

Biogeography of *Matsucoccus josephi* Bodenheimer et Harpaz in Crete and mainland Greece *

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Summary — Surveys have been conducted in natural and planted stands of brutia pine (*Pinus brutia* Ten subsp *brutia*) and Aleppo pine (*P halepensis* Mill) to ascertain the possible occurrence of Israeli pine bast scale *Matsucoccus josephi* Bodenheimer et Harpaz (Homoptera: Matsucoccidae) and its typical associates in mainland Greece and on the islands of Thasos and Crete. Our findings show that in mainland Greece between 21–24 longitude E, *M josephi* is absent from both brutia pine and Aleppo pine. The absence of *M josephi* from brutia pine in Chalkidiki and the island of Thasos raises the possibility that the tree has been introduced by man without the scale insect; the introduction by seed from Asia Minor could have been made for the production of honeydew by *Marchalina hellenica* Gennadius (Homoptera: Margarodidae) whose excretions are the main source of honey in those areas. The occurrence of *M josephi* in Turkey and Crete and its absence from Aleppo pine in mainland Greece tend to confirm that brutia pine is the principal host of the scale. Brutia pine and *M josephi* could have migrated together via the remnants of the land bridge connecting southeast Anatolia to Crete some 4–5 million years ago.

***Matsucoccus josephi* / *Pinus brutia* / *Pinus halepensis* / Greece / Crete**

Résumé — La biogéographie de *Matsucoccus josephi* Bodenheimer et Harpaz en Crète et Grèce continentale. Des visites ont été conduites en Grèce continentale et dans les îles de Thasos et Crète, dans des peuplements autochtones et artificiels de pin brutia (*Pinus brutia* Ten subsp brutia) et pin d'Alep (*P halepensis* Mill) pour vérifier la présence éventuelle du *M josephi* Bodenheimer et Harpaz (Homoptera: Matsucoccidae) et de ses espèces associées typiques. Il en résulte qu'en Grèce continentale, entre les méridiens de 21°–24° E, *M josephi* n'est présent ni sur le pin brutia ni sur le pin d'Alep. L'absence de *Matsucoccus* sur le pin brutia en Chalcidique et à Thasos suggère la possibilité de l'introduction du pin par l'homme. Cette introduction, au moyen de graines provenant d'Asie Mineure, pourrait avoir eu pour but la production de miellat par *Marchalina hellenica* Gennadius (Homoptera: Margarodidae), la principale source de miel dans ces régions. La présence de *M josephi* en Turquie et Crète sur le pin brutia et son absence en Grèce continentale sur le pin d'Alep

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tendent à confirmer la conclusion formulée antérieurement selon laquelle le pin brutia est le principal hôte du Matsucoccus. La migration simultanée du pin brutia et de *M josephi* a pu avoir lieu il y a 4-5 millions d'années, lorsque la Crète était reliée au SE de l'Anatolie.

Matsucoccus josephi / Pinus brutia / Pinus halepensis / Grèce / Crète

INTRODUCTION

The Israeli pine bast scale *Matsucoccus josephi* Bodenheimer et Harpaz (Homoptera: Matsucoccidae) is the most noxious insect in native Aleppo pine, *Pinus halepensis* Mill and introduced *Pinus brutia* Ten ssp *eldarica* (Medw) Nahal in Israel (Mendel *et al*, 1988). The scale settles on all above-ground parts of the tree. During feeding it secretes a poisonous saliva that disrupts water transport and results in the death of new growth or the entire tree (Mendel and Liphschitz, 1988). The scale was first discovered in Israel in 1933 on Mt Carmel ; a few years later, mass mortality of Aleppo pine seedlings in newly-reforested areas near Mt Carmel was noted (Bodenheimer and Neumark, 1955). Since the 1980s, the scale has infested all major pine plantations in Israel, causing severe damage to Aleppo pine and Eldar pine, \approx 30% of the stands of the former being severely injured (Mendel *et al*, 1988). The pest was believed to be endemic on natural Aleppo pine. Scale population outbreaks resulting in widespread mortality have been found to be related to large-scale planting of Aleppo pine over a relatively short time period, unsuitable seed collection practices and use of susceptible seed sources (Mendel, 1984). *M josephi* also occurs naturally in Turkey and Cyprus on brutia pine, *Pinus brutia* Ten spp *brutia*, its principal host (Mendel, 1992). In both these countries as well as in Israel the insect is usually present at low densities on brutia pine and damage is practically nil.

