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THE GENUS QUERNASPIS, A POSSIBLE ASIO-AMERICAN
ELEMENT IN SCALE INSECT BIOGEOGRAPHY
(HOMOPTERA: COCCOIDEA)

By SADAO TAKAGI and JAMES O. HOWELL

Abstract

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Six species of scale insects are referred to *Quernaspis*: 3 from North America and the other 3 from East Asia. The 3 North American and 2 East Asian species are described, all of them with the 2nd instar males. Relationships among the North American species, among the East Asian species, and between the North American and East Asian species are discussed. Three species are described as new: *Q. insularis* Howell, associated with *Quercus* spp. in Georgia, Florida, Arkansas and Texas; *Q. nepalensis* Takagi, associated with *Quercus* spp. in Nepal; *Q. chiulungensis* Takagi, associated with *Castanopsis indica* in Kowloon Peninsula.

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** Collected in connection with the Japan-U.S. Co-operative Science Programme, 1965.

INTRODUCTION

Classic examples of disjunct distribution in plants include many taxa common to North America and East Asia. The origins of these Asio-American elements in plant biogeography are attributed to escapes from the Arcto-Tertiary flora in both regions, combined with the extinction of it in other parts of the world. Animals do not lack similar examples of distribution. Some such bicontinental animal taxa, e.g., the giant salamander family Cryptobranchidae and the crocodylian genus *Alligator*, are deemed on the basis of fossil records to be survivals from the widely distributed Tertiary fauna.

The phytobiogeographical connection between North America and East Asia may lead us to expect that phytophagous animals such as scale insects must have well retained such a connection. By contraries it is not easy to find scale insect taxa distributed in and restricted to these regions. This may at least partly be due to insufficient faunal investigations especially on the side of East Asia. Even areas under long investigations, Ceylon, India, Japan, and Taiwan, must still embrace many undescribed scale insects. Other areas of East Asia, temperate and tropical, are vast in extent and originally belong to one of the most luxuriant regions of the world. We believe that in this group of animals the traces of the Tertiary will certainly be revealed in terms of bicontinental distribution.

The genus *Quernaspis* was proposed by Ferris (1937) for a North American species, *Chionaspis quercus*, and a 2nd species was recently described by Tippins and Beshear (1970) from North America. The Taiwanese species "*Pinnaspis*" *lithocarp*i, described by Takahashi (1931), has been supposed to belong to this genus, but it has not been re-examined.

In the meantime, we have been respectively making study of North American species of *Quernaspis* and of East Asian species tentatively referable to the genus. We have agreed to publish our studies together in order to call attention to a possible Asio-American bicontinental connection in scale insects.

ACKNOWLEDGEMENTS

Mr. Ray Gill, California Department of Agriculture, and Mr. S. Nakahara, U. S. Department of Agriculture, lent material of *Q. quercus* for comparison with the other species in this paper. Miss Ramona J. Beshear and Dr. H. H. Tippins collected most of the *Q. quercicola* and *Q. insularis* material. Prof. S. Hatusima, Kagosima University, identified the host plant of an Asian species.

NORTH AMERICAN SPECIES

[By J. O. HOWELL]

Quernaspis quercus (Comstock)

(Fig. 1, 2 and 14)

Habit. — "The females occur on the bark of the small limbs; the males up on the leaves . . . The scale of the female is long, narrow at the anterior end, much widened posteriorly, and quite convex . . . the [wax] secretion is white . . . but specimens appear dark gray, being more or less covered with the hairs of the stem to which the scale was attached and with dust. Length of scale, 2 mm . . . The scale of the male is

snowy white, . . . the texture is quite loose and the carinae prominent; length 1.25 mm" (Comstock, 1916).

Diagnosis. — *Q. quercus* is separable from *Q. insularis* in having more dorsal submedian macroducts on abdominal segments 3–5 (especially 5) and more submarginal macroducts on abdominal segment 4. It is easily separable from *Q. quercicola* because the median lobes in *Q. quercus* are fused, while those in *Q. quercicola* are separated on the apical half.

Adult female

Body of slide-mounted adult female 1103–1669 long and 644–924 wide; body fusiform, widest across abdominal segments 1–2; free abdominal segments well lobed. Pygidium broadly triangular, margins subtending an angle of about 115° or more. Only two pairs of lobes present, but the pygidial margin sclerotized at the site of the third lobes; median lobes well developed but fused, with a hollow median notch and 1–2 shallow notches on lateral margin. Second lobes notched laterally but not bilobed.

DORSAL SURFACE. — *Ducts.* — With 6 macroducts on each pygidial margin, those on segments 6–7 with a conspicuous sclerotized ring around each orifice. The duct on segment 7 and mesal duct on segment 6 with heaviest sclerotized ring. Submarginal macroducts: Metathorax and basal 3 abdominal segments with numerous small macroducts on lateral lobes, both dorsally and ventrally, these ducts numbering ca. 13–32, 16–38, 14–30, and 14–26 from metathorax through abdominal segment 3 respectively. Larger submarginal macroducts numbering 4–15 on segment 4, and 2–6 on segment 5. Submedian macroducts: 0–11 on abdominal segment 2, 2–20 on abdominal segment 3, 8–16 on segment 4, and 2–7 on segment 5, these ducts becoming smaller on prepygidial segments. Macroducts sparse on anterior of prosoma, and on abdomen.

Setae. — Prosoma with a few short setae, usually a submedian seta on each thoracic segment, and on each abdominal segment 1–7. Marginal setae present on abdominal segments 1–8, noticeably larger on segments 6–8. An additional short seta present near base of each median lobe, possibly representing segment 9.

Anal opening. — Ca. 17.7–22.4 wide, and situated ca. 7–10 times its width from apex of median lobes.

VENTRAL SURFACE. — *Antennae.* — Short, tuberculate, with 1 elongate fleshy seta, one fleshy protuberance, and 2 invaginated setae.

Spiracles. — Situated mesolaterally, anterior spiracle with 3–13 trilocular disc pores; posterior spiracle with 1–2 (rarely 3).

Gland tubercles and gland spines. — Prothorax usually with gland tubercles absent (rarely with 1), mesothorax with 5–12, metathorax with 6–12. Abdominal segments 1–3 with 6–11, 4–8, and 3–8 gland tubercles respectively. Marginal gland spines present, 2–6 on fourth abdominal segment, 4–6 on fifth, 3 (rarely 2) on sixth, 1–3 on seventh, and 1 on eighth.

Ducts. — Microducts fairly numerous on head. A cluster of microducts slightly posterolaterad of each anterior spiracle, varying in number from 2–34. A few submedian ducts usually present on abdomen. Submarginal microducts: 1–2 on segments 4 and 5, 1 (rarely 2) on segment 6, and 1 on segment 7.

Perivulvar pores. — In 5 groups, anterior medians 12–20, anterior laterals 14–26, and posterior laterals 18–26.

