ben-Dov, 20.iii.2011.

Comments on scale insects associated with oaks in Israel

A total of twenty-seven species are determined from nine families on branches and leaves of four native oak tree species in Israel; Asterolecaniidae (3), Coccidae (3), Diaspididae (7), Eriococcidae (3), Kermesidae (6), Kuwaniidae (1), Monophlebidae (1), Pseudococcidae (2), and Putoidae (1). Kuwaniidae is new family recorded in Israel. The following six species are new records for Israel: *Acanthococcus melnikensis* (Eriococcidae), *Acanthococcus roboris* (Eriococcidae), *Asterodiaspis minor* (Asterolecaniidae), *Koroneaspis aegilopos* (Diaspididae), *Melanaspis louristanus* (Diaspididae), and *Kuwania rubra* (Kuwaniidae). Five scale insects that are identified to the genus level are listed, together with their host plants however, photographs for each insect are not provided. We include these five scale insects in the total number of insects found on oaks in Israel from this survey. They are: *Asterodiaspis* sp. (Asterolecaniidae), *Eulecanium* sp. (Coccidae), *Pulvinaria* sp. (Coccidae), *Acanthococcus* sp. (Eriococcidae) and *Kermes* sp. (Kermesidae).

The Diaspididae, with seven species and the Kermesidae, with six species, are the most species-rich families occurring on oaks in Israel. Each of the families, Kuwaniidae, Monophlebidae and Putoidae are represented by a single species. The other families, Asterolecaniidae, Coccidae, Eriococcidae and Pseudococcidae are each represented by two or three species.

Fourteen of the twenty-nine species recorded by Bytinski-Salz and Sternlicht (1967) were also recovered in this current survey. It is important to note that several of the species that were listed by Bytinski-Salz and Sternlicht (1967) are either *nomina nuda*, some species are erroneously synonymized or other species have been synonymized since the time their list was compiled.

The records of species from two families; Asterolecaniidae and Diaspididae have the most discrepancies between the two surveys. Bytinski-Salz and Sternlicht (1967) survey reported three Asterolecaniidae species from oaks in Israel that were not recovered during the present survey; *Asterolecanium bellum* (Russell), (currently = *Asterodiaspis bella*), *Asterolecanium ilicicola* (Targioni Tozzetti), (currently = *Asterodiaspis ilicicola*) and *Asterolecanium quercicola* (Bouche), (currently = *Asterodiaspis quercicola*). Although, it is known that species of the genus *Asterodiaspis* are restricted to oak trees, we cannot include these species in our survey, because no material is available to verify these identification records.

Bytinski-Salz and Sternlicht (1967) listed eight armored scales that were not recovered in this survey. Some of these diaspidids, namely; *Aonidiella aurantii* (Maskell), *Lepidosaphes ulmi* (Linnaeus), *L. beckii* (Newman) and *Diaspidiotus ostreaeformis* (Curtis) are polyphagous and invasive species in many areas; we speculate that these were collected by Bytinski-Salz and Sternlicht from oak trees that were in close proximity to or found within mixed agricultural or ornamental settings in Israel. Although two diaspidids that were listed by Bytinski-Salz and Sternlicht (1967), *Diaspidiotus distinctus* (Leonardi), *Diaspidiotus wuenni* (Lindenger) are known mainly from oaks, (Ben-Dov *et al*., 2013), they were not recovered by us in this survey. Unfortunately, since no material of these two species from the Bytinski-Salz and Sternlicht survey is available, we do not include them as part of the oak fauna of Israel. *Diaspidiotus viticola* Leonardi is only known from *Vitis vinifera* (Ben-Dov, *et al*., 2013), therefore, its association with oaks is doubtful and we assume that this was a misidentification.

Three soft scales species (Coccidae) were listed by Bytinski-Salz and Sternlicht (1967). *Eulecanium coryli* Linnaeus, *Eulecanium pulchrum* Sanders and *Eulecanium tivoni* Sternlicht. Today *E. coryli* is a synonym of *Eulecanium tiliae* (Linnaeus) and *E. pulchrum* is a synonym of *Parthenolecanium rufulum* (Cockerell). *Eulecanium tivoni* Sternlicht is a *nomen nudum* (Ben-Dov *et al*., 2013). The *Eulecanium* sp. that we recovered from our survey closely resembles *E. tiliae*.

Seven species of the Kermesidae family were listed from Israel by Bytinski-Salz and Sternlicht (1967). However, the family Kermesidae in Israel was recently revised (Spodek and Ben-Dov, submitted) and six species remain in this family from Israel. *Nidularia pulvinata* (Planchon) and *Kermes biblicus* Bodenheimer have neither been recovered from extensive field collections in Israel nor from any museum collection depositories. We do not consider these species to be present in Israel. It is also established that *Kermes bytinskii* Sternlicht is a junior synonym of *K. nahalali* and *Kermes palestiniensis* Balachowsky is a junior synonym of *K. greeni* (Spodek *et al*., 2012a; Spodek and Ben-Dov, in press). A new species of *Kermes* was collected during this survey and it will be described in Spodek and Ben-Dov (in press).

