A New Species of *Matsucoccus* (Homoptera: Coccoidea: Margarodidae) from Korea

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ABSTRACT A new species of scale insect, *Matsucoccus thunbergianae* Miller and Park, is described using life history information and morphological characteristics of adult female, adult male, third instar male, and first instar. The species is morphologically similar to *M. matsumurae* (Kuwana) and *M. resinosae* Bean and Godwin; the most obvious structural differences are found in the adult male. The species is univoltine and overwinters as second instars, whereas *M. matsumurae* and *M. resinosae* are bivoltine and overwinter as first instars. Information is given supporting evidence that the same instar of different generations of multivoltine species differ significantly morphologically.

INTRODUCTION

The current status of many species in the genus *Matsucoccus* is confused and requires a detailed study from a world view. Although the genus contains species that are serious pests of pine and several analyses have been completed in restricted geographical areas, a modern, comprehensive study has yet to be undertaken. Problems encountered in studying *Matsucoccus* include : 1) In many instances differences among species are slight and often involve quantitative rather than qualitative features. 2) Material currently available for study is usually restricted to one or two small samples from a single locality. 3) Adult females of the first and second generations of some species, e.g. *Matsucoccus pini* (Green), have quantitative morphological differences (Boratynski 1952). Differences also were discovered by Ben-Dov (1981) between adult females collected in the spring and autumn in *M. josephi* Bodenheimer and Harpaz. It is reasonable to believe that other, multiple-generation species also will show seasonal morphological differences. Therefore, it is necessary to study material from each generation separately in order to make valid interspecific comparisons. The species that is described in this paper has only a single generation each year and therefore is not confounded by morphological differences between generations.

In Korea *Matsucoccus matsumurae* (Kuwana) was found by Kanda in 1941. There has been no record of significant damage by this species since then, and no other species of the genus was found until 1982. However, in May 1983, *Matsucoccus* infestations were discovered that were causing serious damage to 12,000 ha of Japanese black pine(*Pinus thunbergiana* Franco) forests in the southwestern coastal area of the peninsula. In 1985 Park and Park ascertained that the species has only a single generation each year and is biologically quite different from *M. matsumurae*; unfortunately, it is morphologically quite similar to *M. matsumurae*. A detailed taxonomic analysis has yet to be undertaken on *M. matsumurae*, and it is not clear if it is a single species or is a complex of siblings. Some suspect that *M. resinosae* Bean and Godwin is a junior synonym of *M. matsumurae* (McClure et al. 1983).

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The purpose of this paper is to draw attention to the problems that currently confound the taxonomy of *Matsucoccus* and to describe a new species from Korea so that studies on its biology, economic importance, and control can be examined in greater detail.

MORPHOLOGICAL DESCRIPTIONS

Methods

For leg segments it is possible to take measurements in several different ways and therefore to obtain slightly different data. To assist those wishing to duplicate the information presented in this paper, we have drawn a line next to the leg on Figure 1 to delineate the manner in which we collected measurement data.

Specimens were studied using a Zeiss, phase contrast, compound microscope at magnifications of 160, 400, and 1000X. Measurements were collected using an eye-piece micrometer placed in a 10X eye piece.

Counts and measurements were obtained using 15 specimens of each instar of *M. thunbergianae*; additional specimens were studied but were not used for counts and measurements. For comparative data, at least 10 specimens were examined of each instar of *M. resinosae*, Korean populations of *M. matsumurae*, and Chinese populations of *M. matsumurae*. Because of the possibility that at least some of the specimens collected from *Pinus thunbergiana* in Japan are different from *M. matsumurae*, we have excluded this material from our analysis. Specimens collected from other hosts in Japan are included.

Results

Description of Species

***Matsucoccus thunbergianae* Miller and Park, n. sp. (Black Pine Bast Scale)**

Synonymy—*Matsucoccus* n. sp., Park, S.C. and Park, N.C. 1985: 11; Park, S.C. et al. 1986: 609.

Etymology—The species epithet is the genitive form of one of the two recorded hosts of this species, i.e. the Japanese black pine, *Pinus thunbergiana*.

Type data—Holotype adult female, single specimen on slide, with left label "*Matsucoccus/thunbergianae*/Miller and Park/*Pinus thunbergiana*/Kohung, Chollanam-do/Korea/XII-1983, lab. reared/IV-1984/S.C. Park"; right label "HOLOTYPE/*Matsucoccus/thunbergianae*/Miller and Park/1986". The holotype and a series of paratypes are deposited in the United States National Museum of Natural History, Beltsville, Maryland. In addition, there are 26 adult female paratypes, a male allotype, 35 adult male paratypes, 5 pupal male paratypes, 25 first instar paratypes, and 8 third instar males; they are deposited in the following museums: Auburn Coccoidea Collection, Alabama; British Museum of Natural History, London; College of Agriculture, Seoul National University, Suweon, Korea; Forest Research Institute, Seoul, Korea; Museum National d'Histoire Naturelle, Paris, France; Shanghai Institute of Entomology, Academia Sinica, China; University of California, Davis.

Adult Female (3rd Instar)
(Figure 1)

Specimens Examined—The following description is based on 27 specimens from the type locality.