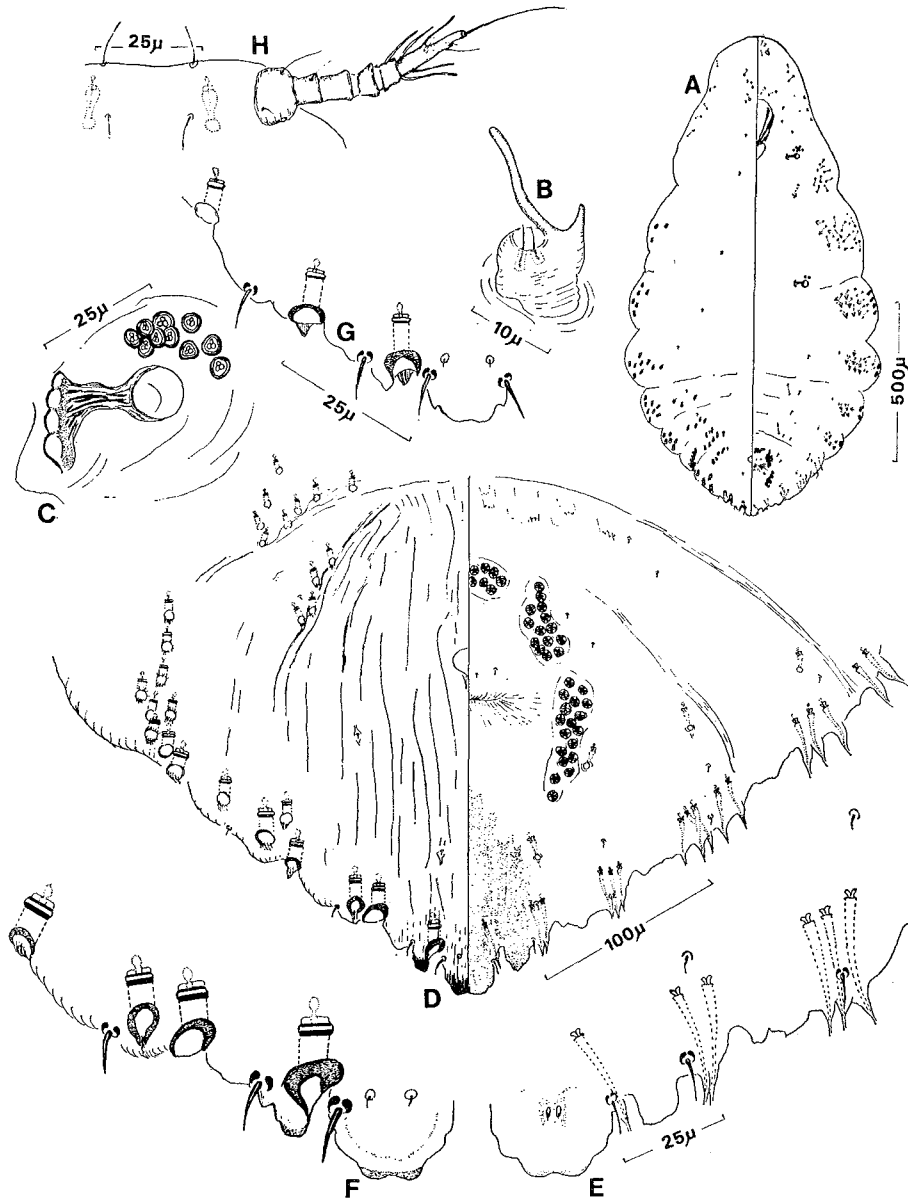


Fig. 1. *Quernaspis quercus* (Comstock). Adult female: general features and body outline (A); antenna (B); anterior spiracle (C); pygidium (D); pygidial margin (E, F). Second instar female: pygidial margin (G). First instar: cephalic margin and antenna (H). California, adult female on *Quercus lobata*, 1st and 2nd instars on *Q. douglasii*.

Setae.—A few short setae scattered over prosoma and along body margin, usually with a submedian seta on head, each thoracic segment, and on abdominal segments 1–5, those on segments 3–5 often paired. Paired submarginal setae on

abdominal segments 1-4; 1 marginal and 1 submarginal seta on each of abdominal segments 5-7, and a single marginal seta on segment 8, marginal setae longest on segments 6 and 7. Seta on segment 8 at base of median lobes very short and difficult to see.

Vulva. - Posterior to anal opening, easily distinguishable.

Material studied. - On *Quercus lobata*, 12 adult females on 12 slides, N. Sacramento, Calif., Feb. 15, 1947, Coll. J. B. Steinweden. On *Q. douglasii*, 2 adult females on 2 slides, Eldorado, Calif., Sept. 1, 1942, Coll. McKenzie and Keifer; 2 adult females on 2 slides, Butte Co., Calif., April 7, 1956, Coll. Don Black. On *Q. velutina*, 1 adult female, Blue Jay, Calif., Feb. 28, 1972, Coll. J. E. Fuller. On *Quercus* sp., 3 adult females on 1 slide, Paradise, Butte Co., Calif., Apr. 10, 1972, Coll. Tipp and Kirby.

Second-stage male

DESCRIPTION. - Body roughly oval, tapering posteriorly. Length of slide-mounted specimens 426 (375-532), width 277 (246-308). Cephalothorax slightly larger than abdomen. Pygidium with two distinguishable pairs of lobes, but neither very well developed.

DORSAL SURFACE. - *Ducts.* - One modified marginal "cup-like" macroduct on each of abdominal segments 2-7, those on segments 5 and 6 noticeably smaller (occasionally the small marginal macroduct on segment 6 not modified, but appears as the more typical "two-barred" duct). One small but typically "two-barred" submarginal macroduct present on each of segments 5 and 6. A few very small submarginal macroducts present on mesothorax. One microduct present submedially and submarginally on head, and occasionally a few submarginally on thorax. A median microduct usually present on abdominal segments 1, 2, 5, and 6. Mesolateral microducts present on abdominal segments 1-7, those on 3-6 usually paired. A few submarginal microducts present on abdominal segments 1-3.

Setae. - Typical for diaspidine second-stage males.

Anal opening. - Ca. 13.6 in width, and situated 3.0 (2.5-3.5) times its width from apex of median lobes.

VENTRAL SURFACE. - *Antennae.* - Small tubercles, with 1 stout seta, 1 short protuberance, and 2 invaginated setae.

Spiracles. - Anterior spiracle with 2 trilocular pores positioned anterolaterad of peritreme, posterior with none.

Ducts. - A few small macroducts on submargin of metathorax, and 1-2 on abdominal segment 1. One microduct submedially on head, and a few submarginally on head and thorax. Abdomen with mesolateral microduct on each of abdominal segments 2-7, forming a longitudinal row. A row of submarginal microducts on abdominal segments 3-7, these ducts usually paired (rarely 1-3 ducts on a given segment). Two marginal microducts present on abdominal segment 4, and 1 on each of abdominal segments 5-8. Other marginal and submarginal ducts scattered on abdominal segments 1-3 as illustrated. A few gland tubercles present on thorax and fused abdominal segments 1-2, as illustrated.

Setae. - Scattered over head and thorax as illustrated. Abdominal segments 4-7 each with a mesolateral seta, segments 2-7 each with a submarginal seta. Marginal setae longest on segments 5-8.

Material studied. - On *Quercus velutina*, 10 on 10 slides, Blue Jay, Calif., Feb.

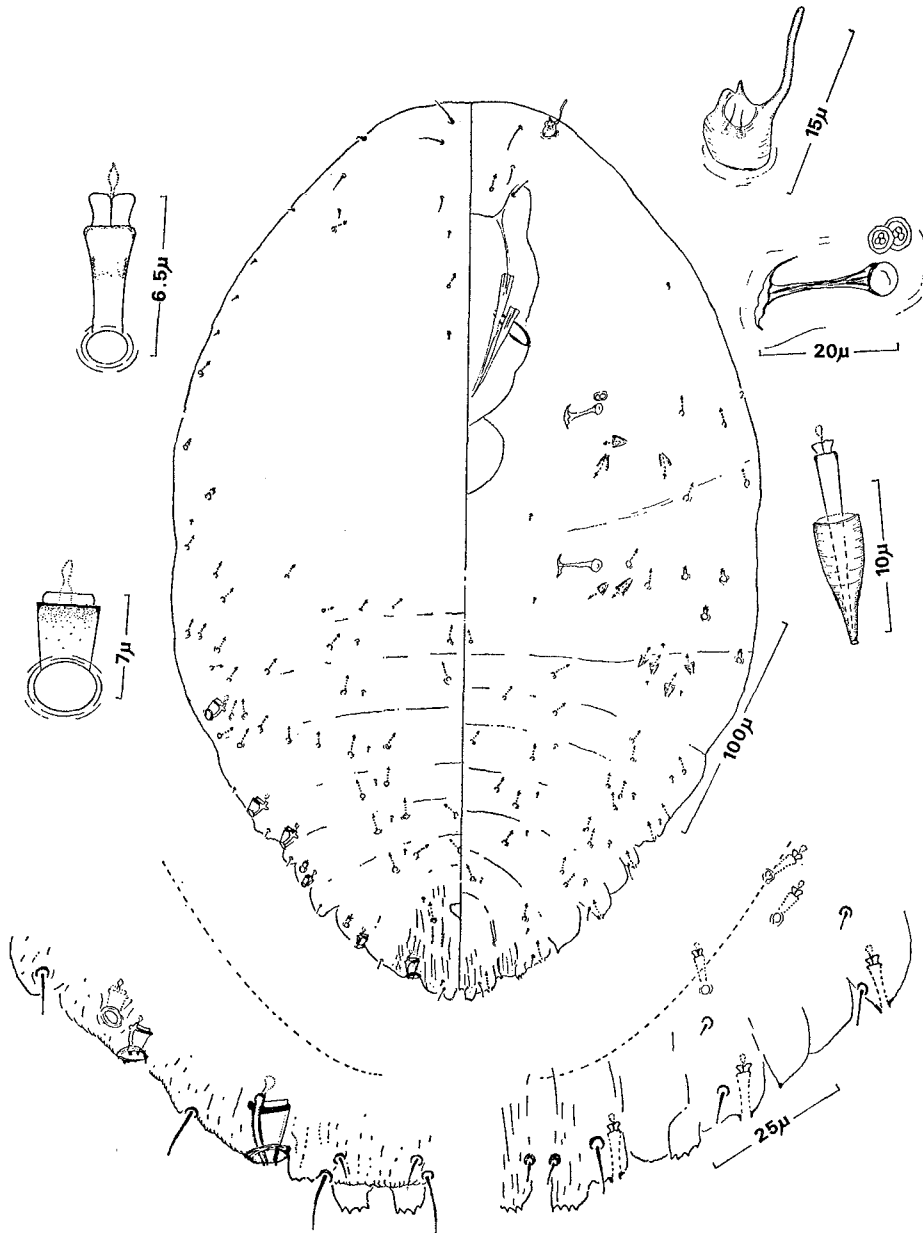


Fig. 2. *Quernaspis quercus* (Comstock). Second-stage male. California, on *Quercus velutina*.

