Israel Journal of Entomology
Vol. XV (1981) pp. 35-51

REDESCRIPTION *OF MATSUCOCCUS JOSEPHI BODENHEMER* AND HARPAZ (HOMOPTERA: COCCOIDEA: MARGARODIDAE)*

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ABSTRACT

The taxonomy of *Matsucoccus josephi* Bodenheimer and Harpaz, a pest of pine trees in Israel was studied. Redescriptions, supplemented by SEM micrographs, are given for first and second instar larvae, third instar male larva, and the adult female. The Lectotype of *M. josephi* is selected. Data are given on interspecific variation in the number of dorsal cicatrices, the number of multilocular pores, and the size of dorsal cicatrices in- the adult female of the species.

The Israel pine Matsucoccus, *Matsucoccus josephi* Bodenheimer and Harpaz (Homoptera: Coccoidea: Margarodidae) was first described from Israel after it was found to cause serious damage to young trees of the Aleppo pine, *Pinus halepensis,* in the course of afforestation projects in the country (Bodenheimer and Harpaz, 1955). The presence and pest status of this scale insect in pine forests in Israel were well recorded subsequently (Halperin, 1975; 1976).

In the early 1970s an unusual decline of Aleppo pine trees was observed in a 45-year-old forest in Israel (Sha'ar haGai, Judean Hills) and it was suggested that the decline was associated with infestations of M *Joseph* (Anonymous, 1975). Therefore, and because of reports on the primary role of a related species, namely, *M. feytaudi* Ducasse, in the decline of *Pinus maritima* forests in southern France (Carle, 1974), several studies were initiated in Israel of the taxonomy, life history, natural enemies, as well as of the role of this pest in the decline of Aleppo pine trees.

The study of *M, josephi* presented here was undertaken to verify whether the *Matsucoccus* populations infesting the declining pines belong to *M. josephi,* and whether more than one species is involved. In addition it was intended to improve our knowledge of the morphology and taxonomy of M. *josephi,* to enable research workers

*Contribution from the Agricultural Research Organization, The Volcani Center, Bet Dagan, Israel, No. 219-E, 1981 Series.

who are engaged in studies of ecology and control of the pest, to distinguish this species from related congeners.

Matsucoccus josephi Bodenheimer and Harpaz, 1955

Matsucoccus josephi Bodenheimer and Harpaz, 1955:12.

Originally described from material taken in Israel on *Pinus halepensis*. As indicated in the type-series (see below) and according to I. Harpaz, Faculty of Agriculture, Rehovot (personal communication, 1978), the type-locality is Zikhron Ya'aqov. The following redescriptions are based on the type-series as well as on additional material collected on pines in various regions of Israel.

All measurements in the following descriptions are given in μm, unless otherwise stated.

FEMALE

The development of the *M. josephi* female, similar to that of other species in this genus, includes two larval instars before maturity.

FIRST INSTAR LARVA (Fig. 1)

Crawler (just after hatching) elongate-oval, 0.3-0.4 mm long, 0.17-0.20 mm wide; colour yellow; eyes black, placed on the margin just posteriorly to the antennae.

During the growing period the size and shape of this instar change considerably. There is an increase in length, followed by a conspicuous swelling of the cephalothorax, whereas the abdominal segments do not swell as much. The growth of the cephalothorax is conspicuously asymmetrical, resulting in the formation of some fully grown first instar larvae in which both antennae are placed close to each other on one side of the body.

The fully grown first instar (0.8-0.9 mm long, 0.7-0.8 mm wide) is pear-shaped, broadly rounded at anterior apex, and tapering at posterior one. The larvae developing on stem, under bark scales, are flat, whereas those developing at needles' bases are globular.

Antennae 6-segmented; total length 89-93; basal segment with one slender seta; second segment with two short setae and a long one that exceeds the distal apex of fourth segment; third segment without setae; segment four with one fleshy seta; segment five without setae; sixth segment with two fleshy setae and four slender setae; sixth segment with two sclerotized tubes, (about 8 long) each with a dilated inner extremity and with an opening (on the constricted part of the segment) 0.5-1 wide; similar structures in first instar larva of *M. pini* were named "sclerotized struts" by Boratynski (1952).

Legs well developed; subequal in size; interval between bases of prothoracic legs and mesothoracic about twice as long as interval between meso- and methathoracic legs; separation between trochanter and femur not conspicuous; each trochanter bears one seta about 80 long; claw with a pointed projection at its base; tarsal digitules, setae-like, about half as long as the claw; claw digitules, slender, dilated apically; size