Description—Holotype, mounted, 4.0mm long, (paratypes 3.1～4.5(3.7)mm), 2.2mm wide (paratypes 1.6～2.4(2.0)mm). Body elongate oval, tapering anteriorly.

Dorsum with cicatrices on abdomen from segments II to VII (paratypes usually without cicatrices on segment II, rarely with 1 or 2 on segment VIII), with total of 213 cicatrices (paratypes with 187∼269(220) cicatrices); segment VII with 11 cicatrices (paratypes with 0∼22(4) cicatrices). Cicatrices oval, largest cicatrix 9μ long (paratypes 9∼15(11)μ), 8μ wide (paratypes 8∼14(10)μ), diameter of largest cicatrix/width 1.2 (paratypes 1.1∼1.5 (1.2)); smallest cicatrix 7μ long (paratypes 6∼9(8)μ); with 1 double cicatrix (paratypes with 0∼4(1)). Bilocular pores scattered over surface, largest on abdomen 10μ in diameter (paratypes 9∼12(10)μ), 8μ long (paratypes 8∼10(9)μ).

Venter with bristle-shaped setae, longest 32μ long (paratypes 28∼44(35)μ). Multilocular pores on abdominal segment VIII, total of 86 such pores (paratypes with 66∼105(82) pores); diameter of largest multilocular 10μ (paratypes 8∼12(10)μ); multilocular diameter/bilocular diameter 1.0 (paratypes 0.8∼1.1(0.9)). Thoracic spiracle diameter 32μ (paratypes 21∼34(29)μ); abdominal spiracle diameter on segment II, 12μ (paratypes 10∼17(12)μ); abdominal spiracle diameter on segment VII, 9μ (paratypes 9∼14(12)μ); spiracular diameter on segment VII/spiracular diameter on segment II, 0.8 (paratypes 0.8∼1.1(0.9)); spiracular diameter on thorax/spiracular diameter on segment II, 2.5 (paratypes 1.6∼3.1(2.4)).

Leg structure as follows: Hind femur 285μ long (paratypes 229∼335(285)μ); tibia 248μ long (paratypes 226∼322(272)μ); tarsus 130μ long (paratypes 109∼157(136)μ); claw 35μ long (paratypes 27∼36(32)μ); length of femur/length of tibia 1.1 (paratypes 0.9∼1.1 (1.0)); length of tibia/length of tarsus 1.76 (paratypes 1.64∼1.92(1.78)). Tarsal digitules each 22μ long (paratypes 22∼29(26)μ).

Antennae 9-segmented, length of segments 3∼9, 443μ (paratypes 398∼502(453)μ); segment 3, 59μ long (paratypes 52∼70(61)μ); segment 4, 68μ long (paratypes 59∼74(67)μ); segment 5, 63μ long (paratypes 56∼74(65)μ); segment 6, 59μ long (paratypes 55∼74(63)μ); segment 7, 59μ long (paratypes 54∼69(61)μ); segment 8, 61μ long (paratypes 52∼68(60)μ); segment 9, 74μ long (paratypes 59∼84(73)μ); length of segment 9/length of segment 6, 1.3 (paratypes 1.0∼1.3(1.2)).

Comparison—This species is similar to *Matsucoccus matsumurae* and *M. resinosae*. *Matsucoccus thunbergianae* differs by having 66∼105(82) multilocular pores and the length of hind tibia/length of tarsus 1.64∼1.92(1.78). The Japanese population of *Matsucoccus matsumurae* (excluding specimens collected on *Pinus thunbergiana*) has 51∼63(56) multilocular pores and the length of the hind tibia/length of tarsus 1.68∼1.75(1.71). The Chinese population has 37∼82(60) multilocular pores and the length of the hind tibia/length of tarsus 1.53∼1.78(1.68). The Korean population has 32∼68(51) multilocular pores and the length of the hind tibia/length of tarsus 1.50∼1.87(1.71). *Matsucoccus resinosae* has 49∼115(67) multilocular pores and the length of the hind tibia/length of tarsus 1.62∼1.78(1.69). Specimens of *M. massonianae* generally fall within the range of these species.

First Instar

Specimens Examined—The following description is based on 25 crawlers that are not enlarged from feeding collected from the type locality.

Description—Mounted, 351∼397(367)μ long, 168∼195(181)μ wide. Body elongate oval, head projecting apically.

Dorsum without structures except submarginal row of small bristle-shaped setae. Remnant of anal opening not seen.

Venter with bristle-shaped setae absent except on appendages, segment VIII, and head; 2nd largest seta on segment VIII, 22~34(29)μ long; longest seta usually broken; small, inconspicuous sensilla located near base of 2nd longest seta. Thoracic spiracles inconspicuous, noticeably smaller than abdominal spiracles; abdominal spiracles on segments I~VII; atrium (excluding sclerotization outside of atrium) of spiracle on segment I, 5~7(6)μ in diameter. Clypeolabral structure from anterior sclerotization to apex of confluence 73~83(77)μ long. Labium rectangular, usually with structure inverted, with apex located anteriorly, 36~42(39)μ long.