28, 1972, Coll. J. E. Fuller.

Quernaspis insularis Howell, n. sp.

(Fig. 3 and 4)

Type Data. - Glynn Co., Georgia, on *Quercus virginiana* and *Q. laurifolia*.

Adult female holotype, 9 adult female paratypes and 4 second-stage male paratypes on 13 slides deposited in the U. S. National Museum of Natural History (Coccoidea Collection), Washington, D. C. 8 adult female paratypes and 4 second-stage male paratypes on 12 slides deposited in the Hokkaidô University (Entomological Institute) collection, Sapporo, Japan. 8 adult female paratypes and 6 second-stage male paratypes on 13 slides deposited in the University of Georgia collection at Experiment. 5 adult female paratypes on 5 slides deposited in the Virginia Polytechnic Institute and State University collection, Blacksburg, Va. 5 adult female paratypes on 5 slides deposited in the British Museum (Natural History), London, England. 5 adult female paratypes on 5 slides deposited in the Auburn University collection, Auburn, Alabama. 5 adult female paratypes on 5 slides deposited in the University of California collection at Davis. 5 adult female paratypes on 5 slides deposited in the Fla. Dept. of Agriculture collection at Gainesville.

Habit. - Adult female usually beneath bark flakes or lichens, when exposed, scale cover white, elongate, narrow anteriorly widening posteriorly, about 1.5 mm long. First exuvium terminal. Male covers on lower surface of leaves, usually found along a vein. First exuvium terminal, the remaining cover with a heavy median carina.

Etymology. - The species epithet refers to Jekyll Island, Ga., the type locality.

Diagnosis. - *Q. insularis* is separable from *Q. quercus* in having a more acute pygidium, fewer dorsal submedian macroducts on abdominal segments 3-5, and usually fewer submarginal macroducts on abdominal segment 4. It is easily distinguished from *Q. quercicola*, by the fused median lobes. In *Q. quercicola*, the median lobes are clearly separated on the apical half.

Adult female

Body of slide-mounted adult female 560-1305 long and 274-566 wide; body fusiform, widest across abdominal segments 1-2. Prepygidial abdominal segments lobed laterally. Pygidium broadly triangular, margins subtending an angle of about 100° or less. Two pairs of lobes present, median lobes fused with a shallow median notch and usually with 3-6 notches on lateral margin. Second lobes well developed, outer lobule reduced, rarely notched; inner lobule with 1-2 notches laterally. Site of third lobes usually represented by a small sclerotized point which is sometimes serrate.

DORSAL SURFACE. - *Ducts* - With 6 macroducts on each pygidial margin, those on segments 6 and 7 with a conspicuous sclerotized ring around each orifice; the duct on segment 7 and the mesal duct on segment 6 with the heaviest sclerotized ring, other pygidial ducts with lessening degrees of sclerotization; usually with one macroduct on segment 4, two on segments 5 and 6 and one on segment 7. Submarginal macroducts: Metathorax and basal 3 abdominal segments with small macroducts on lateral lobe, these ducts dorsal and ventral, numbering ca. 6-14, 3-10, 3-8, and 2-9 anterior to posterior respectively. Larger submarginal macroducts numbering 1-5 on segment 4, and 0 on segment 5. Submedian macroducts: 1-5 on segment 3, 3-4 on segment 4 and 0-2 on segment 5. A few microducts scattered over anterior of prosoma, and few on abdomen.

Setae. - Prosoma with a few short setae; occasionally a submedian seta on meso- and metathorax, and usually a submedian seta on each abdominal segment 1-7. Marginal setae present on abdominal segments 1-8, becoming longer



Fig. 3. *Quernaspis insularis* Howell, n. sp. Adult female: general features and body outline (A); antenna (B); anterior spiracle (C); pygidium (D); pygidial margin (E, F). Second instar female: pygidial margin (G). First instar: cephalic margin and antenna (H). Georgia, on *Quercus virginiana*.

posteriorly. An additional short seta present near fused inner margin of median lobes, probably representing segment 9.

Anal opening. – 10.9–15.0 wide, and situated ca. 10–12 times its width from apex of median lobes.

VENTRAL SURFACE. – *Antennae.* – Short, tuberculate, with 1 elongate fleshy

seta, 1-2 shorter protuberances, and 2 invaginated setae.

Spiracles. - Situated mesolaterally; anterior spiracle with 2-7 trilocular disc pores; posterior spiracle with 1 (rarely 0).

Gland tubercles and gland spines. - Prothorax with 0-4 short gland tubercles, mesothorax with 1-4, metathorax with 3-7. Abdominal segments 1-3 with 3-7, 3-6, and 3-6 gland tubercles respectively. Marginal gland spines well developed, 3-5 on fourth abdominal segment, 1-4 on fifth, 2 (rarely 1) on sixth, 2 on seventh, and 1 on eighth.

Ducts. - A few microducts scattered over head and prothorax, these mostly submarginal, and a few submedian microducts scattered over abdomen, but usually with 1 on each prepygidial segment forming a submedian row. Submarginal microducts: usually 1 on abdominal segments 5 and 6, and 2 (rarely 1) on abdominal segment 7.

Perivulvar pores. - In 5 groups, anterior medians 4-10, anterior laterals 6-14, and posterior laterals 6-16.

Setae. - A few short setae scattered over prosoma, and along body margin, usually with a submedian seta on head and each thoracic segment, and on abdominal segments 1-5, those on 3-5 often paired. Paired submarginal setae present on abdominal segments 1-4; 1 marginal and 1 submarginal seta on each of abdominal segments 5-7, and a single marginal seta on segment 8, marginal setae longest on segments 6-7. Seta on segment 8 very short, at base of median lobes.

Vulva. - Posterior to anal opening, easily distinguishable.

Material studied. - On *Quercus virginiana*, adult female holotype and 21 adult female paratypes on 22 slides, Jekyll Island, Glynn Co., Ga., Mar. 16, 1972, Coll. H. H. Tippins; 5 adult female paratypes on 5 slides, Oct. 17, 1967, other data as above; 2 adult female paratypes on 2 slides, Mar. 16, 1972, other data as above; 8 adult female paratypes on 8 slides, Oct. 12, 1973, other data as above; 1 adult female paratype, Bryan Co., Ga., Sept. 17, 1974, Coll. R. Beshear. On *Q. laurifolia*, 1 adult female paratype, Glynn Co., Ga., Oct. 12, 1973, Coll. H.H. Tippins. On *Q. stellata*, 10 adult female paratypes on 10 slides, Spalding Co., Ga., Aug. 12, 1976, Coll. H. H. Tippins. On *Quercus* sp., 1 adult female paratype, Collier Co., Fla., Nov. 29, 1970, Coll. H. H. Tippins. Pike Co., Ark., 1 adult female paratype, June 13, 1974, Coll. M. Smith; Dekalb, Texas, 1 adult female paratype, Sept. 30, 1970, Coll. M. Smith.

Second-stage male

DESCRIPTION. - Slide-mounted specimens elongate oval, 517 (409-666) long, and 288 (246-330) wide. Cephalothorax slightly longer than abdomen. Only median lobes developed, these not easily distinguishable.

DORSAL SURFACE. - *Ducts.* - One modified marginal "cup-like" macroduct on each of abdominal segments 2-7, the duct on segment 5 noticeably smaller than the others. One small but typically "two-barred" submarginal macroduct on each of segments 5-6. A few very small submarginal macroducts present on metathorax and abdominal segment 1. One microduct submedially and submarginally on head, and occasionally a few submarginal on thorax. Metathorax and abdominal segments 1-3 with a few submarginal microducts as illustrated. Mesolateral microducts present on abdominal segments 2-7, those on segments 4-6 usually paired.