Insect-host plant affinities

Quercus calliprinos and *Q. ithaburensis* share the same number of scale insect species found on them (n=17), and *Q. boissieri* has five species and *Q. look* has the smallest number of species (n=3). Species of scale insect families, such as the armored scales (Diaspididae) and pit scales (Asterolecaniidae) were collected on all four oak species. Other species are only known from a single oak species in Israel, such as *Kuwania rubra* (Kuwaniidae) and *Kermes echinatus* (Kermesidae) on *Q. calliprinos* (Table 2). *Kermes echinatus* is the most widely distributed kermesid. *Kenima galilit* (Coccidae) is the most common scale insect collected in all the sampling sites and it is found on *Q. calliprinos* and *Q. ithaburensis* trees.

We found that seven species are monophagous, exclusive to one sub-genus and one section of the genus *Quercus*; while nine of the species collected are stenophagous and they occur on at least two subgenera of the genus *Quercus*. Five species are polyphagous; the armored scales, *Diaspidiotus zonatus, Hemiberlesia lataniae* and *Targionia vitis,* one eriococcid, *Acanthococcus roboris* and one monophlebid, *Gueriniella serratulae*. The diaspidid, *Chionaspis lepineyi,* is the only species that we recovered that is classified as an oligophagous species, as all of its recorded host plants are from different genera within Fagaceae. The five scale insects collected during this survey that are not identified to the species level are not included in the host range analysis because we do not have information about their hosts from outside of Israel.

Table 2. The number of scale insects by family associated with four oak (*Quercus*) species in Israel from 2010-2013 survey.

	Q. boissieri	***Q. calliprinos***	***Q. ithaburensis***	***Q. look***
Asterolecaniidae	1	2	1	1
Coccidae	1	2	1	
Diaspididae	2	6	7	1
Eriococcidae	1	2	2	
Kermesidae		2	4	2
Kuwaniidae		1		
Monophlebidae		1		
Pseudococcidae			2	
Putoidae		1		
TOTAL	5	17	17	4