Leg structure as follows: Fore femur noticeably more robust than femora of other legs, nearly fossorial in appearance. Hind femur 32~37(35)μ long; tibia+tarsus 37~45 (40)μ long; claw 9~13(12)μ long; length of femur/length of tibia 1.3~1.7(1.5); length of tibia/length of tarsus 1.3~1.7(1.5). Fore femur 29~35(33)μ long; tibia and tarsus nearly fused, separation weakly indicated; tibia+tarsus 27~34(30)μ long; length of femur/length of tibia 1.6~2.0(1.8); length of tibia/length of tarsus 1.1~1.8(1.6).

Antennae 6-segmented, 81~95(91)μ long including intersegmental area, total sclerotization 73~85(80)μ long; segment 1, 12~15 (14)μ long; segment 2, 13~17(15)μ long; segment 3, 2~5(3)μ long; segment 4, 11~15(14)μ long; segment 5, 6~7(7)μ long; segment 6, 25~30(28)μ long; length of segment 6/length of segment 1, 1.8~2.4(2.1); length of segment 6/length of segment 4, 0.8~1.2 (1.1); length of longest fleshy seta on segment 6, 12~15(13)μ long; length of other fleshy seta on segment 6, 9~12(11)μ long; length of longest seta on segment 2, 24~39 (30)μ long.

Comparison—A careful examination has been made of the first instars of *Matsucoccus thunbergianae*, *M. resinosae*, and the Japanese, Korean, and Chinese populations of *M. matsumurae*. We were unable to locate any characters that would successfully distinguish among these taxa in this stage of development. Specimens of *M. massonianae* are distinctly larger than those of *M. thunbergianae*, e.g., former with antennae 96~112(106)μ long, labium 44~52(47)μ long, hind tibia+tarsus 44~59(53)μ long; *M. thunbergianae* has antennae 81~95(91)μ long, labium 36~42(39)μ long, hind tibia+tarsus 37~45(40)μ long.

Third Instar Male
(Figure 2)

Specimens Examined—The following description is based on 8, 3rd instar males from the type locality.

Description—Mounted, 1.6~2.0(1.9)mm long, 0.9~1.2(1.0)mm wide. Body elongate oval.

Dorsum without cicatrices. Bilocular pores scattered over surface, largest on abdomen 8~14(10)μ in diameter, 8~10(9)μ long.

Venter with bristle-shaped setae, longest 20~34(27)μ long. Multilocular pores absent. Thoracic spiracle diameter 17~22(22)μ; abdominal spiracle diameter on segment II, 8~9 (8)μ; abdominal spiracle diameter on segment VII, 6~8(7)μ; spiracular diameter on segment VII/spiracular diameter on segment II, 0.7~1.0(0.9); spiracular diameter on thorax/spiracular diameter on segment II, 2.1~2.6(2.4).

Leg structure as follows: Hind femur 144~207(180)μ long; tibia 166~203(183)μ long; tarsus 79~97(87)μ long; claw 24~30(26)μ long; length of femur/length of tibia 0.9~1.1(1.0); length of tibia/length of tarsus 2.0~2.3(2.1). Tarsal digitules each 18~21(20)μ long.

Antennae 9-segmented, length of segments 3～9, 305～329(319)μ; segment 3, 34～43(38)μ long; segment 4, 39～46(44)μ long; segment 5, 41～49(46)μ long; segment 6, 42～51(46)μ long; segment 7, 37～48(44)μ long; segment 8, 41～52(47)μ long; segment 9, 52～59(55)μ long; length of segment 9/length of segment 6, 1.1～1.4(1.2).

Comparison—We do not have enough material of third instar males of other species to make comparisons with *M. thunbergianae*.

Adult Male (5th Instar)

We have compared the morphology of *M. thunbergianae* with the descriptions of *Matsucoccus bisetosus* Morrison (Beardsley 1968), *M. josephi* Bodenheimer and Harpaz (Bodenheimer and Harpaz 1955), *M. matsumurae* (Kuwana) (Morrison 1928), *M. resinosae* Bean and Godwin (Bean and Godwin 1955), *M. bisetosus* and *M. vexillorum* Morrison (McKenzie 1942, 1943a, 1943b), *M. pini* (Siewniak 1976), and *M. apterus* Koteja, *M. larrsoni* Koteja, *M. pinnatus* (Germar and Berendt), and *M. electrinus* Koteja (Koteja 1984). In a study currently underway with Professor Yang Ping-lan, Shanghai Institute of Entomology, People's Republic of China, Miller has examined the males of four additional species. In each case the general structure of the adult male is surprisingly similar; differences primarily are quantitative. For a detailed description of the general morphology of the adult male refer Beardsley (1968). The characters included below may be of importance in distinguishing among species.

Specimens Examined—The following description is based on 29 specimens from the type locality.

Description— Mounted 1.6～2.3(2.0)mm long, 0.4～0.8(0.6)mm at broadest part of abdomen.

Dorsal surface of metathorax with 2 clusters of setae, with total of 16～51(32) setae. Cluster of tubular ducts on segment 7 composed of 12～18(15) ducts; longest duct 27～30(28)μ long.