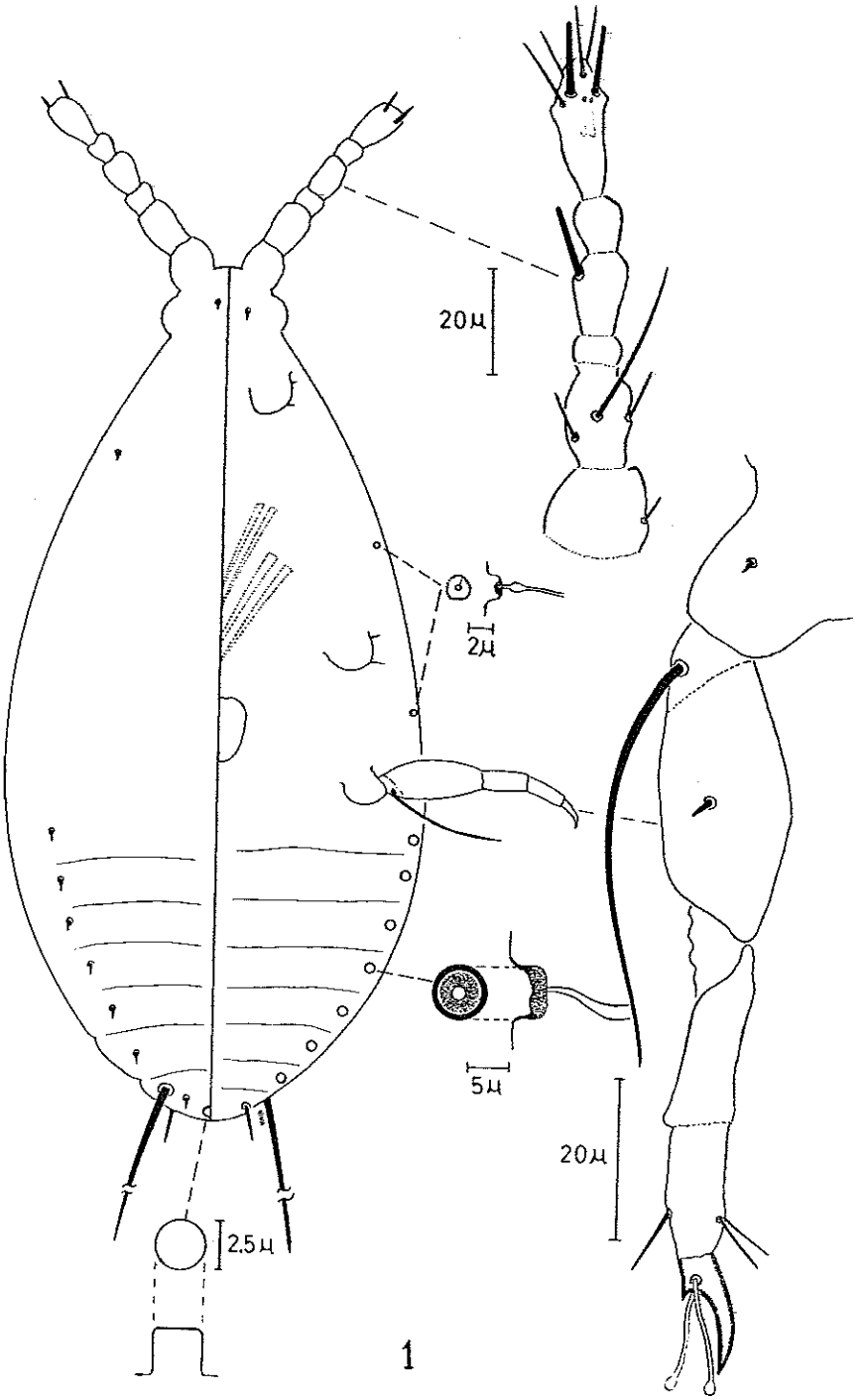


Fig. 1. *Matsucoccus josephi* Bodenheimer and Harpaz. First instar larva.

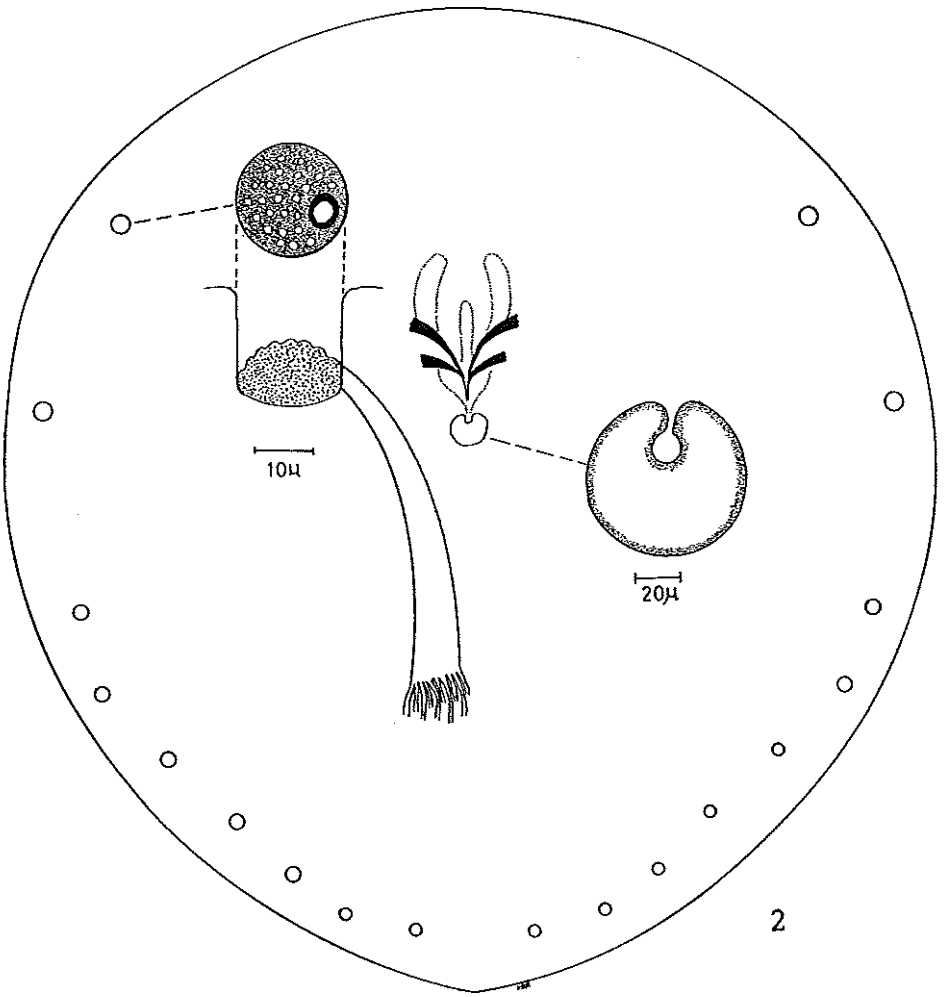


Fig. 2. ***Matsucoccus josephi*** **Bodenheimer and Harpaz. Second instar larva.**

ranges of legs segments: coxa 15-21, trochanter + femur 31-40, tibia 15-22, tarsus 15-18, claw 12-15. *Spiracles* in 9 pairs, two thoracic and seven on abdomen all placed submarginally on ventral surface; trachea of thoracic spiracle opens into a small inconspicuous invagination (diameter about 2); trachea of abdominal spiracle opens into middle of a sclerotized invagination, about 5 in diameter. *Small setae* are placed submarginally on dorsal surface as follows (for half body); one on head, one on prothorax and seven on abdominal segments; posterior segment of abdomen bears ventrally a pair of setae about 30 long, and a pair of apical setae about 190 long. Clypeo-labral shield elliptical in outline, bearing no setae; placed ventrally between meso- and metathoracic legs. Last abdominal segment with a circular opening (diameter about 2.5), invaginated, placed ventrally; extremely inconspicuous; supposed to be the anal opening.

SECOND INSTAR LARVA (Fig. 2)

The shape of this instar is affected by its development site on the tree. It is flat when developing under bark scales, whereas larvae that settled and developed at needles' bases become globular. The general outline of the body is circular or slightly oval; diameter of a fully grown larva up to 3 mm. Young larvae are yellow; derm membraneous. Fully grown ones are dark brown; derm sclerotized.

Few morphological structures can be observed in slide – mounted specimens. Framework of mouthparts placed ventrally at about middle of body; clypeo-labral shield circular in outline (ca. 70) with a deep emargination, through which the stylets protrude; shield with no setae. Nine pairs of spiracles placed ventrally; two thoracic pairs at level of mouthparts, slightly separated from abdominal spiracles; size of spiracles diminishes from thoracic to the abdominal. Each spiracle is formed of a cup-like depression; inner end of the depression is made of a conspicuous dark plate with numerous bright pores; from the pores' plate a single tracheal tube extends medially; slightly widening; at a distance of 3-4 times the diameter of spiracle, the tube divides into a cluster of numerous, small tracheae. Ventral derm posterior to mouth parts with small spine-like projections (Fig. 7).