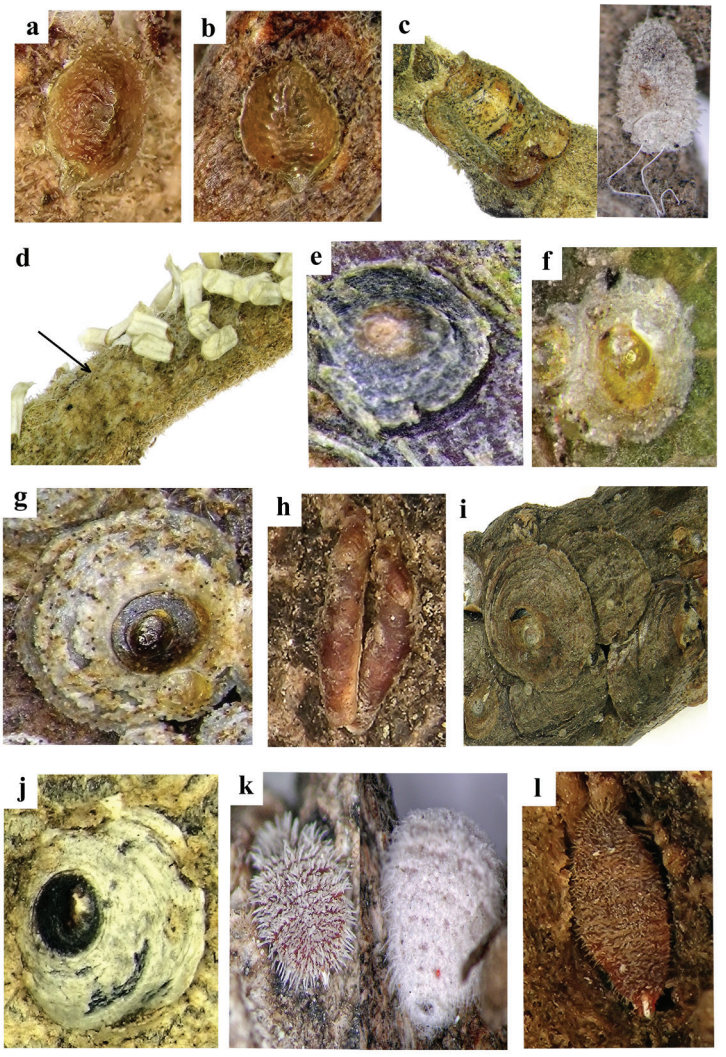

Plate 1. General appearance of adult ♀ and some adult ♂ scale insects by family from 2010-2013 oak survey in Israel; **Asterolecaniidae: a.** *Asterodiaspis mina* Russell; **b.** *Asterodiaspis variolosa* Ratzenburg; **Coccidae: c.** *Kenima galilit* Ben-Dov (adult ♀ and ♂ test); **Diaspididae: d.** *Chionaspis lepineyi* Balachowsky (♀ indicated by arrow and ♂♂); **e.** *Diaspidiotus zonatus* Frauenfeld; **f.** *Gonaspidiotus minimus* Berlese and Leonardi; **g.** *Hemiberlesia lataniae* Signoret; **h.** *Koroneaspis aegilopos* Koroneos; **i.** *Melanaspis louristanus* Balachowsky and Kaussari; **j.** *Targionia vitis* Signoret; **Eriococcidae: k.** *Acanthococcus melnikensis* Hodgson and Trencheva (adult ♀ and white felt sac); **l.** *Acanthococcus roboris* Goux.

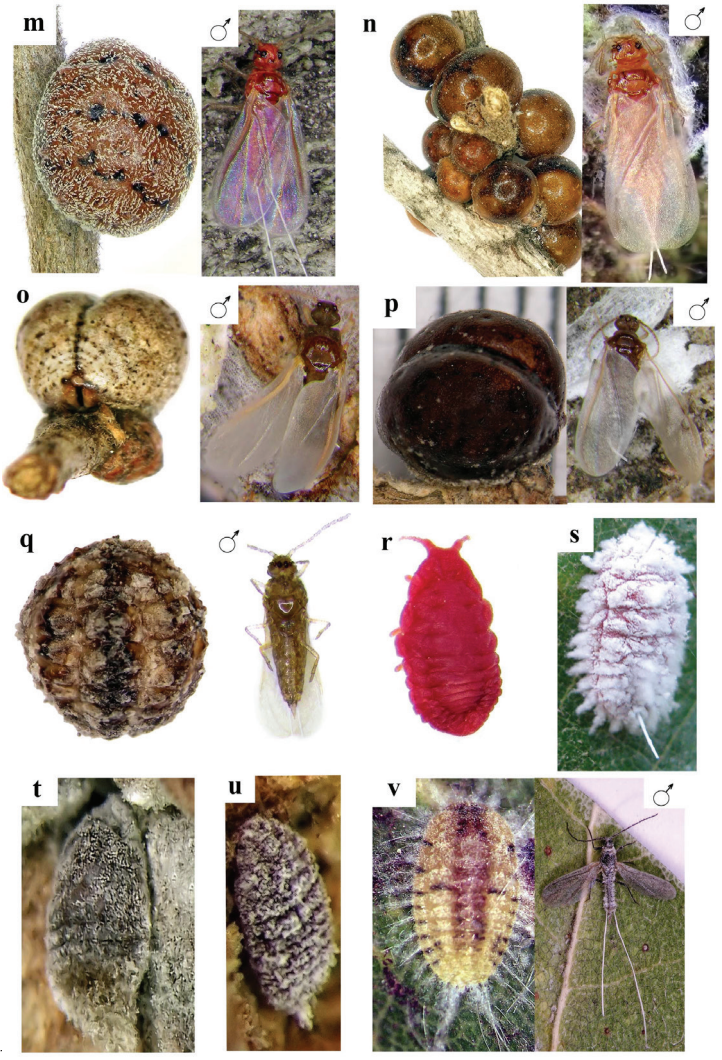

Plate 2. General appearance of adult ♀ and some adult ♂ scale insects by family from 2010-2013 oak survey in Israel; **Kermesidae: m.** *Kermes echinatus* Balachowsky (post-reproductive ♀ and adult ♂); **n.** *Kermes greeni* Bodenheimer (post-reproductive ♀ and adult ♂); **o.** *Kermes nahalali* Bodenheimer (post-reproductive ♀ and adult ♂); **p.** *Kermes spatulatus* Balachowsky (post-reproductive ♀ and adult ♂); **q.** *Nidularia balachowskii* Bodenheimer (post-reproductive ♀ and adult ♂); **Kuwaniidae: r.** *Kuwania rubra* Goux; **Monophlebidae: s.** *Gueriniella serratulae* Fabricius; **Pseudococcidae: t.** *Eurycoccus sternlichti* Williams; **u.** *Phenacoccus alonim* Ben-Dov; **Putoidae: v.** *Puto israelenisis* Ben-Dov (adult ♀ and adult ♂).

Distribution

More than half (13 out of 22) of the species recovered during this survey occur only in the Mediterranean and European regions. Five insects were identified to the genus level and their distribution outside of Israel cannot be determined at this point. Seven species have only been found in Israel and one species, *H. lataniae* is known as a cosmopolitan and polyphagous species. The two pit scales; *Asterodiaspis minor* and *A. variolosa* are found in both Palaearctic and Nearctic regions only on *Quercus* spp. (Ben-Dov *et. al.*, 2013).