Antennae 10-segmented, length of segments 2～10, 1124～1602(1380)μ; segment 2, 40～66(50)μ long; segment 3, 156～231(191)μ long; segment 4, 146～217(181)μ long; segment 5, 143～203(177)μ long; segment 6, 149～205(176)μ long; segment 7, 139～195(170)μ long; segment 8, 122～177(155)μ long; segment 9, 120～172(145)μ long; segment 10, 109～158(135)μ long. Length of segment 4/length of segment 3, 0.8～1.0(1.0); largest width of segment 5, 41～53(46)μ. Number of setae on segment 4, 26～49(36), on segment 8, 29～44(37), on segment 10, 29～43(36); number of club-shaped setae on segment 6, 3～5(4), on segment 9, 4, on segment 10, 5; longest club-shaped seta on segment 10, 32～43(37)μ.

Forewings 1575～2009(1787)μ long. Hamulohaltera 181～261(218)μ long, with 3～7(5) apical setae.

Legs with hind femur 290～358(324)μ long; tibia 428～551(499)μ long; tarsus 125～174(153)μ long. Length of femur/length of tarsus 1.9～2.5(2.1); length of tibia/length of tarsus 2.9～3.8(3.3).

Penial sheath 209～286(248)μ long; longest seta on penial sheath 11～32(17)μ long. Aedeagus 213～265(235)μ long.

Comparison—The adult males of *Matsucoccus thunbergianae* generally are larger than the males of similar species. For example, this species differs by having the penial sheath 209～286(248)μ long; aedeagus 213～265(235)μ long; cluster of tubular ducts on segment 7 with the longest duct 27～30(28)μ long; length of antennal segments 2～10, 1124～1602(1380)μ; segment 2, 40～66(50)μ long; hind femur

290~358(324)μ long; hind tibia 428~551(499)μ long; length of femur/length of tarsus 1.9~2.5(2.1); forewings 1575~2009(1787)μ long. The Japanese population of *Matsucoccus matsumurae* (specimens not recorded from *Pinus thunbergiana*) has the penial sheath 175~252 (233)μ long; aedeagus 186~264(210)μ long; cluster of tubular ducts on segment 7 with the longest duct 19~31(26)μ long; length of antennal segments 2~10, 1273~1567(1388)μ; segment 2, 30~47(36)μ long; hind femur 216 ~322(285)μ long; hind tibia 404~504(447)μ long; length of femur/length of tarsus 1.5~2.2(1.9); forewings 1518~1815(1702)μ long. The Chinese population of *Matsucoccus matsumurae* has the penial sheath 197~272(235)μ long; aedeagus 190~252(208)μ long; cluster of tubular ducts on segment 7 with the longest duct 17~19(18)μ long; length of antennal segments 2~10, 1128~1405(1205)μ; segment 2, 31~39(36)μ long; hind femur 233~284 (258)μ long; hind tibia 360~417(384)μ long; length of femur/length of tarsus 1.8~2.1 (1.9); forewings 1237~1658(1475)μ long. The Korean population of *Matsucoccus matsumurae* has the penial sheath 223~248(239)μ long; aedeagus 205~229(223)μ long; cluster of tubular ducts on segment 7 with the longest duct 17~19(18)μ long; length of antennal segments 2~10, 1142~1456(1321)μ; segment 2, 32~43(37)μ long; hind femur 248~391 (277)μ long; hind tibia 347~434(411)μ long; length of femur/length of tarsus 1.9~2.2 (2.1); forewings 1525~1767(1673)μ long. *Matsucoccus resinosae* has the penial sheath 188~254(228)μ long; aedeagus 180~248(216)μ long; cluster of tubular ducts on segment 7 with the longest duct 17~29(23)μ long; length of antennal segments 2~10, 1079~1307(1212) μ; segment 2, 32~50(39)μ long; hind femur 217~304(262)μ long; hind tibia 326~458(398) μ long; length of femur/length of tarsus 1.8 ~2.0(1.9); forewings 1333~1674(1486)μ long. Specimens of *M. massonianae* differ by having 21~29(24) tubular ducts in cluster on dorsum of segment 7 and 44~86(64) setae on dorsal surface of metathorax; *M. thunbergianae* has 12~18(15) tubular ducts in cluster on dorsum of segment 7 and 16~51(32) setae on dorsal surface of metathorax.

Key to Adult Females of *Matsucoccus*

Matsucoccus thunbergianae fits into a modification of Boratynski's(1952) key as follows:

12. "Dorsal cicatrices totalling 150. Bilocular derm pores on ventral side of body larger (about 11.5μ in diameter), those on dorsal side smaller (about 7.6μ diameter). On *Pinus pinaster*; South-West France (Les Landes) .... *feytaudi* Ducasse"

Dorsal cicatrices totalling 150~800. Bilocular derm pores approximately same size on dorsum and venter 13

13. "Dorsal cicatrices comparatively small, 3.6~9μ in diameter; in 5~8 bands, totalling 400~800 [400~932], usually 600~700. Apical cluster composed of 70~80 [59~101] multilocular derm pores. Largest midventral seta 18μ long, or less. On *Pinus ponderosa* var. *scopulorum*; Arizona, New Mexico (U.S.A.)..................... *vexillorum* Morrison"

"Dorsal cicatrices 7~14μ in diameter, totalling 150~300. Apical cluster composed of 50~75 multilocular derm dores"......13a

13a. Largest midventral seta greater than 25μ long.. 13b

Largest midventral seta less than 25μ long. 15

13b. "Bilocular pores forming a band of about 30 [12~21] ducts between third coxae and 2nd thoracic spiracles. Dorsal cicatrices in 6 transverse rows. ....*eduli* Morrison"

"No transverse band of bilocular derm pores between 3rd pair of coxae and 2nd thoracic spiracles. Dorsal cicatrices in 5 rows," occasionally with one or two pores forming a 6th row··································· ·········*thunbergianae* Miller and Park, n. sp.