ADULT FEMALE (Fig. 3)

Live insects oval; convex; anterior part of body brown, posterior one slightly lighter in colour. Size varies considerably; slide-mounted specimens range from 1.6 mm long, 1.1 mm wide to 4.2 mm long, 3.0 mm wide.

Dorsal derm throughout with circular (diameter 1-2), globular projections (Figs. 10, 13). Dorsal derm with bilocular pores (Figs. 11, 12) on head, thorax and abdomen, placed together with simple setae, in transverse, segmental bands; pores appear to have a bilocular opening surrounded by a dark rim when observed from above; in lateral view these appear as cup-shaped invaginations with dark walls, and with two tubules extending from inner end of the cup. *Dorsal cicatrices* (Figs. 8, 9, 10) circular; diameter (in specimens mounted in Canada Balsam) varies from 9.6 to 27.5; placed in 5-6 transverse bands on abdominal segments, excluding the posterior one; interspecific variation in numbers of cicatrices given in Table 1; on interspecific variation in diameter of cicatrices see below in "Taxonomic Notes." Ventral derm throughout with globular projections similar to those on dorsal surface. *Antennae* 9-segmented placed at cephalic margin; basal segments situated on ventral surface. The basal parts (reticulated) of

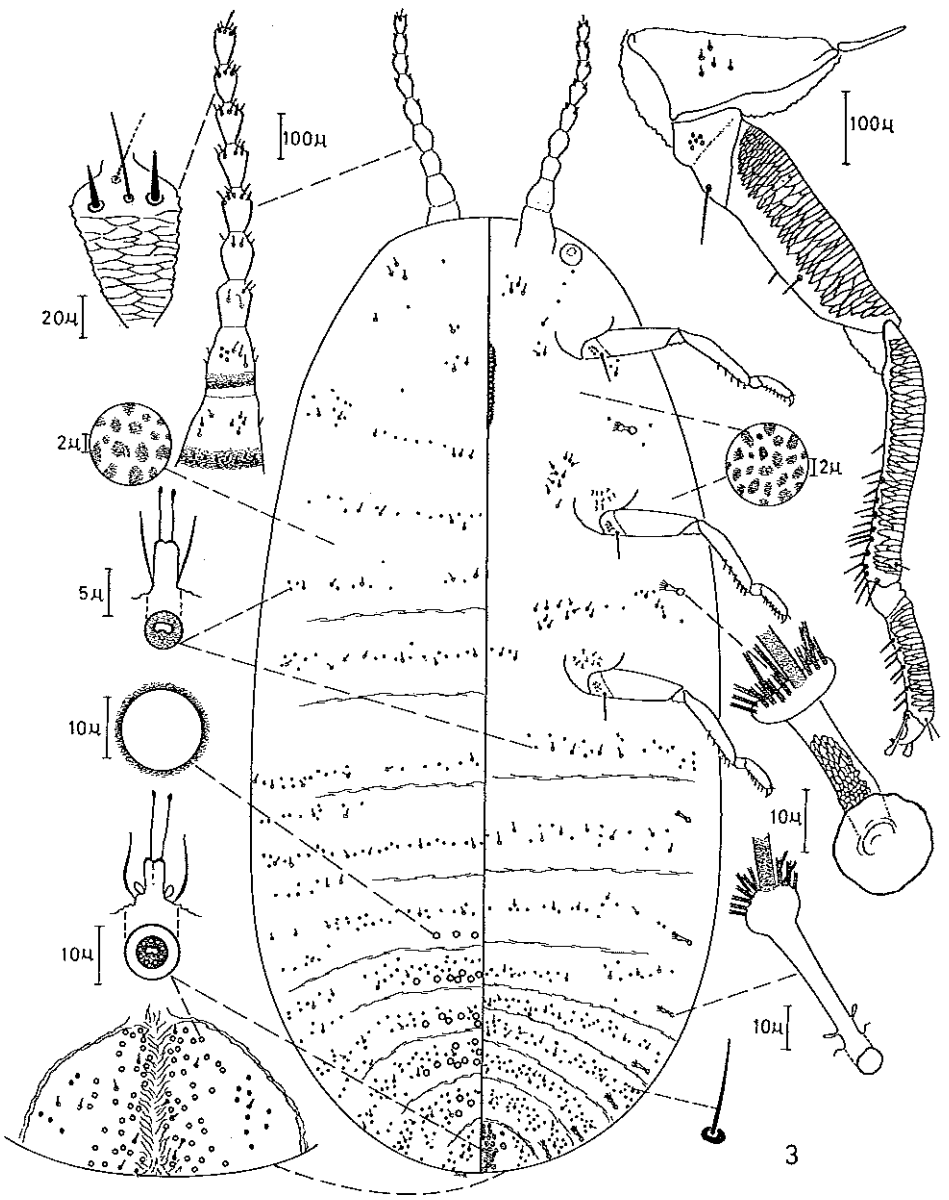


Fig. 3. ***Matsucoccus josephi*** **Bodenheimer and Harpaz. Adult female.**

TABLE 1: RANGES AND MEANS (IN PARENTHESES) OF NUMBER OF CICATRICES, OF NUMBER OF MULTILOCULAR PORES (CLUSTER AROUND VULVA), AND SIZE OF CICATRICES IN *MATSUCOCCUS JOSEPHI* FEMALES, ON *PINUS HALEPENSIS, P. BRUTIA* AND *P. ELDERICA* FROM VARIOUS LOCALITIES IN ISRAEL

Locality and altitude		CICATRICES (No.)		MULTILOCULAR PORES (No.)		CICATRICES (size, μm)	
		Spring (February-March)	Autumn (July-November)	Spring (February-March)	Autumn (July-November)	Spring (February-March)	Autumn (July-November)
Pinus halepensis							
Hazore'a	100 m	66-83 (74)	55-92 (76)	74-102 (88)	55-92 (77)	15.1-27.5 (17.3)	9.6-12.8 (11.5)
Zikhron Ya'akov	150 m Type-series	X	46-70 (57)	x	33-67 (44)	X	9.6-12.8 (10.3)
Zikhron Ya'akov	150 m Topotypic	63-161 (102)	X	64-98 (80)	X	9.6-19.3 (16.2)	X
Segev	170 m	61-120 (99)	54-90 (67)	65-94 (77)	49-84 (63)	9.6-15.1 (14.8)	9.6-15.1 (13.1)
Tarom	300 m	92-122 (102)	52-73 (63)	52-83 (68)	60-78 (69)	9.6-15.1 (12.5)	9.6-12.8 (10.9)
Sha'ar haGai	400 m	65-122 (94)	X	79-107 (95)	X	15.1-19.3 (17.4)	X
Biriya	500 m	65-107 (92)	47-91 (64)	48-60 (55)	45-65 (54)	9.6-15.1 (12.5)	9.6-12.8 (10.3)
Hamasrek	600 m	87-140 (110)	X	62-104 (78)	X	9.6-19.3 (16.4)	X
Tarqumiye	650 m	76-129 (91)	52-67 (53)	70-78 (73)	53-75 (71)	9.6-15.1 (13.9)	9.6-12.8 (10.6)
Jerusalem	700 m	61-117 (88)	X	64-105 (80)	X	12.8-25.7 (19.3)	X
Pinus brutia							
Kedoshim	400 m	85-147 (127)	X	71-163 (110)	X	9.6-25.7 (20.6)	X
Pinus elderica							
Ilanot	50 m	73-151 (117)	X	120-148 (132)	X	9.6-19.3 (15.7)	X