List of scale insect species collected from four oak species in Israel (2010-2013) (*) indicates new species record for Israel

Asterolecaniidae
**Asterodiaspis minor* (Russell)
Asterodiaspis sp. near *repugnans* (Russell)
Asterodiaspis variolosa Ratzenburg

Coccidae
Eulecanium sp. near *tiliae* (Linnaeus)
Kenima galilit Ben-Dov
Pulvinaria sp.

Diaspididae
Chionaspis lepineyi Balachowsky
Diaspidiotus zonatus Frauenfeld
Gonaspidiotus minimus Berlese and Leonardi
Hemiberlesia lataniae Signoret
**Koroneaspis aegilopos* Koroneos
**Melanaspis louristanus* Balachowsky and Kaussari
Targionia vitis Signoret

Eriococcidae
**Acanthococcus melnikensis* Hodgson and Trencheva
**Acanthococcus roboris* Goux
Acanthococcus sp. near *melnikensis* Hodgson and Trencheva

Kermesidae
Kermes echinatus Balachowsky
Kermes greeni Bodenheimer
Kermes nahalali Bodenheimer
Kermes spatulatus Balachowsky
Kermes sp. near *echinatus* Balachowsky
Nidularia balachowskii Bodenheimer

***Kuwaniidae**
**Kuwania rubra* Goux

Monophlebidae
Gueriniella serratulae Fabricius

Pseudococcidae
Eurycoccus sternlichti Williams
Phenacoccus alonim Ben-Dov

Putoidae
Puto israelenisis Ben-Dov

DISCUSSION

Four oak species were studied in this paper as host trees of various scale insects in Israel and additional hosts for each insect species are listed from other countries. *Quercus cerris* was not sampled because of its difficult accessibility. It is interesting to observe that two of the major oak species in Israel, the evergreen species, *Q. calliprinos* and the deciduous species, *Q. ithaburensis* have the same number of scale insect species found on them.

Quercus calliprinos is an East Mediterranean subspecies of, or a vicariad species to, *Q. coccifera* L., which grows in the Mediterranean territories of Europe (Zohary, 1973; Jalas and Suominen, 1976). Four scale insect species have been found exclusively on *Q. calliprinos* in Israel; *Kermes echinatus, K. greeni* (Kermesidae), *Kuwania rubra* (Kuwaniidae) and *Puto israelensis* (Putoidae). The host records from outside of Israel indicate that these species show a preference for evergreen oaks in the Mediterranean Basin. Of the four species mentioned above, *Kuwania rubra* has the widest distribution among Mediterranean countries, including Italy, France and Portugal (Ben-Dov *et al*., 2013). We suggest that the kermesid and putoid species that so far were only recorded from Israel, Greece and Cyprus, are also distributed in countries where Mediterranean evergreen oaks are found.

The deciduous tree, *Q. ithaburensis,* is thought to be a synonym or a subspecies of *Q. macrolepis* Kotschy and it is distributed throughout the southern Mediterranean, in the Balkans including the Greek Islands, Morocco, and Turkey (Eig, 1933; Zohary, 1973). We therefore expect that the scale insect species found in Israel on *Q. ithaburensis* will also be present in other areas where *Q. macrolepis* is distributed.

Quercus boissieri closely resembles *Q. infectoria* Olivier, a species that is distributed throughout southern Europe and the eastern Mediterranean (Zohary, 1973). The five scale insect species on *Q. boissieri* are not exclusive to this tree species and they were also found on other oak species in Israel. In Israel, *Q. boissieri* is host to diaspidids species such as *Diaspidiotus zonatus* and *Targionia vitis*. The distribution of the latter species is widespread throughout the Palaearctic region and they are polypha-

gous feeders on over 100 botanical families. Although *D. zonatus* is also known to feed on five other botanical families, Fagaceae seems to be its preference with records from both *Quercus* and *Fagus* (Ben-Dov *et al*., 2013). The pit scale, *Asterodiaspis minor,* is also known on *Q. boissieri* in Israel and although its host range is restricted to *Quercus* spp., its distribution is wide with records from North America. This is a Palaearctic species and it is considered an invasive in North America, causing injury to the oaks there (Gill, 1993).

The oak species, *Q. look* has the smallest number (n=3) of scale insect species associated with it in Israel. This tree is only found in one location in Israel, at high altitudes, on Mt. Hermon and it belongs with *Q. libani* in the Cerris section of the subgenus *Quercus*. Other oak species in this section extend north into the mountainous regions Lebanon and east towards Iraq and Iran (Zohary, 1973). We record the armored scale, *Melanaspis louristanus,* for the first time in Israel on *Q. look* and *Q. ithaburensis*. It is interesting to note that the only other record of this species is from Iran, on *Q. persica*, an oak species that also belongs to the Cerris section of oaks. From these two records, we can speculate that this armored scale insect prefers oak trees that grow in higher elevations.