Aleppo pine and brutia pine are usually taken as allopatric and their natural range consists of spatially isolated populations (Panetsos, 1981 ; Nahal, 1983), with isozyme analysis providing evidence of intraspecific variation (Schiller *et al*, 1986 ; Conkle *et al*, 1988). Isolated occurrences of one species within the range of the other have been attributed to human intervention (Panetsos, 1981 ; Schiller *et al*, 1986). Aleppo pine is planted in Cyprus, whereas in Turkey supposedly natural stands of Aleppo pine forming small enclaves within brutia pine forests (Kayacik, 1973) are most probably the result of introduction by man (Schiller *et al*, 1986 ; Schiller and Mendel, 1992). Infestation of Aleppo pine by the scale in Cyprus and Turkey are the result of its spread from nearby brutia pine stands. Brutia pine is highly resistant to infestation by *M josephi* (Mendel and Liphschitz, 1988) ; among provenances of Aleppo pine, the Greek seed sources are the least susceptible (Mendel, 1984). From the presence of *M josephi* in Israel, Turkey and Cyprus it could have been expected that the scale would also occur west of longitude 25°E, the main area of distribution of *P halepensis*. Yet there are no reports of its occurrence in Spain, France and Italy by entomologists thoroughly familiar with the genus and engaged in research on *Matsucoccus feytaudi* Ducasse, a major pest of *Pinus pinaster* Ait, nor has the scale been observed in Morocco (F Asael, personal communication).

The presence of *M josephi* in Israel is possibly the outcome of southward migration of brutia pine reaching the distribution

area of Aleppo pine in the environs of Beirut (Mouterde, 1947), and/or the import of brutia pine timber or planting stock from Cyprus (eg Mendel, 1990). Thus, it was reasonable to expect the scale to also occur in eastern Greece where Aleppo pine comes into contact with brutia pine and interspecific hybrids occur (Papaioannou, 1936). The distance between Aleppo pine on Mt Athos, Chalkidiki, and brutia pine on the island of Thasos is ≈ 50 km as the crow flies, and would provide no insurmountable obstacle to the dispersal of the scale.

As part of the study on the biogeography of *M josephi*, surveys were conducted in 1992 in natural and planted stands of brutia pine and Aleppo pine in Greece to ascertain the possible occurrence of the scale in mainland Greece and on the islands of Thasos and Crete.

MATERIALS AND METHODS

Study procedure

Sixteen stands of brutia pine and Aleppo pine were investigated in March–April 1992. Stands of brutia pine were examined in the following areas (the letters refer to the location of the sites in figure 1): Chalkidiki, natural (or supposedly natural) brutia pine near Annea and Mademlako (a); the west part of Crete near Prasas (b) and Anapolis (c); Thasos, 3 sites (d); and planted trees in Piraeus (e). Aleppo pine was examined in the following localities: Chalkidiki, near Annea and Stratonía (f); the Peloponnese, near Olympia (g), Kalogria (h); and a plantation near Corinth (i).

At each site 10–50 trees of different ages, if possible 8–15-yr-old, were examined. In Mademlako only 5 mature trees including the upper parts of the stems and ≈ 30 seedlings from natural regeneration were inspected. Light infestation with live scales can be expected to occur on stem parts during the initial stages of bark peeling; however, dead larvae and exuviae of *M jo-*

sephi, if present, can easily be found under older flakes. Dead larvae and exuviae remain on the stem for many years; therefore a simple visit may permit definite conclusions to be made on the presence or absence of the insect. The bark flakes of the sampled parts were removed, and live and dead adult females were collected with a fine brush. Natural enemies and associated insects were removed from the bark surface with an aspirator. Identification of *M josephi* was made by comparison of microscopic slides of adult females from Crete with those of Israeli females.