X Not observed

segments 3-8 sclerotized, whereas their distal parts are membranous (Fig. 14); in females just after emergence from second instar, segments 3-8 are contracted into each other along their membranous parts, in the form of a telescope; fully extended antenna 703-852 long; segment 1 (basal) 150-188 long; segment 2 – 102-122 long; length of sclerotized parts of segments 3-8, respectively, 60-77, 60-66, 66-72, 56-61, 55-60, 50-60; segment 9 – 50-60 long. Segment 1 with a basal dark rim, with 8-12 minute setae on dorsal aspect of rim, and 6-12 setae on distal part. Segment 2 with a basal dark rim, with 10-15 setae and 3-4 sensory pores on bright part of segment. Sclerotized parts of segments 3-8 (Fig. 14) with a reticulated pattern made of small polygonal areas; membranous parts of these segments with globular projections (Fig. 14) similar to those on whole surface of body. Segments 5-8, each with two stout, fleshy spines, and 2-4 more slender setae. Segment 9, all sclerotized, and all with pattern of polygonal areas; bears apically two fleshy spines and four slender setae. *Eyes* (Fig. 13), placed ventrally, just posterior to antennae. *Bilocular pores* on ventral surface of head, thorax and abdomen; on thorax and abdomen placed together with simple, pointed setae, in transverse, segmental bands. *Spiracles* two pairs on thorax, and seven abdominal pairs; thoracic spiracles larger than abdominal; all spiracles with a long atrium that expands at its inner end, where it splits into a tuft of tracheae; one of the tracheal tubes wider than the rest; part of atrium-wall of abdominal spiracles with a reticulated pattern, which is absent in abdominal spiracles. *Legs* well-developed; subequal in size and shape. *Coxa* triangular in shape, 240-270 wide at base, about 120 high; with two V-shaped apophyses; each of both surfaces with 4-6 minute setae. *Trochanter* about 120 long; obliquely separated from femur; with a transverse line that separates it into a basal area with 6-8 sensory pores (on each aspect), and a distal one that bears a single seta about 80 long. *Femur* 280-300 long; with a reticulated pattern similar to that of basal parts of antennal segments 3-8; with 10-12 small setae and 2-3 long ones. *Tibia* 280-320 long; with a reticulated pattern; with 15-20 stout spines along inner margin and 8-10 more slender setae distributed on both surfaces. *Tarsus* two-segmented, 180-200 long; basal segment without a reticulated pattern; distal part with reticulation, and with 8-12 stout spines along inner margin. *Claw*, about 40 long; without denticle. *Tarsal digitules* present as two slender, simple setae. *Claw digitules* longer than claw, slightly knobbed apically. *Mouthparts* absent; with a longitudinal fold in derm, placed medially between fore coxae. *Vulva*, a longitudinal opening on ventral surface of posterior segment; surrounded on each side by a cluster of *multilocular pores*; each cluster with a subequal number of pores in a specimen; number of pores varies considerably, as shown in Table 1. *Anal opening* absent.

MALE

The adult male of *M. josephi* emerges following a development which includes first, second (the cyst stage), and third larval instars, as well as a prepupa and a pupa. Since the adult females in *Matsucoccus* species are most suitable for accurate species determination, redescriptions are not given here for all male stages.

No morphological differences were observed between the male and female first instar larvae, or between the male and female second instar larvae.