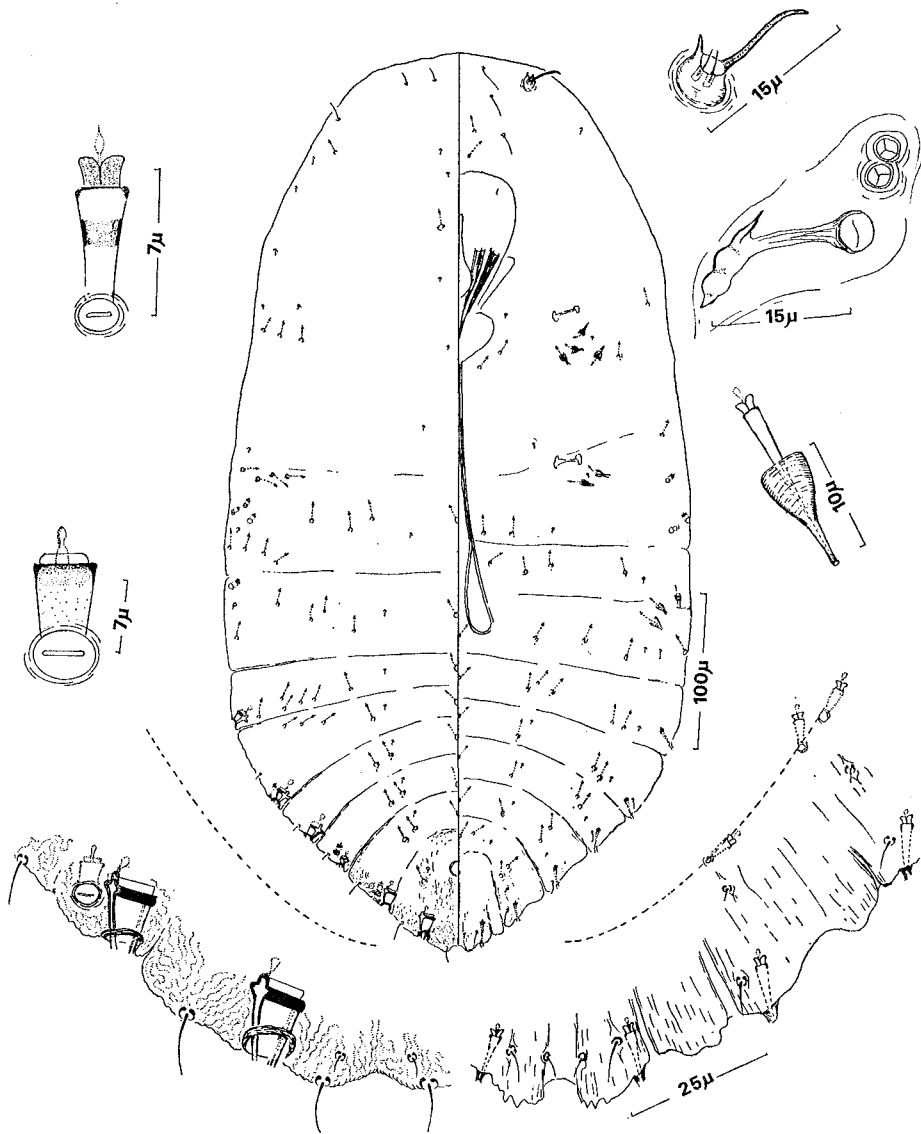


Fig. 4. *Quernaspis insularis* Howell, n. sp. Second-stage male. Georgia on *Quercus virginiana*.

Setae. - Setal pattern typical, as illustrated.

Anal opening. - 9.5 (8.2-10.2) wide, and situated 4.8 (4.0-6.3) times its diameter from apex of median lobes.

VENTRAL SURFACE. - *Antennae*. - Small tubercles, with 1 stout seta, 2-3 shorter protuberances, and 2 invaginated setae.

Spiracles. - Anterior spiracle with 1-2 trilocular pores anterolaterad of peritreme, posterior with none.

Ducts. - A few small macroducts submarginally on metathorax. 1 microduct

submedially on head, and a few submedially and submarginally on thorax. Abdomen usually with 1 median and 1 mesolateral microduct on segments 1-7; a row of submarginal microducts on abdominal segments 1-7, those on segments 3-7 usually paired. Other microducts often scattered over abdominal segments 1-3. Marginal microducts present on abdominal segments 1-8, each with a very short tubercle. A few gland tubercles present on thorax and on abdominal segments 1-2 as illustrated

Setae.—Scattered over head and thorax as illustrated. Abdominal segments 4-7 each with a single, short mesolateral seta. A single short submarginal seta present on abdominal segments 1-7 (usually paired on segments 1-2). Marginal setae longest on segments 5-8.

Material studied.—On *Quercus virginiana*, 5 paratypes on 4 slides, Cumberland Island, Camden Co., Ga., Sept. 4, 1968, Coll. R. Beshear; 7 paratypes on 7 slides, Glynn Co., Ga., Oct. 12, 1973, Coll. H. H. Tippins; 1 paratype, Glynn Co., Ga., May 26, 1976, Coll. R. Beshear. On *Q. laurifolia*, 1 paratype, Glynn Co., Ga., Sept. 12, 1973, Coll. H. H. Tippins.

Quernaspis quercicola Tippins and Beshear

(Fig. 5 and 6)

Habit.—Adult female occurring on bark, scale elongate, oyster-shell shaped, exuvium terminal. Scale 2 mm long, 0.5 mm wide, white, but appearing gray because of extraneous material. Scale of male white, smooth, elongate without a carina. Males on edge of leaf blades.

Diagnosis.—*Q. quercicola* differs from all known North American species of *Quernaspis* in having the median lobes separated on the apical half.

Adult female

Body of slide-mounted adult female 610-1114 long and 252-375 wide; body fusiform, widest across abdominal segments 3-4; free pygidial segments well lobed; pygidium subtending an angle of about 90°. Two pairs of lobes present, the pygidial margin only faintly sclerotized at the site of the third lobes. Median lobes well developed, separated their entire length dorsally, but fused ventrally along the basal one-half to two-thirds. Median lobes serrate, with 4-6 notches on lateral margin. Second lobes fairly well developed, bilobed, inner lobule with 0-3 lateral notches, the outer lobule reduced.

DORSAL SURFACE.—*Ducts.*—With 7 macroducts on each pygidial margin, the posterior 4 ducts with a conspicuous sclerotized ring surrounding each orifice. Sclerotized ring on segment 7 asymmetrical and produced mesally into a club-like paraphysis, the other 3 macroducts with lessening degrees of sclerotization. 2 macroducts on segments 4-6 (rarely 1 on 6), and 1 on segment 7.

Submarginal and submedian macroducts absent on pygidium. Metathorax and basal 3 abdominal segments with a few smaller ducts on lateral lobes, these numbering ca. 6-12, 4-8, 5-8, and 3-4 from metathorax through abdominal segment 3 respectively. Several microducts present on prosoma and on abdomen.

Setae.—Prosoma with a few short setae, usually a submedian seta on each thoracic segment, and on each abdominal segment 1-7. Marginal setae present on abdominal segments 1-8, noticeably longer on segments 6-8. An additional

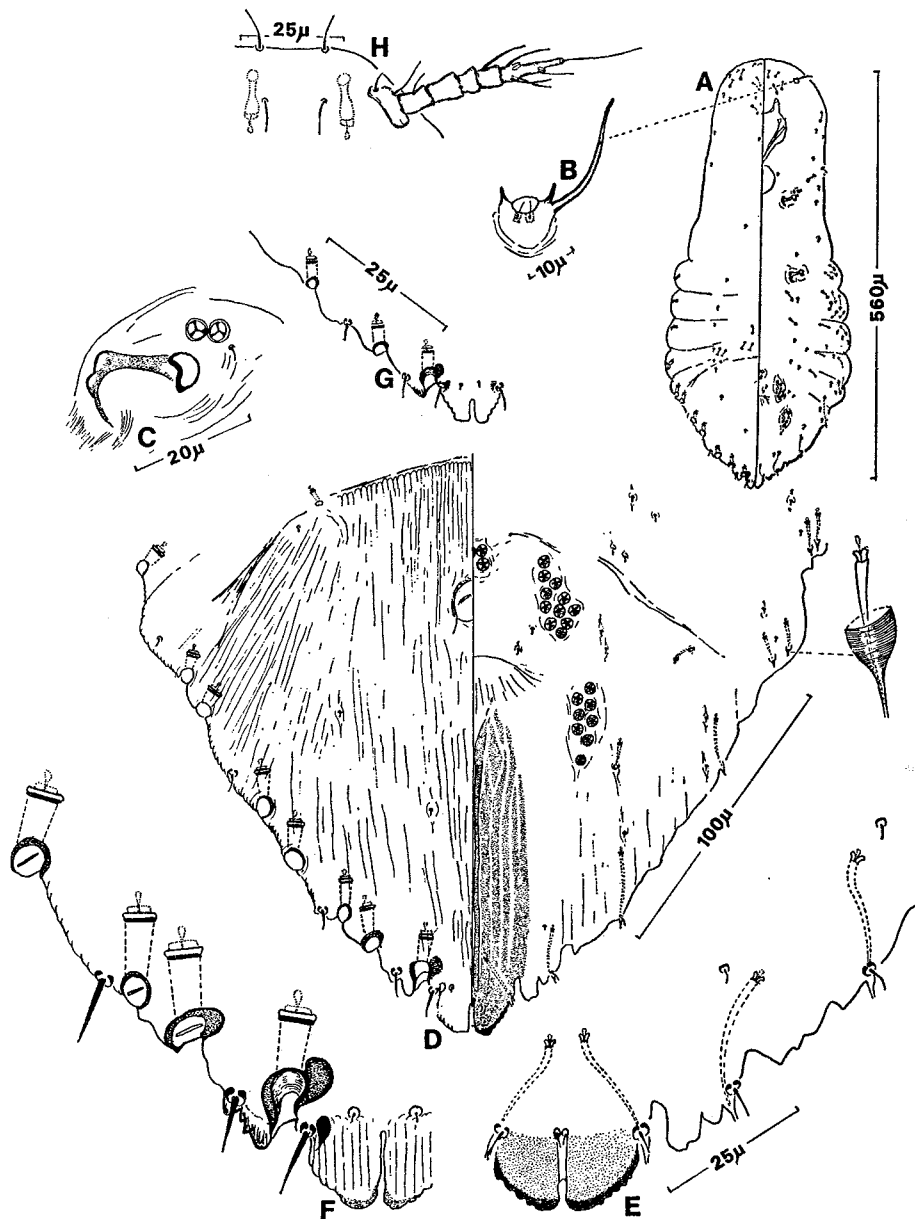


Fig. 5. *Quernaspis quercicola* Tippins and Beshear. Adult female: general features and body outline (A); antenna (B); anterior spiracle (C); pygidium (D); pygidial margin (E, F). Second instar female: pygidial margin (G). First instar: cephalic margin and antenna (H). Georgia, on *Quercus virginiana*.

short seta present near base of each median lobe, probably representing segment 9.