Figures in brackets are taken from Ray (1982).

Seasonal Differences in Morphology

Seasonal differences in numbers and measurements of certain morphological structures have been reported for *Matsucoccus pini* (Boratynski 1952) and *M. josephi* (Ben-Dov 1981). In each case, the overwintering generation possessed more cicatrices than the summer/fall generation in the adult female. In *M. pini*, Boratynski also reported that the length of the body, antennae, and some setae was longer in the overwintering generation, but he did not find seasonal differences in the number or size of the multilocular pores or bilocular pores. He also did not find seasonal differences in the size of the cicatrices. In *M. josephi*, Ben-Dov found larger numbers of multilocular pores and larger sized cicatrices in the adult females collected early in the year.

We have examined five specimens from each of the overwintering and summer generations of *Matsucoccus resinosae* and the Chinese population of *M. matsumurae*. Our data indicate that the tibia length, tarsus length, and claw length are approximately the same, but the overwintering generation has more multilocular pores and larger cicatrices than the summer generation. The overwintering generation of *M. resinosae* has the cicatrices 9.3～14.8(11.7)μ long, tibia 241～310(262)μ long, tarsus 145～174(154)μ long, claw 33.4～42.9(37.6)μ long, and 49～115(81) multilocular pores; the summer form has the cicatrices 11.9～18.8(14.1)μ long, tibia 249～261(254)μ long, tarsus 148～154(151)μ long, claw 34.8～37.7(35.7)μ long, and 51～65(56) multilocular pores. The overwintering generation of the Chinese population of *M. matsumurae* has the cicatrices 10.2～14.8(12.9)μ long, tibia 252～299(272)μ long, tarsus 142～168(156)μ long, claw 37.1～41.5(39.2)μ long, and 58～74(68) multilocular pores; the summer form has the cicatrices 12.2～16.8(14.7)μ long, tibia 244～313(267)μ long, tarsus 153～180(165)μ long, claw 35.4～40.6(39.6)μ long, and 37～82(54) multilocular pores. This is in general agreement with the findings of Boratynski and Ben-Dov. We also have examined 5 specimens of the overwintering and summer generations of the Korean population of *M. matsumurae*. In contrast to the above observations, the two generations of this population have approximately the same cicatrix size, number of multilocular pores, and claw, tibia, and tarsus length. The overwintering generation has the cicatrices 8.7～13.9(10.7)μ long, tibia 174～276(220)μ long, tarsus 116～157(129)μ long, claw 31.3～38.6(34.4)μ long, and 32～68(52) multilocular pores; the summer generation has the cicatrices 11.2～11.6(11.4)μ long, tibia 235～261(248)μ long, tarsus 130～154(143)μ long, claw 31.9～37.7(36.4)μ long, and 46～60(56) multilocular pores.

We also have studied adult males to determine if the seasonal morphological differences measured in adult females also occur in this instar. Unfortunately, insufficient material is available for a detailed analysis, but in *Matsucoccus matsumurae* from Korea and *M. resinosae* we discovered one characteristic that does shows these differences. In each species there are more setae on the dorsal surface of the metathorax in the overwintering generation than in the summer generation. In *M. matsumurae* there are 30～49(40) setae in the overwintering generation and 17～32(23) in the summer; in *M. resinosae* there are 17

Table 1. Biological comparison of *Matsucoccus* species attacking pines in the *Sylvestres* subsection of *Pinus*.

Matsucoccus species	Distribution	Pine hosts in native range	Reproduction	Generations each year	Overwintering stage	References
thunbergianae	Korea	*thunbergiana* *densiflora*	bisexual	1, partial 2[a]	2nd instar	Park & Park 1985
dahuriensis	China	*sylvestris* var. *mongolica*	unknown	1	1st instar	Hu et al. 1984
feytaudi	France, Spain, Portugal, Morocco	*pinaster*	bisexual	1	2nd instar, 3rd instar male	Riom & Gerbinot 1977
boratynskii[b] (=*insignis*)	USSR	*sylvestris*	unknown	unknown	unknown	Bodenheimer & Neumark 1955 Borchsenius 1955 Danzig 1959
josephi	Israel	*halepensis*	bisexual	5~6	various	Bodenheimer & Neumark 1955 Ben-Dov 1981
massonianae	China	*massoniana*	bisexual	1	2nd instar, 3rd or 4th instar male	Hu & Wang 1976
matsumurae	Japan, Korea, China	*densiflora* *thunbergiana* *tabulaeformis* *massoniana*	bisexual	2, partial 3[a]	1st instar	Kanda 1941 Taketani 1972 McClure et al. 1983 Young 1979
mugo	Germany	*mugo* var. *pumilo*	unknown	unknown	unknown	Siewniak 1970 Siewniak 1983
pini	England, Spain, Poland, Finland	*sylvestris* *nigra*	parthenogenetic[c]	2	1st instar	Boratynski 1952 Cadahia 1971 Siewniak 1976
resinosae	United States	*resinosa*	bisexual	2, partial 3	1st instar	Anderson et al. 1976 Grimble & Miller 1976 McClure 1983
yunnanensis	China	*yunnanensis*	parthenogenetic	2	various	Qi & Wang 1981

[a] Park, unpublished data.