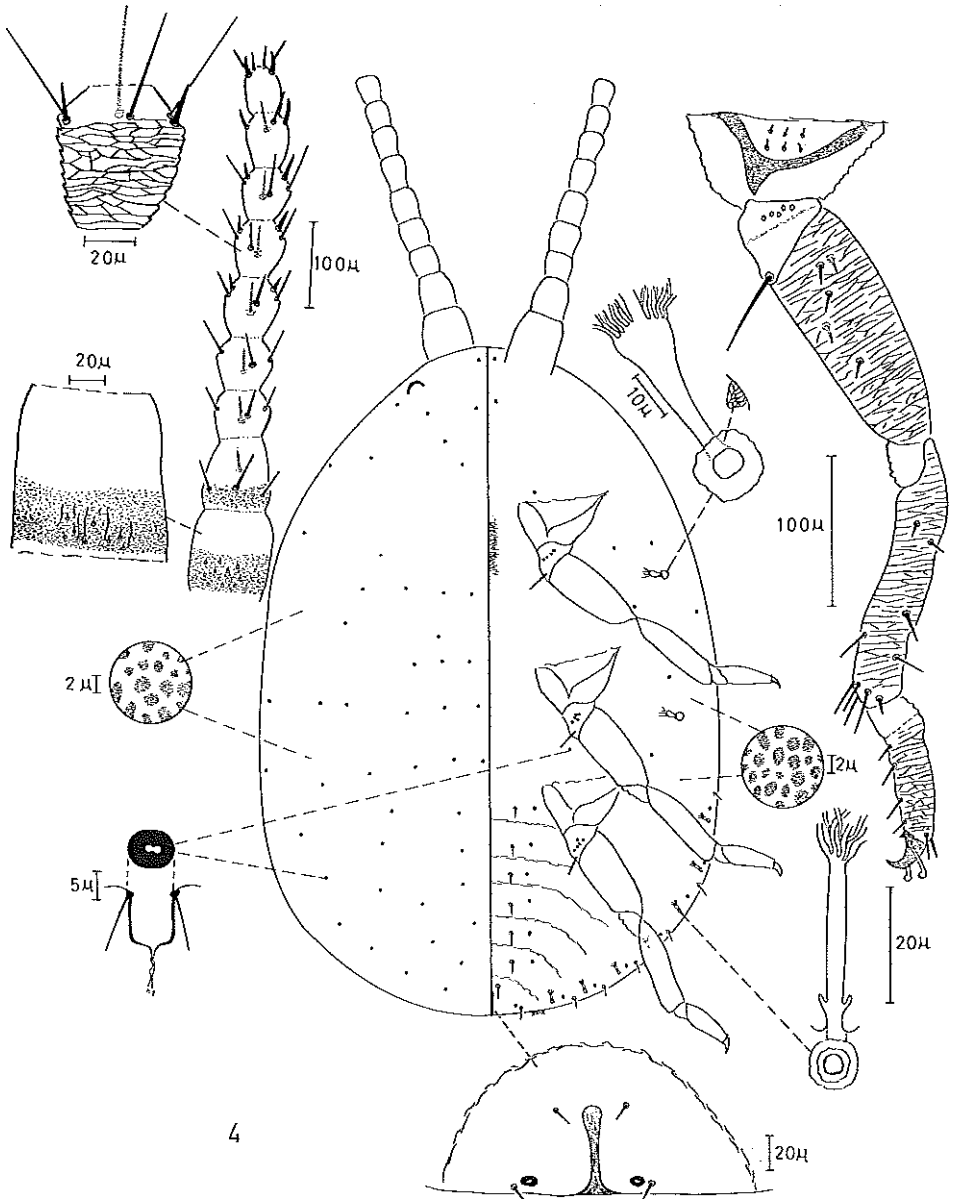


Fig. 4. ***Matsucoccus josephi*** **Bodenheimer and Harpaz. Male third instar larva.**

THIRD INSTAR LARVA (Fig. 4)

Live larvae are brownish-yellow; general outline oval; 1-1.4 mm long, 0.7-0.8 mm wide. Dorsal and ventral derm membranous. Dorsal derm throughout with minute (1-2) circular, globular projections similar to these structures in adult female (see Figs. 10, 11). *Eyes* placed dorsally on submargin, just posterior to antennae. *Bilocular pores* sparsely distributed on dorsal surface; pore have a "bilocular appearance" when observed from above; in lateral view the pore appear as cup-like invagination, with sclerotized walls. Ventral derm throughout with globular projections as on dorsal surface. *Antennae* 9-segmented placed close to each other on cephalic apex; basal segments placed on ventral surface. The basal parts of segments 3-8 are clerotized, whereas their distal parts are membranous, so that in larvae just after moulting the segments are contracted into each other in the form of a telescope; full extended antennae 600-620 long; segment 1 (basal) about 100 long, segment 2-85 long; length of sclerotized parts of segments 3-8, respectively, 40, 50, 50, 50, 50, 50; segment 9, 50 long. Segment 1 basally with a dark rim and about 10 minute setae on dorsal part of rim. Segment 2 basally with a dark rim and 4 setae. Sclerotized parts of segments 3-8 with a reticulated pattern made of small polygonal areas; membranous parts of these segments with globular projections similar to those on derm of body. Whole of segment 9 with reticulated pattern. Segments 3-4 each with 4 slender setae. Segments 5-8 each with 4 slender setae and 2 fleshy spines. Segment 9 with 2 fleshy spines and 4 slender setae at apex of segment. *Legs* well-developed, subequal in size and shape. *Coxa* triangular in shape, about 150 wide at base, 60 high; with two V-shaped apophyses; each of both aspects with 5-10 minute setae. *Trochanter* (about 80 long) obliquely separated from femur; with a transverse line that separates it into two areas-basal with 4-5 sensory pores (on each aspect), and distal that bears one seta 65 long. *Femur* (about 200 long) with a reticulated pattern similar to that of basal parts of antennal segments 3-8. *Tibia* (170-190 long) with reticulated pattern; with 4-5 stout spines near articulation joint to tarsus. *Tarsus* two-segmented; basal segment about 25 long without reticulated pattern; distal segment about 80 long with reticulated pattern. *Claw* about 50 long, without denticle; with a small pointed projection at base. *Tarsal digitules* present as two slender, simple setae. *Claw digitules* stout, longer than claw, with knobbed apices. *Mouthparts* absent; with a longitudinal fold in derm placed medially between fore coxae. Two pairs of thoracic *spiracles* and 7 abdominal pairs; thoracic spiracles larger than abdominal; from opening of thoracic spiracle extends a long atrium (about 30 long) that widens in its inner end and split into a tuft of fine tubules; from opening of abdominal spiracle extends a long atrium (about 35 long) which slightly expands at its inner end, where it split into a tuft of fine tubules. *Bilocular pores* same structure and size as pores on dorsal surface, distributed on head, thorax and abdomen; on median area of each of 7 abdominal segments, a pore (for half body) is placed lateral to a seta. Posterior segment of abdomen with a medio-ventral groove placed longitudinally and surrounded by 4 setae and two bilocular pores; at anterior end of groove appears to occur a very fine tubular structure, the details of which could not be confirmed.

MATERIAL EXAMINED. Lectotype ♀ (designated here) and 8 paralectotypes ♀♀, ISRAEL, Zikhron Ya'aqov, 6.VII.1949, *Pinus halepensis*; all deposited in Bodenheimer's

Collection of Coccoidea (BCR), Department of Entomology, Faculty of Agriculture, Rehovot. In addition to the type-series, numerous samples were studied (see Table 1), taken on *Pinus halepensis, P. elderica* and *P. brutia* at various localities in Israel; all deposited in Coccoidea Collection (ICV), Division of Entomology, Agricultural Research Organization, Bet Dagan.

TAXONOMIC NOTES. Distinction between species in the genus *Matsucoccus* in based entirely on morphological characters of the adult female. The females of *M. josephi* resemble the females of the European species – *M. feytaudi* Ducasse, *M. insignis* Borchsenius, *M. matsumurae* (Kuwana), *M. mugo* Siewniak and *M. pini* Green – all of which have a 9-segmented antenna. By the presence of two fleshy spines on each of antennal segments 5-9, *M. josephi* differs from *insignis, matsumurae, mugo* and *pini*, which are characterized by two fleshy spines only on antennal segments 6-9. *M. josephi* is morphologically close to *M. feytaudi* (the females of both species have two fleshy spines on antennal segments 5-9), but may be distinguished by the following combination of characters*:
1) Dorsal cicatrices in *feytaudi* are disposed in 4 segmental bands, as compared to 5 or 6 bands in *josephi*. 2) The range and mean of numbers of cicatrices in *M. feytaudi* are 168-281 (205), as compared with 61-161 (97) in the spring generation and 46-92 (67) in the autumn generation of *M. josephi*. 3) The antenna of the *M. feytaudi* female (850-1010 μm) is longer than that of *M. josephi* (703-852 μm).

The numbers of dorsal cicatrices and of multilocular pores in females of *Matsucoccus* species have been used as distinguishing characters at the specific level (See Morrison, 1939; Boratynski, 1952). However, Rieux (1976) showed in his study of *M. pini* that the frequency (range and means) of these characters is highly variable, presenting an altitude-dependent pattern. Rieux's observations point to the need to re-evaluate the reliability of these characters for taxonomic purposes.