Anal opening.—Ca. 10.9–14.0 wide, and situated ca. 13 times its width from apex of median lobes.

VENTRAL SURFACE.—*Antennae.*—Short, tuberculate, with 1 elongate fleshy

seta, 1-2 shorter protuberances, and 2 invaginated setae.

Spiracles. - Situated mesolaterally; 2-3 trilocular disc pores, positioned slightly anterolaterad of each anterior spiracle; no such pores near posterior spiracle.

Gland tubercles and gland spines. - Prothorax with 0-2 small submarginal gland tubercles; mesothorax with 0-3, metathorax with 1-4. Abdominal segments 1-3 with 2-3, 1-3, and 1-3 gland tubercles respectively. Marginal gland spines present, 2-3 on fourth abdominal segment, and 1 on each of segments 5-8.

Ducts. - Microducts numerous on prosoma, sparse on abdomen. Occasionally 1 submarginal microduct present on segments 4-5.

Perivulvar pores. - In 5 groups, anterior medians 4-6, anterior laterals 6-14, and posterior laterals 6-8.

Setae. - Several short setae scattered over prosoma and along body margin, usually with a very short submedian seta on head and each thoracic segment, and on abdominal segments 1-5, those on segments 3-5 often paired. Paired submarginal setae present on abdominal segments 1-4; 1 marginal and 1 submarginal seta on each of segments 5-7, and a single very short marginal seta on segment 8, this seta located at base of median lobes. Marginal setae longest on segments 6-7.

Vulva. - Posterior to anal opening and easily distinguishable.

Material studied. - On *Quercus laurifolia*, 7 paratype adult females on 7 slides, Cumberland Island, Camden Co., Ga., June 14, 1969, Coll. R. Beshear; 2 adult females on 2 slides, Camden Co., Ga., June 16, 1971, Coll. R. Beshear; 1 adult female, Irwin Co., Ga., Sept. 18, 1973, Coll. R. J. Beshear. On *Q. nigra*, 1 adult female, Lowndes Co., Ga., Nov. 4, 1971, Coll. H. H. Tippins. On *Quercus* sp., 1 adult female, Echols Co., Ga., May 25, 1976, Coll. R. Beshear.

Second-stage male

DESCRIPTION. - Body elongate-oval, length of slide-mounted specimens 573 (543-616), width 265 (258-269). Cephalothorax slightly longer than abdomen. Pygidial margin with 3 pairs of lobes, the median lobes well developed, lobes 2 and 3 with numerous tooth-like projections; pore prominences also with several "teeth", giving entire pygidial margin a ragged appearance.

DORSAL SURFACE. - *Ducts.* - Typical two-barred macroducts present, 1 each on margin of abdominal segments 2-7. Usually with a single microduct submedially on head, occasional marginal and submarginal microducts on thorax, and numerous microducts scattered over abdomen as illustrated.

Setae. - Dorsal setal pattern typical for diaspidine second-stage males.

Anal opening. - 9.7 (9.5-10.2) wide, and situated 5.6 (4.8-6.1) times its width from apex of median lobes.

VENTRAL SURFACE. - *Antennae.* - Small tubercles, with 1 stout seta, 2-3 shorter protuberances, and 2 invaginated setae.

Spiracles. - Anterior spiracle with 1-2 trilocular pores anterolaterad of peritreme, posterior spiracle with none.

Ducts. - A few small macroducts submarginally on abdominal segment 1. Two microducts on head, one submedially anterior to clypeolabral shield, and 1 posterolaterad of antenna; a few microducts submarginally on thorax. Microducts on abdomen in 2 sizes, larger ducts in a longitudinal marginal row, 1 duct on each of abdominal segments 1, and 3-8; 2 marginal microducts on segment 2. Large marginal microducts on segments 7 and 8 with definite pore prominences. Smaller

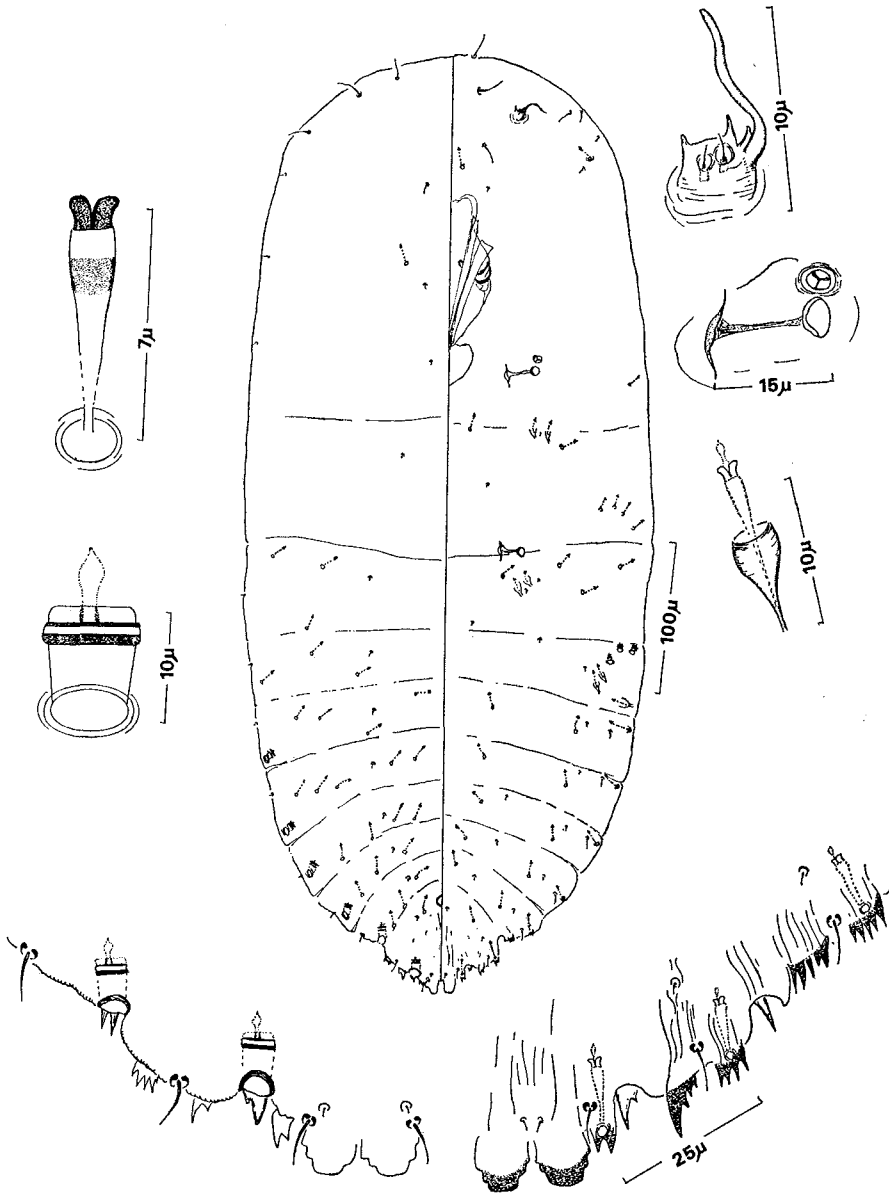


Fig. 6. *Quernaspis quercicola* Tippins and Beshear. Second-stage male. Georgia, on *Quercus virginiana*.

microducts in a longitudinal submedian row as illustrated. Submargin of abdomen with 1 small microduct on each of segments 2-7. A few gland tubercles on thorax and abdominal segment 1 as illustrated.

Setae.—Scattered over head and thorax. A short mesolateral seta on each of abdominal segments 4-7. A single short submarginal seta on abdominal segments

1-7. Marginal setae longest on segments 5-8.