It is noteworthy that so far, seven scale insect species are only recorded from Israel. Similar information has not been published from countries adjacent to Israel and perhaps this is an explanation for this limited distribution information. We suspect that these species are also present in other Mediterranean countries on *Quercus* spp. because most of the species from Israel are regional and host-specific to oak.

In Israel, oak trees have a high diversity of coccoids associated exclusively with them compared to other trees. Of the scale insects that are known to be exclusive to *Quercus* spp. in the world, many of these are found in Israel. Representative species of the families Kermesidae and Kuwaniidae, as well as several species of the genus, *Asterodiaspis* belonging to the pit scale family Asterolecaniidae are present in Israel. The number of species and the number of scale insects families found on oaks in Israel is comparable to other surveys in the Mediterranean region. Pellizzari and Camporese (1990) studied the entomofauna of oak forests in Italy and recorded a total of 31 scale insect species belonging to eight families. Longo *et al*. (1991) showed nineteen species from seven families in two Italian regions; Calabria and Sicily. Trencheva *et al*. (2009) surveyed oak habitats in Bulgaria and Greece in order to determine sources of scale insect honeydew utilized by bees. They record sixteen species belonging to five families from Bulgaria and twenty-five species from four families in Greece.

A possible explanation for the host-specificity of scale insects on oaks in Israel may be due to the fact that oak trees are dominant, native trees in Israel with a long history in the region (Liphschitz and Biger, 1990). Southwood (1961), Connor *et al*. (1980) and Southwood *et al*. (2005) suggested that native trees will harbor significantly more insects than introduced ones and Kozár and Kosztarab (1982) considered that this similar phenomenon found in Western Palaearctic countries was related to the oak trees great abundance in ancient geological times. They speculate that the monophagous coccoids on oaks might have evolved earlier and possibly parallel with their

hosts. This co-evolutionary hypothesis suggests that over time phytophages become increasingly specialized and in time evolve to specialists. Thus, the earlier a tree is colonized in an area, the more specialized phytophages should occur on it (Berenbaum, 1983). These theories may help to explain the abundance of host-specific character of scale insects on oaks in Israel. Oaks first appeared in the Mediterranean Basin 3.5-2.3 million years ago (myr) (Blondel and Aronson, 1999; Thompson, 2005) and the earliest records of scale insects in the Mediterranean region are known from specimens encased in Lebanon amber dating back to the Lower Cretaceous period (125-135 myr) (Koteja and Azar, 2008). However, almost all the main lineages of modern coccoids have been identified from Tertiary amber (dated to Eocene, Oligocene, and Miocene, 1.6-65 myr) (Gullan and Kosztarab, 1997).

Conclusions

This study illustrates a rich and indigenous scale insect fauna associated with the native oak tree species of Israel. Six species of scale insects are reported here for the first time from Israel. Five others are unidentified to the species level and may be potentially new to science. Kuwaniidae is a new scale insect family for Israel; in the Western Palaearctic this family is known so far only from Italy, France, and Portugal. In Israel, almost half of the total scale insect species (70 of 166, representing 42.1%) are cosmopolitan and most of these species are pests of economic importance to agricultural crops with most of the latter being invasive species (Ben-Dov, 2012). Knowledge of the local entomofauna contributes to Israel's natural heritage. Surveys such as the one in this study, focus on endemic flora and fauna, thus expanding existing biodiversity data that may serve to promote an awareness of conservation values in Israel and the region.

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REFERENCES

Aloni, R. and Orshan, G. 1972. A vegetation map of the lower Galilee. *Israel Journal of Botany* 21: 209-227.

Amar, Z., Gottlieb, H., Varshavsky, L., and Iluz, D. 2005. The Scarlet Dye of the Holy Land. *BioScience* 55: 1080-1083.

Balachowsky, A.S. 1953. Sur les *Kermes* Boitard (Hom: Coccoidea) des Chênes du Bassin Oriental de la Méditerranée. France. *Revue de Pathologie Végétale et d'Entomologie Agricole de France* 32: 181-189.

Balachowsky, A.S. and Kaussari, M. 1953. Sur un *Melanaspis* Ckll. nouveau (Coccoidea-Diaspidinae) vivant sur chêne en Iran. *Revue de Pathologie Végétale et d'Entomologie Agricole de France* 32: 28-31.

Ben-Dov, Y. 2001a. A new genus and species of soft scales (Hemiptera:Coccoidea:Coccidae) from oaks in Israel. *Phytoparasitica* 29: 400-404.

Ben-Dov, Y. 2001b. A new species of *Puto* from oaks in the eastern Mediterranean (Hemiptera: Coccoidea: Pseudococcidae). *Revue Francaise d'Entomologie* 23: 105-108.

Ben-Dov, Y. 2012. The scale insects (Hemiptera: Coccoidea) of Israel-checklist, host plants, zoogeographical considerations and annotations on species. *Israel Journal of Entomology* 41-42: 21-48.