The present observations (Table 1) show that the variation range of the numbers of dorsal cicatrices and of multilocular pores in *M. josephi* is much wider than that given in the original description, and that observed in the type-series. Considering all the samples studied, the number of cicatrices varies between 46 to 161, and the variation range of multilocular pores is 33-163. In addition the results of our counts show that usually the maximum numbers and the means of cicatrices and of multilocular pores per female of the spring generation (February-March) are considerably higher than the same parameters for the autumn generation. On the other hand, the present observations (Table 1) do not point to altitude-dependance of the above characters in populations of *M. josephi* in Israel.

The size of dorsal cicatrices was employed, in combination with other characters, for specific identification in *Matsucoccus* (see Morrison, 1939; Boratynski, 1952). However, observations made on the above character in *M. josephi* females (see Table 1) indicated that it varies considerably. The interspecific variation in the size of cicatrices was studied by measuring the diameter of all cicatrices on the posterior band in each

*The above characters of *M. feytaudi* were observed and counted in specimens from France, Villeneuve Loubet, February 1976, on *Pinus maritima*, coll. D. Schvester.

specimen from all samples. Measurements were taken from specimens mounted in Canada Balsam. The results show (Table 1) that the minimum diameter of a cicatrice is 9.6 μm, but the maximum size may be about 3 times as big, up to 27.5 μm. The average diameter of a cicatrice, calculated from all samples as a total, is 14.4 μm. The results indicate that the cicatrices are bigger (average diameter 16.2 μm) in females of the spring generation than of the autumn generation (average diameter 11.1 μm).

The above redescription of the first instar larva of *M. josephi*, shows the occurrence of, apparently, an anal opening in this instar, a structure which previously was not observed in *M. josephi* (Bodenheimer and Harpaz, 1955), nor in other species (Boratynski, 1952; Rieux, 1976). McKenzie (1943) appears to have drawn a similar structure for the first instar larva of *M. vexillorum* Morrison, but did not refer to this structure in the text.

WAX SECRETION IN *M. JOSEPHI*

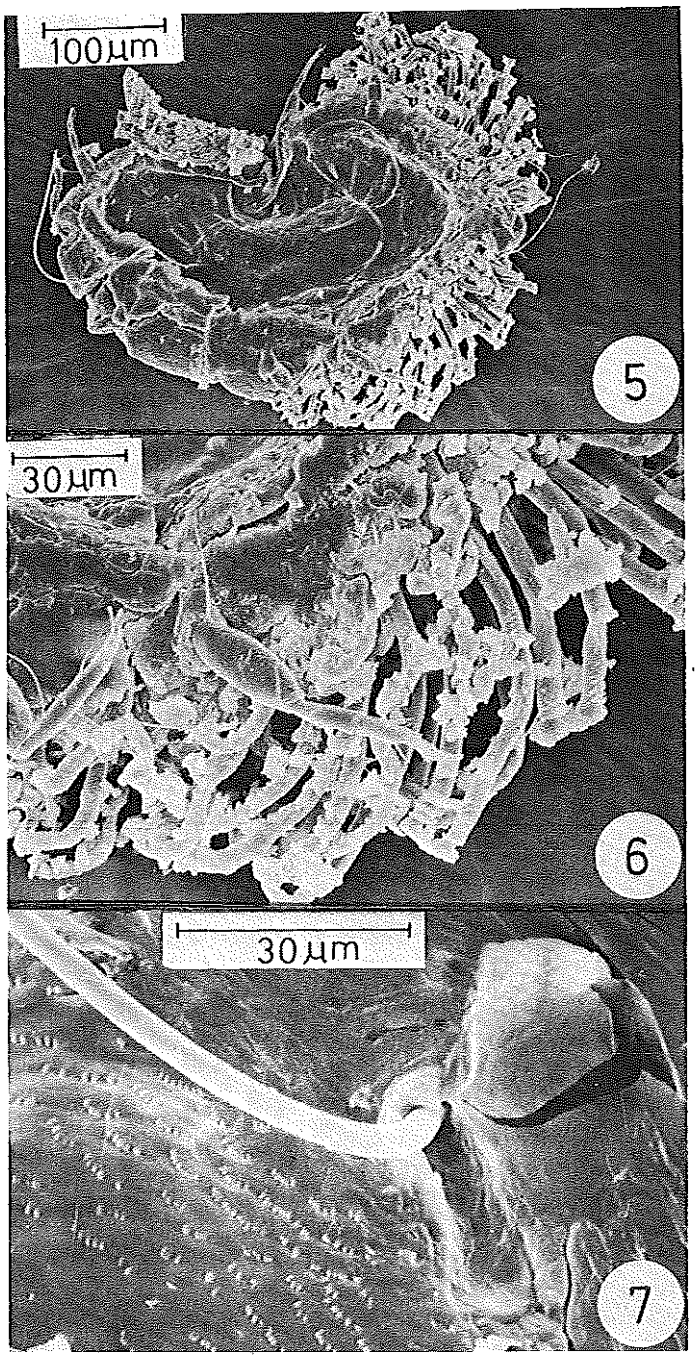
The structure of various wax filaments which are secreted by developmental stages and adults of *M. josephi* was observed by means of a scanning electron microscope. These observations are shown in Figs. 5, 6, 11, 12, 16.

The first instar larva, after settling and during its growth period, secretes white wax filaments (Figs. 5, 6) – each 50-70 μm long and 5-7 μm wide – which surround the margin of the posterior part of the body. The width of these filaments subequals the diameter of the orifices of the abdominal spiracles. Since no secretory orifices are present in the abdomen, it is assumed that these filaments are secreted through the openings of the abdominal spiracles.