Material studied. On *Quercus laurifolia*, 1 2nd stage ♂, Cumberland Island, Camden Co., Ga., June 14, 1969, Coll. R. Beshear; 1 2nd-stage ♂, Camden Co., Ga., Sept. 1, 1970, Coll. R. Beshear. On *Quercus* sp., 3 2nd-stage ♂ on 3 slides, Echols Co., Ga., May 25, 1976, Coll. R. Beshear.

DISCUSSION. - The adult female of *Q. quercicola* is an aberrant form of the genus *Quernaspis*. The separation of the median lobes immediately separates it from all known North American species in the genus. It is further separated by the absence of pygidial macroducts in the submedian and submarginal series, and by the more pronounced asymmetrical club-like paraphysis which arises from the sclerotized ring around the orifice of the macroduct in the first interlobular space. *Q. quercus* and *Q. insularis*, however, are very similar morphologically, and *Q. insularis* has no doubt been commonly misidentified as *Q. quercus*.

Quernaspis quercus and *Q. insularis* have a number of morphological similarities in the second-stage male. Macroducts on the margin are atypical, showing a "sclerotized frame" on one side, and the pygidial lobes are reduced and only lightly sclerotized. *Q. quercicola*, however, has typical "two-barred" macroducts on the margin, and the pygidial lobes are much better developed and are more heavily sclerotized.

The first instars of *Q. quercicola* are very similar morphologically to the other 2 North American species. In particular, all 3 species have "suranal ducts", a character known to occur only in the Chionaspidina (Howell and Tippins, 1977). All three species also possess submedian setae on the venter of the meso- and metathorax, but not on the prothorax. This characteristic is also common to all described 1st instars of the Chionaspidina, but is not commonly found in other species of the Diaspidinae.

Key to adult females

1. Median lobes separate on apical half; no pygidial macroducts in submarginal or submedian series *Q. quercicola*
- Median lobes fused over their entire length; pygidial macroducts present submarginally and submedially 2
2. Submedian macroducts usually numerous on pygidium, 8-16 on segment 4 *Q. quercus*
- Submedian macroducts not numerous on pygidium, 3-4 on segment 4 *Q. insularis*

Key to second-stage males

1. Macroducts on margin typical "two-barred"; 3 pairs of pygidial lobes present, median lobes well developed *Q. quercicola*
- Macroducts on margin atypical with sclerotized frame on one side; at most only 2 pairs of pygidial lobes present, none of these well developed 2
2. Only median lobes present, these poorly developed; marginal modified ("cup-like") macroduct on segment 5 reduced in size *Q. insularis*
- Median and second lobes present, poorly developed; marginal modified ("cup-like") macroducts on segments 5 and 6 reduced in size *Q. quercus*

EAST ASIAN SPECIES

[By S. TAKAGI]

Quernaspis nepalensis Takagi, n. sp.

(Fig. 7-9)

Sheopuri, Bagmati Zone, Nepal, alt. ca. 2000 m, on the branches of *Quercus semecarpifolia*, Aug. 31, 1975, coll. S. Takagi (material 75NPL-119).

Dunche, Bagmati Zone, Nepal, alt. 2280 m, on the branches of *Quercus semecarpifolia*, Sept. 18, 1975, coll. S. Takagi (material 75NPL-230).

Near Syabru, Bagmati Zone, Nepal, alt. 2400 m, on the branches of *Quercus lanuginosa*, Sept. 20, 1975, coll. S. Takagi (material 75NPL-248).

Mounted specimens include 83 adult females (53 from 75NPL-119; 22 from 75NPL-230; 8 from 75NPL-248), over 30 2nd instar males (from 75NPL-230), and exuvial casts. The description is based on about 30 adult females (1 of them is the holotype, which is deposited in the Entomological Institute, Hokkaidô University) and 15 2nd instar female exuvial casts from 75NPL-119 and 15 2nd instar males.

Adult female elongate, on slide about 2.2-2.4 times as long as wide and attaining about 1.6 mm in length. Cephalothorax slender, gradually broadening towards robust abdomen, free abdominal segments little or slightly lobed laterally; pygidium broad, roundish along free margin. Derm remaining membraneous except for pygidium. Sclerotized submarginal dorsal bosses 1 on each of abd. i, iii and v, at times also on abd. iv.

Median lobes fused together basally, their apices well separated, each lobe more or less roundish or rather triangular, not serrate or notched, at most with a slight prominence on lateral side. Second lobes reduced to marginal serrations laterally to a strongly sclerotized, pointed pore prominence. Third and 4th lobes also suggested by marginal serrations. Four sets of paired marginal gland spines on each side of pygidium, belonging to abd. v-viii, each pair composed of gland spines unequal in length, the pair on lateral side of median lobe much smaller than the others; 2-4 gland spines on abd. iv, 1 or 2 of them situated on margin and more or less elongate, the remainder if present (usually present) occurring within margin and more or less conical. Small gland spines on meso- and metathorax and abd. i-iii, conical or tubercular, produced apically into a slender membraneous process, arranged as follows: 1 or 2 in mesothoracic region; 2-5 lateroposteriorly to posterior spiracle; 3-10, 2-5, and 2-6 on abd. i, ii, and iii, respectively, in submarginal region.

Dorsal macroducts of pygidium short and robust; 1 marginal between median and 2nd lobes (on abd. vii), with a thick rim around orifice, 1-3 in submedio-submarginal region anteriorly to the macroduct; 5-11 on abd. vi, 2 of them situated on or near margin, the others scattered in submedio-submarginal region; 2-7 scattered in submedian region and 6-10 in submarginal to marginal region on abd. v, total 9-16. Prepygidial macroducts scattered as anteriorly as mesothoracic region on dorsal surface and beyond anterior spiracles on ventral surface, gradually reduced in size towards anterior segments, becoming hardly distinguishable from microducts in thoracic region; dorsal macroducts scattered in submedian and submarginal regions on metathorax and prepygidial abdomen, and also in median region on meso- and metathorax and often also on abd. i or on abd. i and ii;

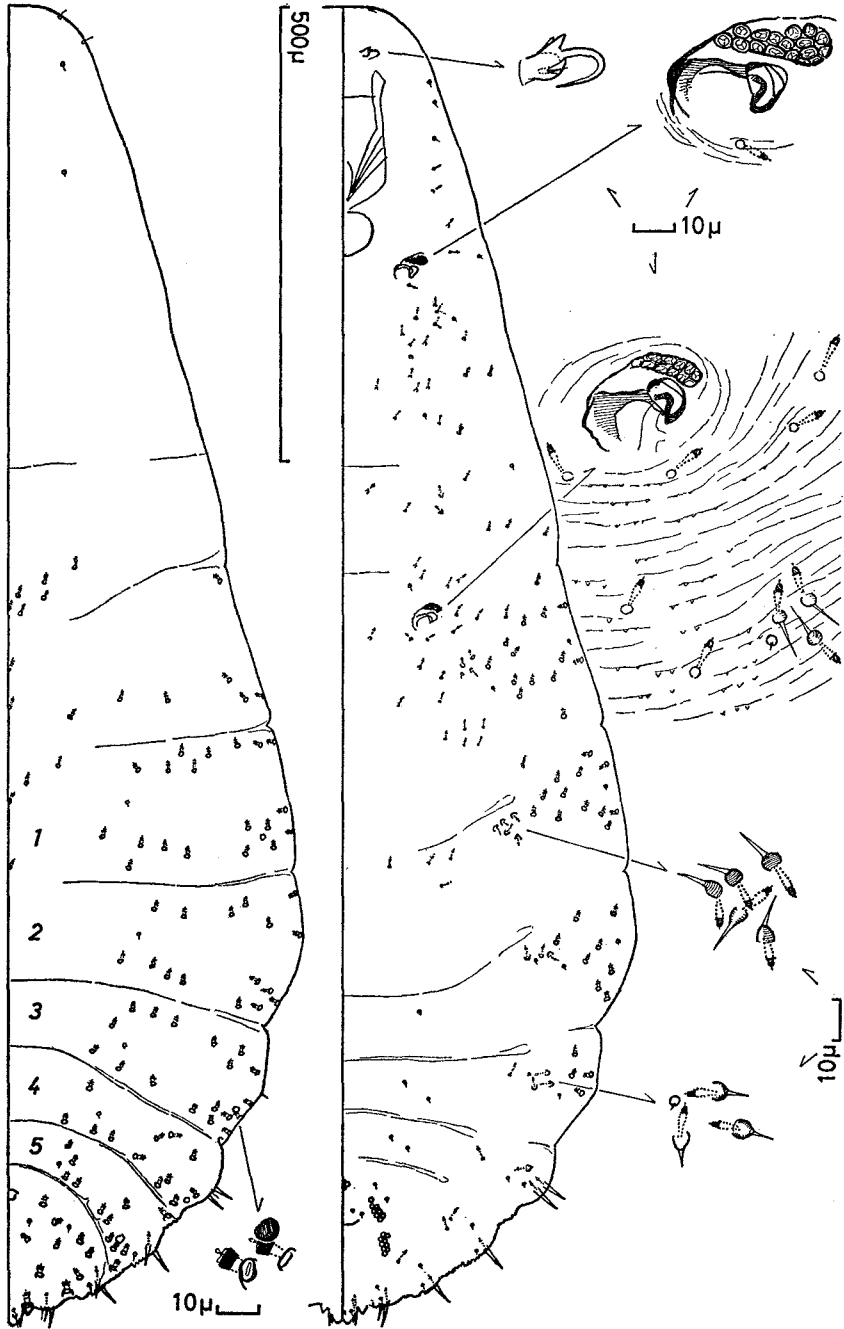


Fig. 7. *Quernaspis nepalensis* Takagi, n. sp. Adult female. 75NPL-119.