Ben-Dov, Y. and Hodgson, C.J. 1997. Collecting and mounting Pp. 389-395. In: Ben-Dov, Y., Hodgson, C.J. (eds.) *Soft Scale Insects-Their Biology, Natural Enemies and Control*. Vol.7A. Elsevier, Amsterdam, New York, 452 pp. doi: 10.1016/S1572-4379(97)80067-X

Ben-Dov, Y., Miller, D.R., and Gibson, G.A.P. 2013. ScaleNet: a Database of the Scale Insects of the World. Scales in a Region Query Results. Available from http://www.sel.barc.usda.gov/SCALENET/SCALENET.HTM (accessed September, 2013).

Berenbaum, M. 1983. Coumarins and caterpillars: a case study for co-evolution. *Evolution* 37: 163-179.

Blondel, J. and Aronson, J. 1999. *Biology and wildlife of the Mediterranean region*. Oxford University Press, New York, 328 pp.

Bodenheimer, F.S. 1924. The Coccidae of Palestine. First report on this family. *Zionist Organization Institute of Agriculture and Natural History, Agricultural Experiment Station Bulletin* 1: 1-100.

Bodenheimer, F.S. 1927a. Third note on the Coccidae of Palestine. *Agricultural Records, Tel Aviv* 2: 177-186.

Bodenheimer, F.S. 1927b. Les frontières écologiques d'une cochenille le *Gueriniella serratulae* Fab. *Bulletin de la Société Entomologique de France* 1927: 195-198.

Bodenheimer, F.S. 1935. Studies on the zoogeography and ecology of Palearctic Coccidae I-III. *EOS* 10: 237-271.

Bodenheimer, F.S. 1941. Seven new species of Coccidae from Anatolia. *Revue de la Faculté des Sciences de l'Université d'Istanbul* 6: 65-84.

Bodenheimer, F.S. 1943. A first survey of the Coccoidea of Iraq. Government of Iraq, Ministry of Economics, *Directorate General of Agriculture Bulletin* 28: 1-33.

Bodenheimer, F.S. 1944. Note on the Coccoidea of Iran, with description of new species. *Bulletin de la Société Fouad 1er d'Entomologie* 28: 85-100.

Bodenheimer, F.S. 1953. The Coccoidea of Turkey III. *Revue de la Faculté des Sciences de l'Université d'Istanbul* (Ser. B) 18: 91-164.

Brändle, M. and Brandl, R. 2001. Species richness of insects and mites on trees: expanding Southwood. *Journal of Animal Ecology* 70: 491-504.

Bullington, S. W. and Kosztarab, M. 1985. A revision of the family Kermesidae (Homoptera) in the Nearctic Region based on adult and third instar females. *Bulletin of the Virginia Polytechnic Institute and University Research Division* 85: 1-118.

Bytinski-Salz, H. and Sternlicht, M. 1967. Insects associated with oaks (*Quercus*) in Israel. *Israel Journal of Entomology* 2: 107-143.

Connor, E.F., Faeth, S.H., Simberloff, D., and Opler, P.A. 1980. Taxonomic isolation and the accumulation of herbivorous insects: a comparison of introduced and native trees. *Ecological Entomology* 5: 205-211.

Dalla Montá, L.D., Duso, C., and Malagnini, V. 2002 (2001). Current status of scale insects (Hemiptera: Coccoidea) in the Italian vineyards. *Bollettino di Zoologia Agraria e di Bachicoltura* (Milano) 33: 343-350.

Eig, A. 1933. A historical-phytosociological essay on Palestinian forests of *Quercus aegilops* L. ssp. *ithaburensis* (Desc.) in past and present. *Beihefte zum Botanischen Centralblatt*. 40: 225-272.

Foldi, I. 2009. Archaeococcoid scale insects (Hemiptera: Coccoidea) from the tropical high mountains of the Andean Cordillera, South America. *Zootaxa* 2300: 1-38.

Galet, P. 1982. In: *Les maladies et parasites de la vigne*. Tome II. [Diseases and parasites of grapevine. Vol. II.]. Ecole National Supérieure Agronomique de Montpellier, Montpellier, France, 1876 pp.

Gavrilov, I.A. 2010. Descriptions of two new species of Pseudococcidae (Homoptera: Coccinea) and additions to the scale insect fauna of Bulgaria. *Zootaxa* 2635: 32-40.

Gerson, U. and Zor, Y. 1973. The armored scales insects (Homoptera: Diaspididae) of avocado trees in Israel. *Journal of Natural History* 7: 513-533.

Gill, R.J. 1988. *The Scale Insects of California*: *Part 1. The Soft Scales* (Homoptera: Coccoidea: Coccidae). California Dept. of Food & Agriculture, Sacramento, CA., 132 pp.

Gill, R.J. 1993. *The Scale Insects of California*: *Part 2. The Minor Families* (Homoptera: Coccoidea). California Department of Food & Agriculture, Sacramento, CA., 241 pp.