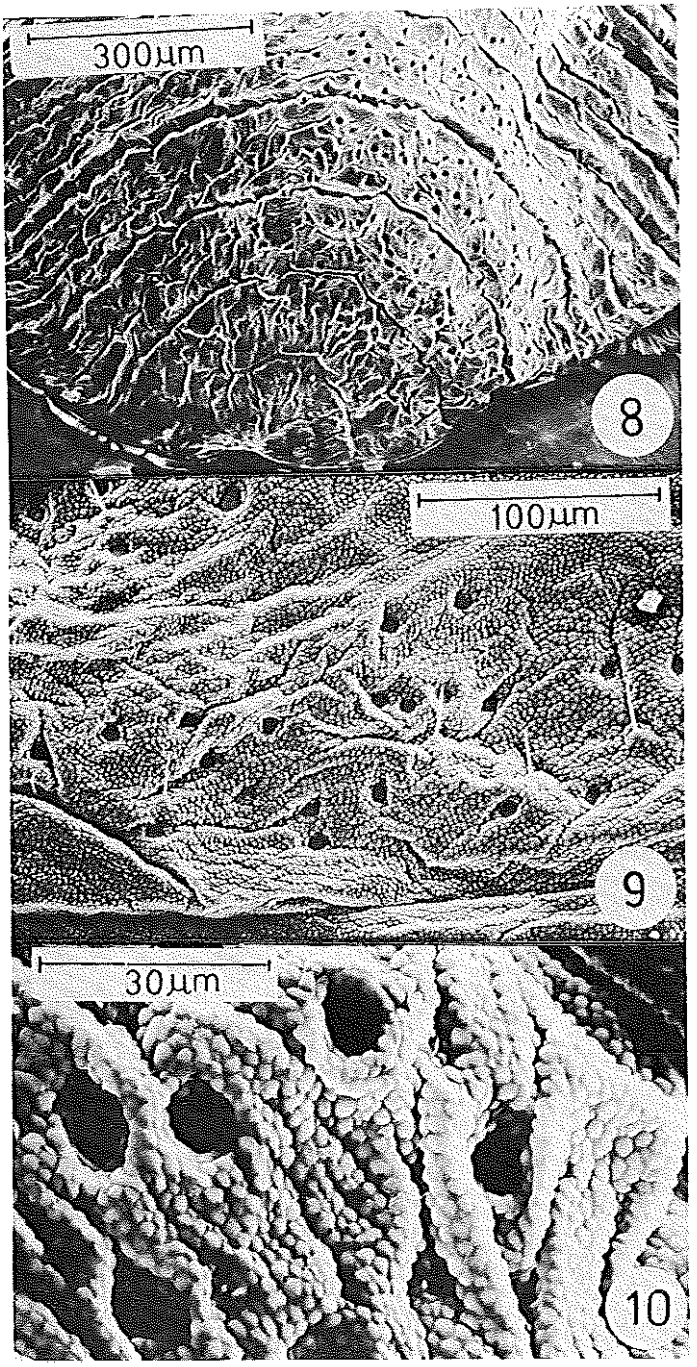
The adult female secretes two kinds of wax filaments: the *bilocular pores* discharge very long filaments (Fig. 11) that subsequently form the ovisac, and the *multilocular pores*, which surround the vulva, secret rounded filaments (Fig. 12) that cover the eggs uniformly. It was shown recently (Gerson, 1980) that the occurrence of these filaments on coccoid eggs is a common characteristic in the major families of the Coccoidea.

The male third-instar larva secretes long, thin filaments that envelop completely the body in the form of a cocoon. The prepupal and pupal stage develop within this cocoon. The filaments are discharged from bilocular pores that are similar in structure to those in the adult female (See Figs. 3, 4) and are distributed on dorsal and ventral derms.

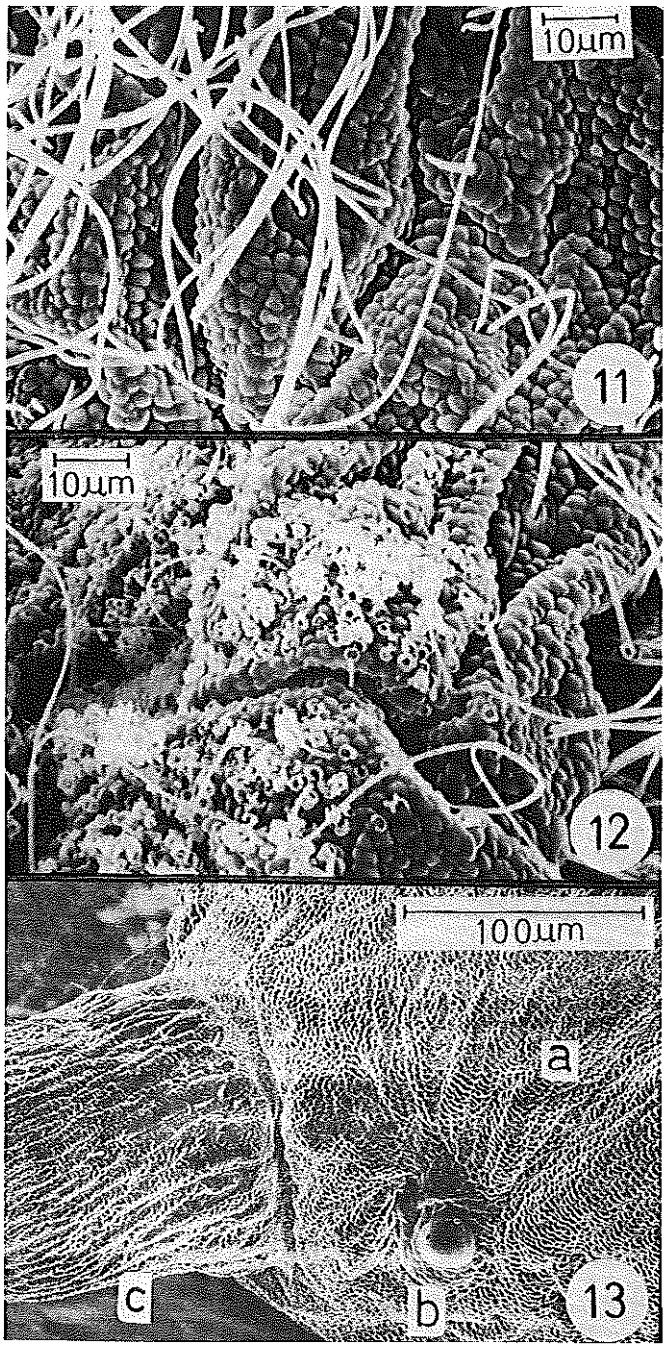
Adult male of *M. josephi* produces thin and long filaments (Fig. 6) which are secreted from a cluster of tubular ducts on dorsum of eighth abdominal segment. The filaments (12-20 in number) are 2.0-2.2 mm long. Production of similar filaments was reported in two other species of *Matsucoccus: M. bisetosus* Morrison (Beardsley, 1968) and *M. pini* Green (Rieux, 1976).