[b] *Matsucoccus boratynskii* Bodenheimer & Neumark and *M. insignis* Borchsenius were described in 1955; based on Ben-Dov (pers. corr.), the editor of Hassadeh sent Bodenheimer & Neumark(1955) to Harpaz for review on February 23, 1955; theerfore this book must have been published in February or earlier. The issue date of Borchsenius (1955) is uncertain, but it is unlikely that it was before February. Therefore, by the law of priority *M. boratynskii* is the valid name and *M. insignis* is a junior, objective synonym.

[c] Cadahia (1971) reported bisexuality in the summer generation and parthenogenesis in overwintering generation.

~34(27) in the overwintering generation and 12~30(20) in the summer. We suspect that additional seasonal differences will be discovered when more material is analyzed.

BIOLOGICAL CONSIDERATIONS

Matsucoccus-Pinus Relationship

Matsucoccus species occur only on *Pinus* and individual *Matsucoccus* species are restricted to pine hosts in a single *Pinus* subgenus or subsection. As stated earlier, *M. thunbergianae* is morphologically most similar to *M. matsumurae* and *M. resinosae*; based on the classification of Critchfield and Little (1966), hosts of these three *Matsucoccus* species are restricted to the *Pinus* subsection *Sylvestres*. Of the 12 *Matsucoccus* species that occur on hosts in the *Sylvestres* subsection, none are found on pine hosts outside of this subsection. If a coevolutionary hypothesis is invoked, it follows that *Matsucoccus* species that occur on the *Sylvestres* subsection hosts are most likely to be closely related. Since with few exceptions, this hypothesis very likely is correct, biological characteristics of *M. thunbergianae* are compared with similar characteristics of the other *Matsucoccus* species infesting *Sylvestres* hosts.

The genus *Matsucoccus* originally contained both branch and needle feeders, but Young (1980) described the genus *Sonsaucoccus* for the needle infesting species previously included in *Matsucoccus*. *Sonsaucoccus* includes seven species, two of which occur on pine species in the *Sylvestres* subsection. Biological information on *Sonsaucoccus* species has not been included in this report.

Biological Comparison

A summary of biological information on *Matsucoccus* species that infest the subsection *Sylvestres* is given in Table 1.

Infestations of *M. matsumurae* recently have been discovered in the southeastern extremity of the peninsula of Korea, about 200km east of the area infested by *M. thunbergianae*. Based on observations made in this region by Seung-Chan Park, some additional biological differences are given in Table 2.

DISCUSSION

Based primarily on biological differences, *Matsucoccus thunbergianae* is considered to be a new species to science. It is interesting that the most obvious differentiating morphological characters are found in the adult male. It also is interesting that no taxonomic differences could be found among the first instars of *M. thunbergianae*, *M. matsumurae* and *M. resinosae*. It would be useful to examine other character systems, such as electrophoretic data, to detemine if they would be of value in clarifying the taxonomic status of these difficult, but economically important, scale insects.

Seasonal differences in the number and dimensions of certain morphological features are reported to occur in adult females of three species of *Matsucoccus*. In each species there is a tendency for the overwintering population to have larger appendages and cicatrices and more wax producing structures than the summer generation. Seasonal differences are not consistent from one species to the next, i.e., appendage length may vary seasonally in one species but not in another, but both may have more multilocular pores in the overwintering generation. We also have been able to document similar variation in the number of setae on the metathorax of the adult male. This is the first report of this phenomenon in this stage.

The origin of *M. thunbergianae* is not known. Since its discovery in 1983, survey results have shown that the zone of infesta-

Table 2. Biological differences between Korean populations of *Matsucoccus thunbergianae* and *M. matsumurae*.

Biological Characteristics	*M. thunbergianae*	*M. matsumurae*
Host most commonly damaged	*Pinus thunbergiana*	*P. densiflora*
Stage most readily observed	Egg sacs	Preadult, pupal cocoons
Site of oviposition	Bark crevices & nodal area of trunk	Nodal area of branches
Site of cocoon	Bark crevices of trunk	Undersides of branches
Adult emergence period	April	Overwintering generation: May Summer generation: September to October

tion has been expanding at a rate of about 4km each year. This situation poses a serious threat to the forests of *Pinus thunbergiana* in the southern coastal areas of Korea and suggests that the species is introduced. An alternative hypothesis also is possible. The stands of Japanese black pine in the area infested by *M. thunbergianae* were devastated about 30 years ago by the pine gall midge, *Thecodiplosis japonensis*, an introduced pest from Japan. The midge killed most of the pine trees during the early period of introduction, but natural regeneration occurred soon after, producing pure, even-aged, dense stands of the pine over a vast area. In addition, for more than ten years, aerial applications of chemicals occurred in the same area for control of the pine caterpillar, *Dendrolimus spectabillis*. It is quite possible that these chemicals significantly reduced the population levels of natural enemies. These conditions might be responsible for the outbreak of an indigenous species of *Matsucoccus*. Although *M. thunbergianae* has not been located elsewhere in Korea, light infestations could be extremely difficult to detect.