Gill, R.J. 1997. *The Scale Insects of California*: *Part 3. The Armored Scales* (Homoptera: Diaspididae). California Department of Food & Agriculture, Sacramento, CA., 307 pp.

Gullan, P.J. and Kosztarab, M. 1997. Adaptations in scale insects. *Annual Review of Entomology* 42: 23-50.

Hecht-Poinar, E.I., Costello, L.R., and Parmeter, J.R. 1989. Twig blight of oaks in California. *California Agriculture* 43: 15-16.

Hegi, G. 1981. Illustrierte Flora von Mitteleuropa, Band III, Teil 1. Verlag Paul Parey, Berlin, Hamburg, 504 pp.

Hodgson, C.J. 1994. *The scale insect family Coccidae: an identification manual to genera*. Wallingford, Oxon, UK: CAB International, 639 pp.

Hodgson, C.J. and Trencheva, K. 2008. A new species of *Eriococcus* (Hemiptera: Sternorrhyncha: Coccoidea: Eriococcidae) and redescriptions of *Eriococcus roboris* Goux and *E. thymelaeae* Newstead, with a key to the *Eriococcus* species on *Quercus* in the western Palaearctic. *Zootaxa* 1959: 1-38.

Jalas, J. and Suominen, J. (eds.). 1976. *Atlas Florae Europaeae. Distribution of Vascular Plants in Europe*. The Committee for Mapping the Flora of Europe & Societas Biologica Fennica Vanamo, Helsinki, 128 pp.

Japoshvili, G. and Karaca, I. 2003. New record of encyrtid parasitoids of *Kermes palestiniensis* Balachowsky (Hemiptera:Kermesidae), with the description of a new species of *Blastothrix* Mayr (Hymenotpera: Encyrtidae) from Turkey. *Entomological News* 114: 187-191.

Karschon, R. 1982. In defense of the Turks. A study of the destruction of Tabor oak forests in the southern Plain of Sharon. *La-Yaaaran* 32: 54-59.

Kennedy, C.E.J. and Southwood, T.R.E. 1984. The Number of Species of Insects Associated with British Trees: A Re-Analysis. *Journal of Animal Ecology* 53: 455-478.

Kosztarab, M. and Kozár, F. 1988. *Scale Insects of Central Europe*. Akademiai Kiado, Budapest, 456 pp.

Koteja, J. and Azar, D. 2008. Scale insects from Lower Cretaceous amber of Lebanon (Hemiptera: Sternorrhyncha: Coccinea). *Alavesia* 2: 133-167.

Kozár, F. and Kosztarab, M. 1982. Coccoidea of Central European forests and their relationships. *Acta Musei Reginaehradecensis S.A. Supplementum* 203-211.

Liphschitz, N. and Biger, B. 1990. Ancient dominance of the *Quercus calliprinos-Pistacia palaestina* association in Mediterranean Israel. *Journal of Vegetation Science* 1:67-70.

Longo, S., Russo, A., and Mazzeo, G. 1991. Note faunistiche su Homoptera Coccoidea infeudati al gen. *Quercus* in Calabria and Sicily. [Faunistic notes on Homoptera Coccoidea injurious to gen. *Quercus* in Calabria and Sicily.] In: Phytopathological Problems of *Quercus* in Italy (*Aspetti Fitopatologici delle Querce*), Palazzo Medici Riccardi. Associazione Fitopatologica Italiana, Florence, 10 pp.

Marotta, S. and Tranfaglia, A. 1990. New and little known species of Italian scale insects (Homoptera: Coccoidea). In:, *Proceedings of the Sixth International Symposium of Scale Insect Studies,* Part II. Cracow, Poland: August 6-12, 1990. Agricultural University Press, Cracow, 107-112.

McKenzie, H.L. 1967. *Mealybugs of California with taxonomy, biology, and control of North American species (Homoptera: Coccoidea: Pseudococcidae)*. University of California Press, Berkeley, 526 pp.

Naveh, Z. and Dan, J. 1973. The human degradation of Mediterranean landscape in Israel. In:, *Ecological Studies. Analysis and Synthesis*. Castri, F.D. and Monney, H. (eds.), Springer, Berlin, Germany, 373-390.

Pellizzari-Scaltriti, G. and Camporese, P. 1991. [Contribution to the knowledge of scale insects (Homoptera, Coccoidea) living on oaks in Italy.] Contributo alla conoscenza delle cocciniglie (Homoptera, Coccoidea) delle querce in Italia. In: Atti del Convegno: *Problematiche fitopatologiche del genere Quercus in Italia*. Florence, Italy. 193-209.

Pellizzari, G., Porcelli, F., Seljak, G. and Kozar, F. 2011. Some additions to the Scale insect fauna (Hemiptera: Coccoidea) of Crete with a check list of the species known from the island. *Journal of Entomological and Acarological Research* 43: 291-300.