RESULTS AND DISCUSSION

Our findings show that in mainland Greece between 21–24° longitude E, *M josephi* is absent from both brutia pine and Aleppo pine; (the occurrence on brutia pine of *M josephi* in eastern Greece, which was not visited, needs further investigation). The insect was recorded only from the island of

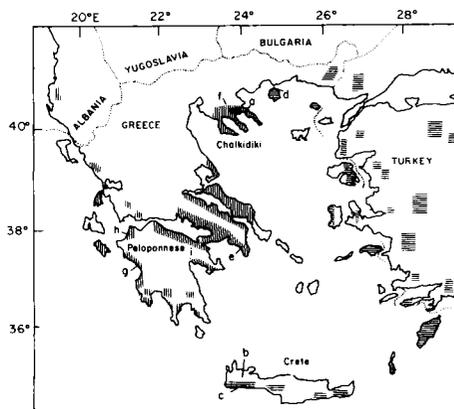


Fig 1. Locations sampled for occurrence of *Matsucoccus josephi* in Greece. a: Annea and Mademlako; b: Prasas; c: Anapolis; d: Thasos; e: Piraeus; f: Stratonía; g: Olympia; h: Kalogria; i: Corinth. Approximate natural distribution of *Pinus halepensis* (vertical bars) and *P brutia* ssp *brutia* (horizontal bars) modified after Critchfield and Little (1966) and Panetsos (1975). In Greece, *M josephi* was found only in Crete.

Crete at very low densities, *ie* a single dead larva or empty exuvia per 1 000–2 000 cm² bark area suitable for infestation. Live larvae or adults were found on only a few trees. Among the natural enemies of *Matsucoccus*, *Elatophilus* sp (Hemiptera: Anthocoridae) (6 larvae and 1 adult) was collected only at Anapolis (Crete) from a single tree. Still unidentified pseudoscorpions (Pseudoscorpionidae) were found in all brutia pine stands (except for the planted trees at Piraeus) but not from any of the Aleppo pine investigated. At Prasas (Crete) *M josephi* was associated with *Marchalina hellenica* Gennadius (Homoptera: Margarodidae). The density of *M josephi* in Crete is similar to that on brutia pine in southern Turkey, but is markedly lower than that in Cyprus (Mendel, 1992). The presence of the specialized predator, *Elatophilus* sp, in Crete provides additional evidence of the native occurrence of the scale on the island (*eg* Mendel *et al*, 1991).

The ≈ 30 species of Matsucoccidae are obligatory parasites of pine; each species develops on 1 or a few host species of a given subsection or section of the genus *Pinus* (Rieux, 1975; Ray, 1982; Liphshitz and Mendel, 1989). Bast scales are rare in their native habitats or occur at very low densities and are not considered serious pests. However, severe outbreaks resulting in most cases in the destruction of large forest areas are the outcome of the introduction of *Matsucoccus* spp into environments stocked with susceptible genotypes of the host tree or with related susceptible pines (Bean and Godwin, 1955; Li *et al*, 1980; Schvester and Ughetto, 1986; Binazzi and Covassi, 1987). *M josephi* develops only on taxa of the subsection Halepenses, *viz* *P halepensis* and subspecies of *P brutia* (Liphshitz and Mendel, 1989). *P brutia* subsp *brutia* from its entire natural range, including seed sources from Crete and Greece, is highly

resistant to infestation by the scale, whereas Aleppo pine is susceptible (Mendel, 1984). Resistance to *M josephi* is most probably acquired through long coevolution between brutia pine and the scale. Hence, Eldar pine, *Pinus brutia* subsp *eldarica*, is highly susceptible to the scale because of its absence in the natural range of the tree (Mendel, in preparation). The heavy losses of Aleppo pine in Israel due to outbreaks of *M josephi* may be due to the fact that the insect was introduced from abroad (Mendel *et al*, submitted for publication).

Brutia pine is taken to be native to Crete and is widely distributed from high elevations to almost sea level (Zohary and Orshan, 1965); thus, its range bears some resemblance to that in Turkey. Panetsos (1981), discussing the distinctive features of provenances of brutia pine, suggests that the trees from Crete differ clearly from the rest of the subspecies. Hence, brutia pine from Crete was probably isolated from its main range in Anatolia earlier than the population of Thrace (northeastern Greece). We suggest that brutia pine and *M josephi* could have migrated together *via* the land bridge from southeast Anatolia to Crete some 4–5 million years ago (the island was disconnected from the mainland only between the late Miocene and the Pliocene) (Steininger and Rogl, 1984). The maximum rise in eustatic level by 150 m of the Ionian Sea during the Quaternary (Fabricius, 1984) did not eliminate brutia pine and its fauna from the more elevated areas in Crete. However, the possibility cannot be dismissed that brutia pine became extinct due to human activity in the past 5000 yr and that it was later reintroduced to the island. If indeed this is the case, the introduction must have been made by planting saplings, since *Matsucoccus* spp cannot be transferred by seed.