Matsucoccus matsumurae is the only species that currently is reported from Japan. It overwinters in the first instar(Table 1), but in December 1983 Seung-Chan Park found a population overwintering as second instars in Japanese black pine forests on Kyushu Island in the southern part of Japan. Since this population and *M. thunbergianae* have the same overwintering stage and host species, it is entirely possible that they comprise the same species. This assumption is supported by a preliminary morphological study of specimens of *Matsucoccus* collected on *P. thunbergiana* from Japan. Although the material is very poor, the males tend to be larger than males of *M. matsumurae* and the females tend to have more multilocular pores; these are features that are consistent with our understanding of *M. thunbergianae*. Since the suggestion that *M. thunbergianae* is native to Japan is highly speculative, it is strongly suggested that investigation of the systematics and ecology of the Kyushu populations be undertaken. If the species is indigenous to Japan then research in Kyushu could be important in locating effective methods for controlling the destructive populations of *M. thunbergianae* in Korea.

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& Neumark (1955). We also are grateful to Dr. David K. Reed, Asian Parasite Laboratory, USDA at Seoul, Korea, for his help with manuscript preparation, and to Dr. Douglas C. Ferguson, Mr. Sueo Nakahara (SEL), Dr. Mark S. McClure, Connecticut Agricultural Experiment Station, New Haven, and Dr. Michael L. Williams, Auburn University, Auburn, Alabama, for their valuable criticisms of the manuscript.

摘 要

*Matsucoccus*屬은 世界의 소나무林에 걸쳐 分布하고 있으며 이중 우리나라 全南地方에서 海松林에 被害를 주는 솔껍질깍지벌레가 新種으로 밝혀져 *M. thunbergianae*로 命名하였다. 新種의 虫態別 形態 및 生活史가 近緣種과 比較되었는데 이는 *M. matsumurae* (Kuwana) 및 *M. resinosae* Bean & Gcdwin과 가장 形態가 비슷하였다. 本種은 1年 1世代 發生하며 2齡虫으로 越冬하는 反面 *M. matsumurae*와 *M. resinosae*는 1年 2世代 發生하며 1齡虫으로 越冬한다. 1年 2世代 以上 發生하는 種들에 있어서 世代間의 形態的 差異도 언급되었다.

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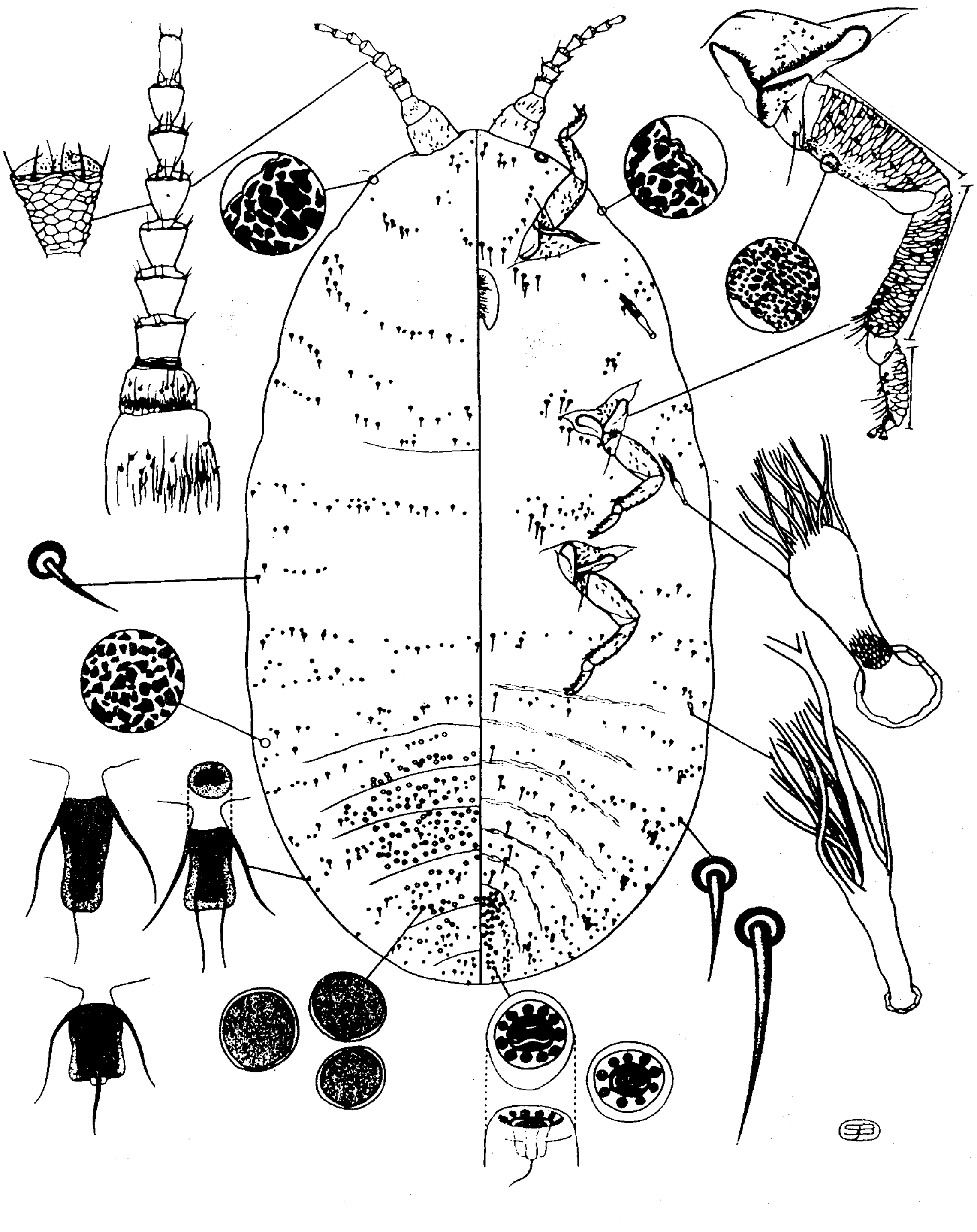