Pritchard, A.E. and Beer, R.E. 1950a. Biology and control of *Asterolecanium* scales on oaks in California. *Journal of Economic Entomology* 43: 494-497. Pritchard, A.E. and Beer, R.E. 1950b. Oak pit scales: control possible with emulsion-type foliage oil and toxaphene spray. *California Agriculture* 9: 14.

Russell, L. 1941. A classification of the Scale Insect Genus *Asterolecanium*. United States Department of Agriculture. *Miscellaneous Publication* No. 424. Washington, D.C., 322 pp.

Schwarz, O. 1937. Monographie der Eichen Europas und des Mittelmeergebietes, *Fedded Repert*, Dahlem bei Berlin, Sonderbeiheft D. Lfg.5.

Silvestri, F. 1939. Compendio di Entomologia Applicata. Parte speciale. In:, *Compendio di Entomologia Applicata*. Parte speciale. Tipografia Bellavista, Portici, 974 pp.

Southwood, T.R.E. 1961. The number of species of insect associated with various trees. *Journal of Animal Ecology* 30: 1-8.

Southwood, T.R.E., Wint, G.R.W., Kennedy, C.E.J., and Greenwood, S.R. 2004. Seasonality,

abundance, species richness and specificity of the phytophagous guild of insects on oak (*Quercus*) canopies. *European Journal of Entomology* 101: 43-50.

Southwood, T.R.E., Wint, G.R.W., Kennedy, C.E.J., and Greenwood, S.R. 2005. The composition of the arthropod fauna of the canopies of some species of oak (*Quercus*). *European Journal of Entomology* 102: 65-72.

Spodek, M. and Ben-Dov, Y. 2014. A taxonomic revision of the Kermesidae (Hemiptera: Coccoidea) in Israel with a description of a new species. Zootaxa (in press)

Spodek, M., Ben-Dov, Y., and Protasov, A. 2012a. Taxonomy of *Kermes greeni* Bodenheimer (Hemiptera: Coccoidea: Kermesidae) with a new synonymy. *Zootaxa* 3545: 67-75.

Spodek, M., Ben-Dov, Y., Ghanim, M., and Mendel, Z. 2012b. Morphological and molecular taxonomy of *Nidularia balachowskii* Bodenheimer (Hemiptera, Coccoidea, Kermesidae) with notes on its life history in Israel. *ZooKeys* 254: 23-45.

Stumpf, C.F. and Lambdin, L. 2006. Pit Scales (Sternorrhyncha: Cocccoidea) of North and South America. Tennessee Agricultural Experiment Station. University of Tennessee Institute of Agriculture, Knoxville, Tennessee, 231 pp.

Thompson, J.D. 2005. Plant evolution in the Mediterranean. Oxford University Press, New York, 304 pp.

Trencheva, K., Gounari, S., Trenchev, G., Kapaxidi, E., and Karetsos, G. 2009. Scale insects on oak trees (*Quercus* spp) in Bulgaria and Greece. 137-141 In: Branco, M., Franco, J.C. and Hodgson, C.J. (eds.), *Proceedings of the XI International Symposium on Scale Insect Studies*, Oeiras, Portugal, 24-27 September 2007. ISA Press, Lisbon, Portugal, 322 pp.

Williams, D.J. 1958. A new species of *Eurycoccus* Ferris (Homoptera: Pseudococcidae) from Israel. *Proceedings of the Royal Entomological Society of London Series B: Taxonomy* 27: 22-24.

Williams, D.J. 1985. *Australian mealybugs*. London: British Museum (Natural History), 431 pp.

Williams, D.J. 2004. Mealybugs of Southern Asia. Kuala Lumpur: Southdene SDN. BHD.: The Natural History Museum, 896 pp.

Williams, D.J., Gullan, P.J., Miller, D.R., Matile-Ferrero, D., and Han, S.I. 2011. A study of the scale insect genera *Puto* Signoret (Hemiptera: Sternorrhyncha: Coccoidea: Putoidae) and *Ceroputo* Sulc (Pseudococcidae) with a comparison to *Phenacoccus* Cockerell (Pseudococcidae). (In English). *Zootaxa* 2802: 1-22.

Wu, S., Nan, N., Gullan, P., and Deng, J. 2013. The taxonomy of the Japanese oak red scale insect, *Kuwania quercus* (Kuwana) (Hemiptera: Coccoidea: Kuwaniidae), with a generic diagnosis, a key to species and description of a new species from California. *Zootaxa* 3630: 291-307.

Zohary, M. 1961. On the oak species of the Middle East. *Bulletin of the Research Council of Israel* 9D: 161-186.

Zohary, M. 1962. *Plant life of Palestine, Israel and Jordan*. Ronald Press, New York, 262 pp.

Zohary, M. 1973. *Geobotanical Foundations of the Middle East*, Vols. I and II. Gustav Fisher Verlag, Stuttgart, 739 pp.