If the occurrence of brutia pine in Chalkidiki and Thasos is the result of the west-

ward migration from Asia Minor, one would expect scale to occur there as well. The absence of *M josephi* on brutia pine in Greece raises the question whether the occurrence of the tree there is the outcome of artificial introduction. Both Aleppo pine and brutia pine are used for resin tapping and bee grazing in Western Turkey and Greece. The former produces twice as much resin as the latter (Panetsos, 1975 ; Papagiannopoulos, 1983). Papaioannou (1954) recommended the removal of brutia pine in areas of contact between the species in order to preserve the high resin yield of Aleppo pine, as he considered that hybridization could lower yields. On the other hand, brutia pine due to its longer period of intensive growth than that of Aleppo pine may be a better host than the latter for *Marchalina hellenica* whose honeydew is the main source of honey in Chalkidiki, Thasos, Crete and Western Turkey (Crane and Walker, 1985). Artificial infestation of pines with *M hellenica* is a long-established tradition (ND Avtzis, personal communication). Thus, introduction of brutia pine from Asia Minor to Chalkidiki and Thasos could have been aimed at high honeydew production by *M hellenica*. The pine must have been raised from imported seed, since transfer of wildlings or nursery stock which are suitable hosts of *M josephi* would have resulted in the introduction of the scale into areas where it was previously absent. For example, brutia pine is known to have been planted on Princes' Islands in the Sea of Marmara (Schimitschek, 1944 ; Mendel, 1992), and the presence of both *M hellenica* and *M josephi* doubtlessly accounts for the use of saplings.

In conclusion, the presence of *M josephi* on *P brutia* subsp *brutia* is believed to be evidence of the autochthonous character of the pine in Crete. The absence of scale on brutia pine in northeastern mainland Greece and the offshore island of Thasos indicates an artificial introduction of the tree.

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REFERENCES

- Bean JL, Godwin PA (1955) Description and bionomics of a new pine scale, *Matsucoccus resinosa*. *For Sci* 1, 164-176
- Binazzi A, Covassi M (1987) Il *Matsucoccus feytaudi* Ducasse nelle pinete Ligurii di ponente. *In: Accademia Nazionale Italiana di Entomologia. Convegno da Legno Avversita del Bosco e Delle Specie Arboree da Legno*. Florence, 15-16 October 1987, 197-222
- Bodenheimer FS, Neumark S (1955) *The Israeli Pine (Matsucoccus)*. Kiryat Sepher, Jerusalem
- Conkle MT, Schiller G, Grunwald C (1988) Electrophoretic analysis of diversity and phylogeny of *Pinus brutia* and closely related taxa. *System Bot* 13, 411-424
- Crane E, Walker P (1985) Important honeydew sources and their honeys. *Bee World* 66, 105-112
- Critchfield WB, Little EL (1966) *Geographic Distribution of the Pines of the World*. USDA For Serv Misc Publ 991
- Fabricius FH (1984) Neogene to Quaternary geodynamics of the area of the Ionian Sea and surrounding land masses. *In: The Geological Evolution of the Eastern Mediterranean* (Dixon JE, Robertson AHF, eds) Blackwell, London, 819-824
- Kasapligil B (1978) Past and present pines of Turkey. *Phytologia* 40, 99-199
- Kayacik H (1973) Pines in Turkey and an investigation about their geographical distribution,