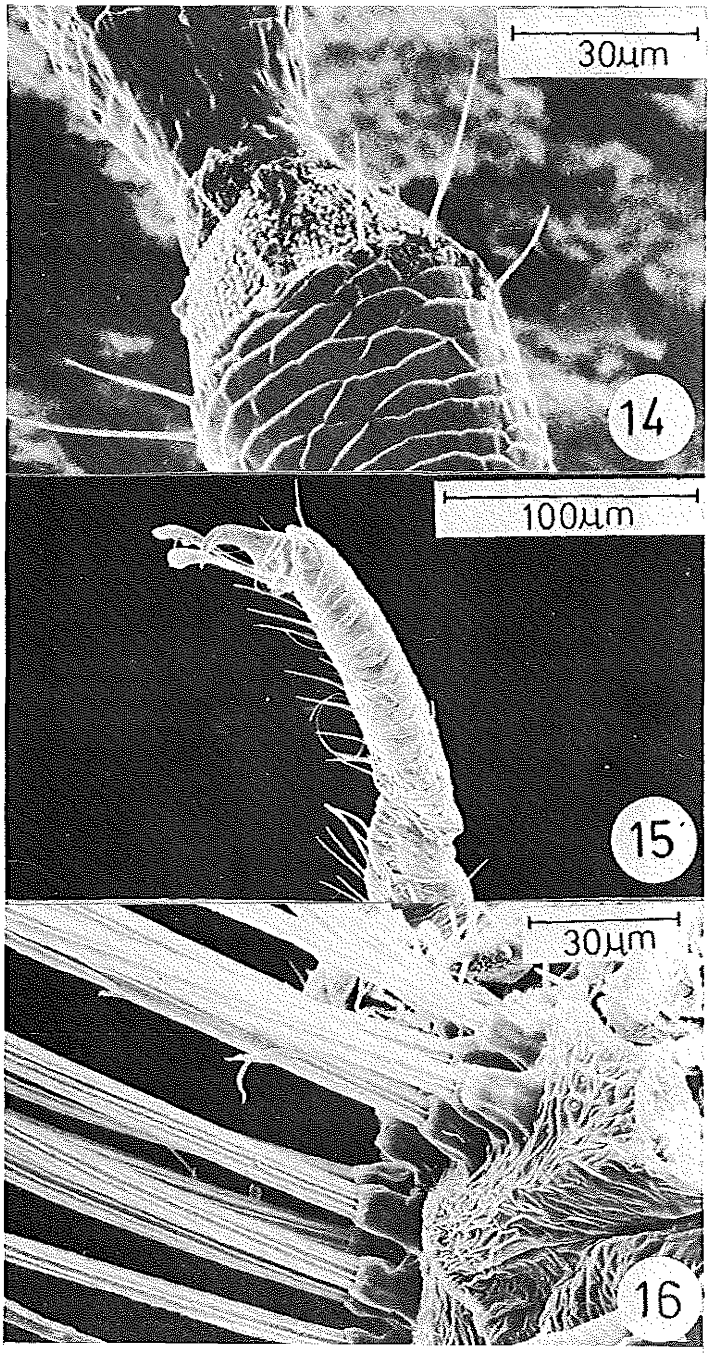
Figs. 5-7. Micrographs of *Matsucoccus josephi* Bodenheimer and Harpaz. 5. First instar larva (settled), ventral aspect. 6. First instar larva (settled), wax filaments. 7. Second instar larva, mouthparts and surrounding area.



Figs. 8-10. Micrographs of adult female, *Matsucoccus josephi* Bodenheimer and Harpaz. 8. Distribution of dorsal cicatrices. 9, 10. Details of dorsal cicatrices.



Figs. 11-13. Micrographs of adult female, *Matsucoccus josephi* Bodenheimer and Harpaz. 11. Wax filaments secreted from bilocular pores. 12. Wax filaments secreted from bilocular pores, and rounded wax filaments secreted from multilocular pores. 13. a – external appearance of body derm. b – eye. c – basal segment of antenna.



Figs. 14-16. Micrographs of *Matsucoccus josephi* Bodenheimer and Harpaz. 14. Adult female, fourth and fifth antennal segments. 15. Adult female, tarsus and claw. 16. Adult male, wax filaments secreted from tubular ducts on dorsum of eighth abdominal segment.

ACKNOWLEDGEMENTS

My thanks and appreciation are expressed to Messrs. Y. Golan, Y. Shinar and Z. Madar, Forestry Department, Keren Kayemet LeYisrael, Eshtaol, for their kind and willing cooperation in the course of this study; to Prof. I. Harpaz, Faculty of Agriculture, Rehovot, for making available to us the type-series of *M. josephi*; to Ms. Lelia Arkan and Ms. Rivka Lev, SEM unit, Agricultural Research Organization, Bet Dagan, for preparation of the SEM micrographs; and to Mr. D. Schvester, Station de Recherches Forestière d'Avignon, France, for supplying the material of *M. feytaudi*.

REFERENCES

Anonymous, 1975. [Report of the research team on the decline of the Aleppo pine in Sha'ar haGai Forest.] Division of Scientific Publications, Agricultural Research Organization, The Volcani Center, Bet Dagan, Mimeograph, 62 pp., July 1975 (in Hebrew).

Beardsley, J.W. 1968. External morphology of the adult male of *Matsucoccus bisetosus*. *Annals of the Entomological Society of America* 61:1449-1459.

Bodenheimer, F.S. and I. Harpaz. 1955. II. Description of the various stages of *Matsucoccus josephi* n. sp. pp. 12-22, *in:* Bodenheimer, F.S. and S. Neumark. 1955. The Israel pine *Matsucoccus* (*Matsucoccus josephi* nov. spec.). Kiryat Sepher Ltd., Jerusalem 122 pp. + 4 pl. + XIX.

Bodenheimer, F.S. and S. Neumark. 1955. The Israel pine *Matsucoccus* (*Matsucoccus josephi* nov. spec.). Kiryat Sepher Ltd., Jerusalem, 122 pp. + 4 pl. + XIX.

Boratynski, K.L. 1952. *Matsucoccus pini* (Green, 1925), (Homoptera; Coccoidea: Margarodidae): Bionomics and external anatomy with reference to the variability of some taxonomic characters. *The Transactions of the Royal Entomological Society of London* 103:285-326.

Carle, P. 1974. Le dépérissement du Pin Mésogéen en Provence. Rôle des insectes dans les modifications d'équilibre biologique des forêts envahies par *Matsucoccus feytaudi* Duc. (Coccoidea: Margarodidae). *Annales des Sciences Forestières* 31:1-26.

Gerson, U. 1980. Wax filaments on coccoid eggs. *Israel Journal of Entomology* 14:81-85.

Halperin, J. 1975. [Injury caused by *Matsucoccus josephi* to Aleppo pine over 10 years old, and the decline of the Sha'ar haGai forest.] Division of Scientific Publications, Agricultural Research Organization, The Volcani Center, Bet Dagan, Special Publication No. 50, 20 + I pp. (Hebrew, with English summary).

Halperin, J. 1976. [Forest pests. pp. 623-640. *in:* The Encyclopedia of Agriculture, Vol. 3, 893 pp.] Published by The Encyclopedia of Agriculture, Tel Aviv. (In Hebrew).

McKenzie, H.L. 1943. Notes on *Matsucoccus vexillorum* Morrison (Homoptera: Coccoidea: Margarodidae). *Microentomology* 8:53-57.

Morrison, H. 1939. Descriptions of new species of *Matsucoccus* (Hemiptera: Coccidae). *Proceedings of the Entomological Society of Washington* 41:1-20.

Rieux, R. 1976. *Matsucoccus pini* (Green, 1925) (Homoptera: Margarodidae) dans le sud-est de la France. Variations intraspécifiques. Comparaisons avec des espèces les plus proches. *Annales de Zoologie – Ecologie animale* 8:231-263.