Fig. 1. Adult Female *Matsucoccus thunbergianae* (Holotype). Kohung, Chollanam-do, Korea, April 1983, on *Pinus thunbergiana*, Collected by S.C. Park.

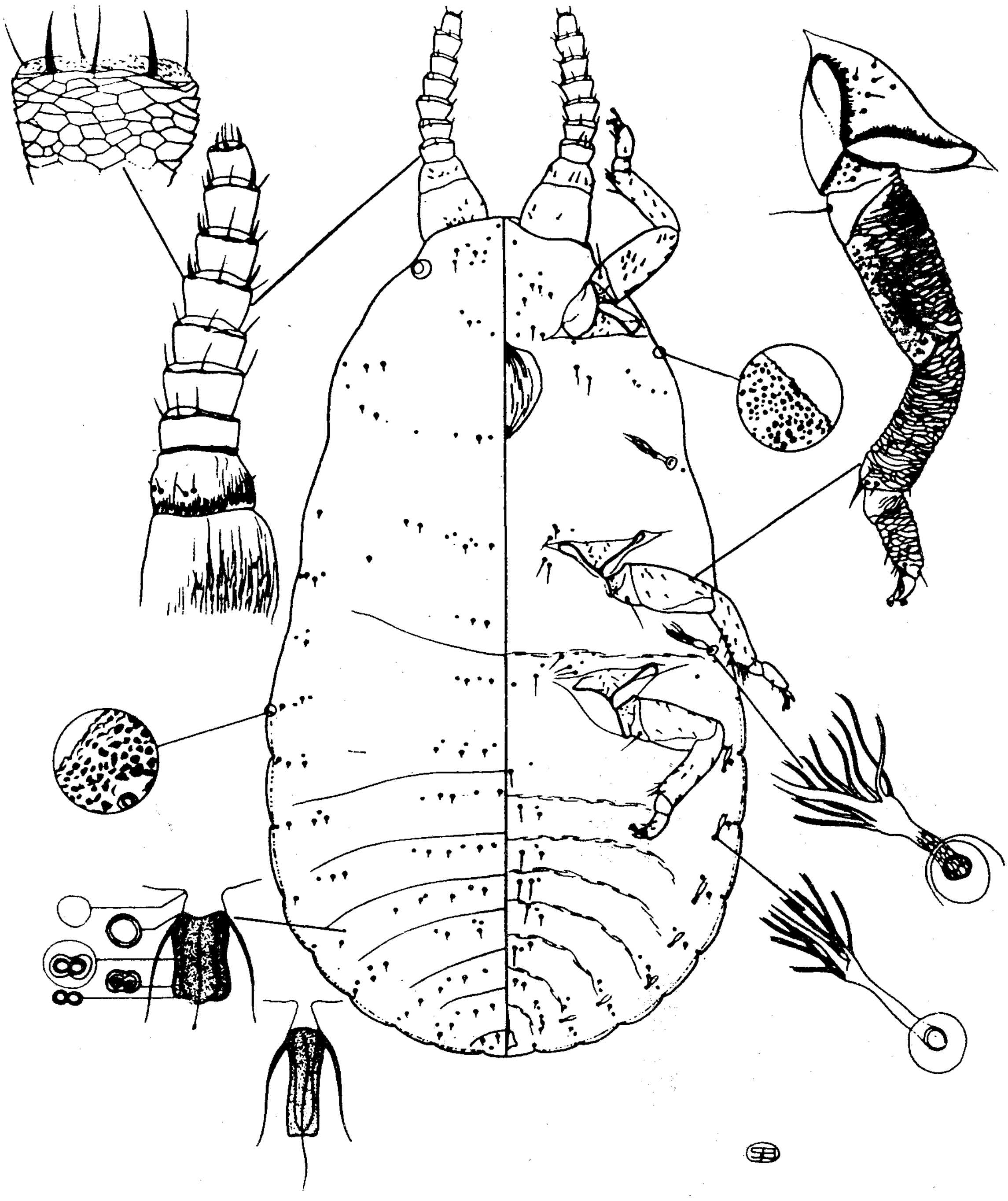

Fig. 2. Third instar male *Matsucoccus thunbergianae.* Kohung, Chollanam-do, Korea, march 1983, on *Pinus thunbergiana,* collected by S.C. Park.