- III Aleppo pine (*P halepensis* Mill). *Orman Fakultesi Dergisi Ser A* 23, 147-160 (in Turkish, with English summary)
- Li G, Zhuang L, Han R, Liu X, Xia R (1980) A study of the pine stem coccid *Matsucoccus matsumurae* Kuwana. *Rep Inst Lianing Prov* 9, 1-27 (in Chinese, with English summary)
- Lipshchitz N, Mendel Z (1989) Interactions between hosts and non-hosts of *Pinus* spp and *Matsucoccus josephi*: anatomical responses of the stem to infestation. *New Phytol* 113, 135-142
- Mendel Z (1984) Provenance as a factor in susceptibility of *Pinus halepensis* to *Matsucoccus josephi* (Homoptera:Margarodidae). *For Ecol Manage* 9, 259-266
- Mendel Z (1990) Origin of the pine processionary caterpillar *Thaumetopoea wilkinsoni* Tams (Lep Thaumetopoeidae) in Israel. *J Appl Entomol* 109, 311-314
- Mendel Z (1992) The occurrence of *Matsucoccus josephi* in Cyprus and Turkey and its relation to decline of Aleppo pine. *Entomol Gen* 17, 299-306
- Mendel Z, Carmi E, Podoler H (1991) Relations between the genera *Matsucoccus* (Homoptera: Margarodidae) and *Elatophilus* (Hemiptera: Anthocoridae) and their significance. *Ann Entomol Soc Am* 84, 502-507
- Mendel Z, Lipshchitz N (1988) Unseasonal latewood and encrusted pits are the cause of dying in *Pinus halepensis* and *Pinus eldarica* infested with *Matsucoccus josephi*. *Jour Exp Bot* 39, 951-959
- Mendel Z, Saphir N, Madar Z, Golan Y, Speter E, Zehavi A (1988) The effect of habitat and age of Aleppo pine plantations on the damage caused by *Matsucoccus josephi*. *Hassadeh* 68, 2203-2207 (in Hebrew)
- Mouterde P (1947) *La Végétation Arborescente des Pays du Levant*. Publ École Française d'Ingénieurs, Beirut, No 13
- Nahal I (1983) Le pin brutia (*Pinus brutia* subsp *brutia*). *For Méd* 2, 165-172
- Panetsos CP (1975) Natural hybridization between *Pinus halepensis* and *P brutia* in Greece. *Silvae Genet* 24, 163-168
- Panetsos CP (1981) Monograph of *Pinus halepensis* (Mill) and *P brutia* (Ten). *Ann For Za-gr* 9, 39-77
- Papagiannopoulos AD (1983) Studies on the resin tapping of *Pinus halepensis* and *P brutia*: productivity, resin flow factors and mechanism, and anatomical effect of tapping (English abstract of a thesis in Greek, Department of Forests and Natural Environment, Aristoteleian University, Thessaloniki, Greece); *For Abstr* (1986) 47-01456
- Papaioannou J (1936) Über Artbastarde zwischen *Pinus brutia* Ten und *Pinus halepensis* Mill in Chalkidiki (Griechenland). *Forstwiss Zentralbl* 58, 194-205
- Papaioannou J (1954) Hybridization of Mediterranean pines and its influence on resin production and especially in Greece. *Dasos* 25-28, 104-106 (in Greek)
- Ray CR (1982) Revision of the genus *Matsucoccus* (Homoptera: Coccoidea:Margarodidae) in North America. PhD Thesis, Auburn Univ, Auburn/Alabama, AL
- Rieux R (1975) La spécificité alimentaire dans le genre *Matsucoccus* (Homoptera: Margarodidae) avec référence spéciale aux plantes-hôtes de *M pini* Green. Classement des *Matsucoccus* d'après leurs hôtes. *Ann Sci For* 32, 157-168
- Schiller G, Conkle MT, Grunwald C (1986) Local differentiation among Mediterranean populations of Aleppo pine in their isoenzymes. *Silvae Genet* 35, 11-19
- Schiller G, Mendel Z (1992) On the origin of *Pinus halepensis* Mill in Turkey: synthesis of genetic and entomological studies. In: (*Docum*) *Int Sympt Popul Genet Gene Conservation For Trees*. Bordeaux, France, August 1992
- Schimitschek E (1944) *Forstinsekten der Türkei und ihre Umwelt*. Volk und Reich, Prague
- Schvester D, Ughetto F (1986) Différences de sensibilité a *Matsucoccus feytaudi* Ducasse 1942 (Coccoidea:Margarodidae) selon des provenances de pin maritime (*Pinus pinaster* Ait). *Ann Sci For* 43, 459-474
- Steininger FF, Rogl F (1984) Paleogeography and palinspastic reconstruction of the Neogene of the Mediterranean and Paratethys. In: *The Geological Evolution of the Eastern Mediterranean* (Dixon JE, Robertson AHF, eds) Blackwell, London, 659-668
- Zohary M, Orshan G (1965) An outline of the geobotany of Crete. *Suppl Israel J Bot* 14, 1-49