Fig. 8. *Quernaspis nepalensis* Takagi, n. sp. Adult female: pygidium (A, B). Second instar female, exuvial cast: pygidial margin (C, D). 75NPL-119.

ventral macroducts scattered in submarginal region on abd. i-iii and thoracic segments.

Perivulvar disc pores in 5 groups; 2-8 medians, 4-10 anterolaterals, 4-14 posterolaterals, total 30-45 (mean 34.8). Anal opening in bottom of pygidium. Anterior spiracles situated just posteriorly to mouth-parts, each with a cluster of about 10-23 trilocular disc pores; posterior spiracles each with a similar or more or less smaller cluster of disc pores. Antennae each with 1 fleshy seta and two minute setae.

Exuvial cast of 2nd instar female elongate pyriform, attaining about 0.8 mm in length, about 1.6-1.7 times as long as wide, with a distinct demarcation between metathorax and abd. i. Median lobes appressed together, each lobe rounded, with a distinct notch laterally. Second and 3rd lobes reduced to serrations. Pore prominence between median and 2nd lobes well sclerotized and acute. Marginal gland spines single, on abd. ii-viii. Four marginal dorsal macroducts on each side of pygidium, belonging to abd. iv-vii. Smaller macroducts 1 on each of abd. i-iii near margin (rarely 2 on abd. i); 3-5 on metathorax and 1-3 on mesothorax, scattered within margin; similar submedian dorsal macroducts 1 on each of abd. iv-vi, often lacking on 1 or 2 or all of these segments.

Second instar male elongate ovate. Pygidial margin ragged with sclerotized tooth-like processes. Ducts on metathorax and abdomen on both dorsal and ventral surfaces and also on mesothorax on ventral surface, scattered on thorax, but forming longitudinal rows on abdomen; 1 macroduct located on supposed abd. iii near margin appearing different from others but little "cup-like" in structure. Conical or tubercular gland spines just posteriorly to anterior spiracle, latero-posteriorly to posterior spiracle, and on base of abdomen submarginally, usually 3 or 4 in number in each position. Anterior spiracles each with 2-7 trilocular disc pores; posterior spiracles each with 1-3.

Scale of female slender, highly convex dorsally (the body of a living adult female, therefore, must be plump), with exuvial casts terminal, yellowish brown, and with secretion white, smooth, appearing tough; whole scale attaining about 2 mm in length. Scale of male with secretion white, flat and carinate.

Adult female specimens mounted from 75NPL-248 (near Syabru, on *Quercus lanuginosa*) are different from those from 75NPL-119 and 75NPL-230 (Sheopuri and Dunche, on *Quercus semecarpifolia*), having fewer perivulvar disc pores (Table 1). But in the number of pygidial dorsal macroducts no distinct difference is found between them. Although not all of the mounted specimens are in good condition to give exact numbers of other macroducts, gland spines and spiracular disc pores, numerical reduction of these external secretories in the Syabru specimens is apparently never as remarkable as that of the perivulvar disc pores. The Syabru specimens may tentatively be referred to *Q. nepalensis*.

Quernaspis lithocarpi (Takahashi)

This species was described by Takahashi (1931) from Taiwan under the name



Fig. 9. *Quernaspis nepalensis* Takagi, n. sp. Second instar male. 75NPL-230.

Pinnaspis lithocarpi on the basis of specimens collected on the leaves of *Lithocarpus* sp. It has been thought of as a *Quernaspis* species by later authors. So far as based on the original description it is very close to *Quernaspis chiulungensis* n. sp., differing from the latter by the median lobes wholly fused together and not serrate.

Table 1. Total number of perivulvar disc pores
in *Quernaspis nepalensis*.

Material	75NPL-119	75NPL-230	75NPL-248
<i>n</i>	29	21	8
range	30-45	32-41	23-31
mean	34.8	34.9	26.8

The macroducts and perivulvar disc pores may be more numerous in *Q. lithocarpi* than in *Q. chiulungensis*.

Quernaspis chiulungensis Takagi, n. sp.

(Fig. 10-12)

Kowloon [Chiulung] Peninsula, opposite Hongkong Island, on the leaves of *Castanopsis indica* (identified by Prof. S. Hatusima), Apr. 22, 1965, coll. S. Takagi.

Mounted specimens include about 130 adult females, about 50 2nd instar males, and exuvial casts. The description is based on about 30 adult females (1 of them is the holotype, which is deposited in the collection of the Entomological Institute, Hokkaidō University), 15 2nd instar female exuvial casts, and 15 2nd instar males.

Adult female elongate, on slide about 2.5 times as long as wide and attaining about 1 mm in length. Cephalothorax gradually broadening posteriorly, free abdominal segments little or slightly lobed laterally; pygidium roundish along free margin. Derm remaining membraneous except for pygidium.

Median lobes set quite close together, united basally, each lobe pointed apically, roughly serrate on long sloping outer margin. Second lobes reduced to marginal serrations laterally to a well-sclerotized, conical pore prominence. Third and 4th lobes obsolete. Four single marginal gland spines on each side of pygidium, belonging to abd. v-viii. Prepygidial submarginal gland spines small, conical or tubercular, with apex protruded into a slender, membraneous process; 1 occasionally present on abd. iv, 1-2 on abd. iii, 2-4 on abd. ii and also on abd. i, 1-3 on metathorax, 1-3 at times present on mesothorax.

Dorsal macroducts of pygidium short and robust; 1 marginal between median and 2nd lobes (on abd. vii), with a thick rim around orifice; usually 4 macroducts on abd. vi (1 submedian, 1 submarginal, and 2 marginals); 4-7, usually 5 or 6, on abd. v (usually 2 submedians, 1 or 2 submarginals, and 2 marginals). Smaller submarginal macroducts scattered as anteriorly as metathorax; about 6-8 on each of metathorax and abd. i and ii, some of them dorsal and others ventral; about 2-4 on each of abd. iii and iv, dorsal. Prepygidial submedian dorsal macroducts small, on abd. i-iv, few on each segment (1 or 2 on abd. i and also on abd. ii, rarely absent on abd. i; 1 or 2, or at times 3 or 4 on abd. iii; 2 or 3 on abd. iv).

Perivulvar disc pores in 5 groups; 2-4 medians, 2-6 anterolaterals, 2-7 posterolaterals, total 19-25 (mean 21.9). Anal opening in bottom of pygidium. Anterior spiracles situated just posteriorly to mouth-parts, each with a single trilocular disc pore; posterior spiracles without disc pore. Antennae each with 1 fleshy seta and 2 minute setae.

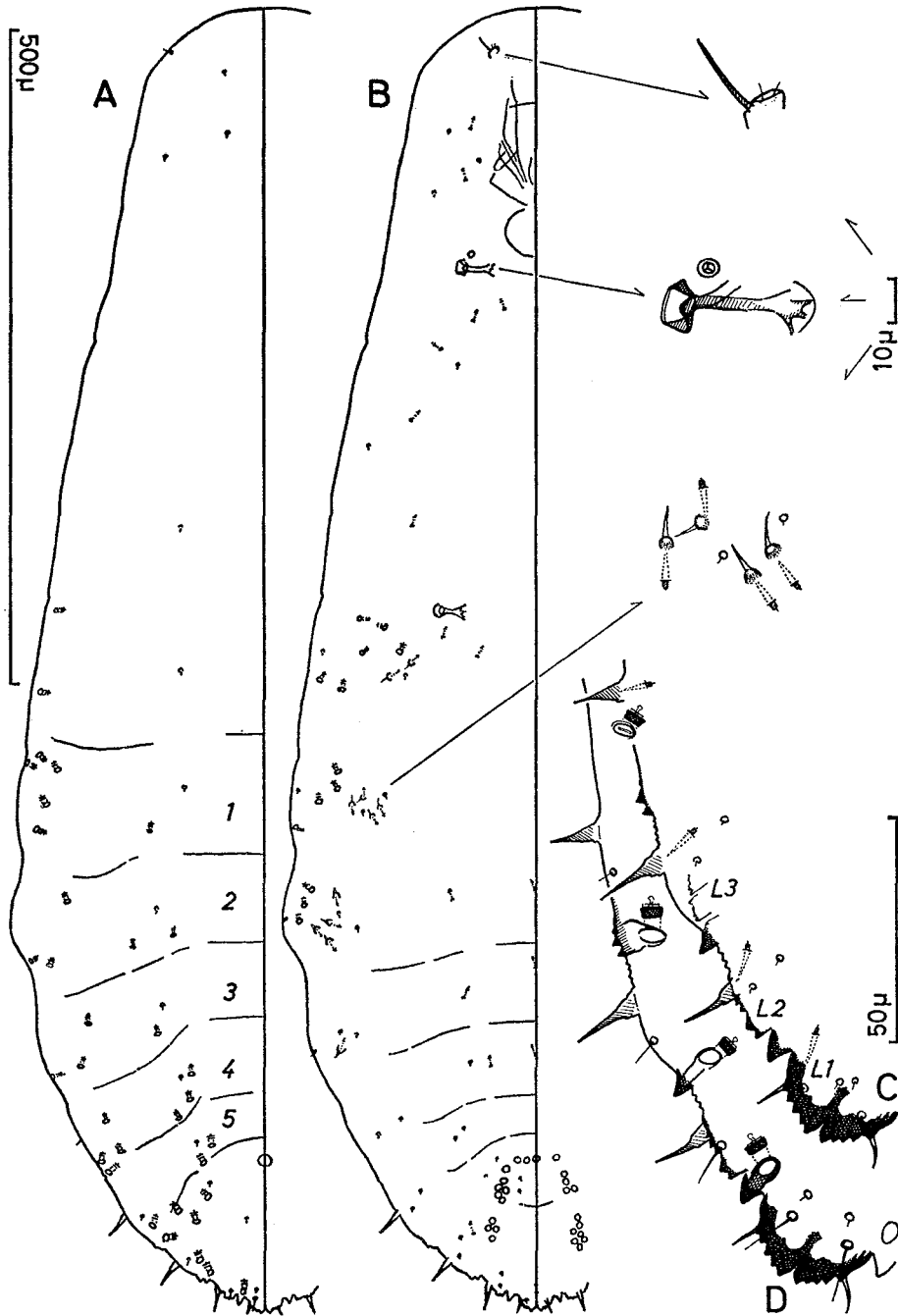


Fig. 10. *Quernaspis chinlungensis* Takagi, n. sp. Adult female (A, B). Second instar female, exuvial cast: pygidial margin (C, D.) Kowloon Peninsula, on *Castanopsis indica*.



Fig. 11. *Quernaspis chiulungensis* Takagi, n. sp. Adult female: pygidium. Kowloon Peninsula, on *Castanopsis indica*.

Exuvial cast of 2nd instar female elongate pyriform, attaining about 0.6–0.8 mm in length, about 1.4–2.0 times as long as wide. Pygidial margin similar to that of adult female. Four marginal macroducts on each side of pygidium,

belonging to abd. iv-vii; 4 small macroducts on each side of prepupoidal region along margin, 1 on each of metathorax and abd. i-iii.

Second instar male elongate ovate. Pygidial margin ragged with sclerotized processes, among which the posteriormost processes (median lobes) are robust and serrate. Ducts on metathorax and abdomen on both dorsal and ventral surfaces and also on mesothorax on ventral surface, forming longitudinal rows on abdomen; 2 macroducts situated on supposed abd. ii and iii near margin appearing to be different from others but little "cup-like" in structure. Small gland spines 2-4 (usually 2) just posteriorly to anterior spiracle, 1 or 2 (usually 1) lateroposteriorly to posterior spiracle, and 3 on base of abdomen in submarginal region. Anterior spiracles each with 1 trilocular disc pore; posterior spiracles without disc pores.

Scale of female elongate, well convex dorsally, with exuvial casts terminal and pale yellow, and with secretion grayish white; whole scale attaining about 1.5 mm in length. Scale of male with secretion white and carinate. Scales of both male and female occurring on the underside of leaves.

Relationship among the East Asian species

The only remarkable difference presumed between *Q. lithocarpi* and *Q. chiulungensis* is that the median lobes of the pygidium are fused wholly in the former and only basally in the latter. The median lobes provide useful characters for scale insect taxonomy. But the state of them is not always constant for a taxon, and is evaluated in combination with other characters. We even know some cases where the median lobes show remarkable variations in connection with feeding sites. Both *Q. lithocarpi* and *Q. chiulungensis* feed on the leaves of the host plants, so that the difference of the median lobes between them is not ecophenotypic. This difference, however, cannot be taken seriously when other characters are taken into consideration. Although *Q. lithocarpi* is known to me only from the description, I have little doubt that *Q. lithocarpi* and *Q. chiulungensis* are very close in phylogenetic relationship. Their localities, Taiwan and Kowloon Peninsula, are also quite close.

Differences in adult female characters between *Q. chiulungensis* (with its close relative *Q. lithocarpi*) and *Q. nepalensis* are quite obvious, but it is easy to abstract from these species a common body plan involving most observable features. Some of the characters taking part in constructing the plan are: appressed median lobes flanked on each side with a strong, pointed pore prominence, which is confluent with the sclerotized thickened rim of a marginal macroduct situated at its base, and which is followed by marginal serrations standing for the 2nd lobe; short macroducts tending to be scattered rather than arranged in well-defined segmental rows; and so on. The 2nd instar larvae of both sexes are also identical between *Q. chiulungensis* and *Q. nepalensis* in general construction of body.

The 1st instar larvae of *Q. chiulungensis* and *Q. nepalensis* should briefly be described here on the basis of exuvial casts. They have 6-segmented antennae, of which the terminal segment is a little shorter than the preceding segments united (Fig. 12, A shows the antenna of the 1st instar male of *Q. chiulungensis*). A pair of enlarged dorsal ducts are found on the head in either sex of *Q. chiulungensis*; they are present in the female but absent in the male of *Q. nepalensis*. In the 1st



Fig. 12. *Quernaspis chiulungensis* Takagi, n. sp. First instar male, exuvial cast: antenna (A). Second instar male (B-D). Kowloon Peninsula, on *Castanopsis indica*.

instar female of *Q. nepalensis* the marginal processes around the abdominal apex are well developed, whereas in the male they are somewhat reduced. In *Q. chiulungensis* these processes are more reduced in both sexes and almost into traces in the male. The "suranal ducts" (see p. 46) are found in these Asian species, too, in the 1st instar larvae of both sexes.

DISCUSSION AND CONCLUSION

Q. quercicola seemingly deviates from the other North American species. All these species, however, form a sequential series in the numbers of the dorsal ducts, gland spines, spiracular disc pores and perivulvar disc pores of the adult females. These external secretories agree in becoming successively fewer from *quercus* through *insularis* to *quercicola* (Fig. 13). The pygidia of the adult females also become successively more acute following this order. Contrarily, the separated median lobes abruptly appear in the adult female of *Q. quercicola*. But as in the case of the Asian species *Q. lithocarpus* and *Q. chiulungensis* this state of the median lobes may not be taken too seriously. In the other Asian species *Q. nepalensis* the median lobes are obviously fused together basally in the adult female, but in the 2nd instar female they are merely appressed together.

Q. quercicola remarkably differs from the other North American species in the 2nd instar males, first by lacking "cup-like ducts", and secondly by having well-developed marginal processes of the pygidium. But some "cup-like ducts" are occasionally replaced by usual ducts in *Q. quercus*. Further, a drastic change of 2nd instar male characters was reported in the *nachiensis*-series of *Fiorinia*, a group of species closely related so far as based on female characters (Takagi, 1975).

The series *quercus* - *insularis* - *quercicola* may possibly be identical or approximately so with an evolutionary sequence. Separated median lobes such as seen in *Q. quercicola* must originally be primitive in comparison with fused lobes, but it is also possible that the state in *Q. quercicola* is an atavism. We have no intention to go further. But we would like to emphasize that all the North American species possibly form a close phylogenetic group in spite of "aberrant" characters displayed by one of them.

The East Asian species also form a fairly close group (see above), which is remarkably similar to the North American group. In the adult females both groups are peculiarly characterized by having appressed median lobes flanked on each side with a strong, sclerotized process accompanied by a thickly rimmed, short macroduct. The strong process flanking the median lobe is, however, the pore prominence of the 7th abdominal segment in the Asian species, whereas it is probably the inner lobule of the 2nd lobe in the American species. In *Q. quercus* a small prominence is at times visible on the inner side of the process, and it is supposed to be the reduced pore prominence (Fig. 14, A). This is also true in the 2nd instar female (Fig. 1, G; Fig. 14, B-E). In the Asian species the 2nd lobes are reduced to marginal serrations instead. Another difference lies with the enlarged asymmetrical sclerosis around the marginal macroduct between the median and 2nd lobes of the North American species. Although a sclerosis is present in the Asian species, it is not so pronounced or as asymmetrical as that found in the American species. Further, in the American species the macroducts

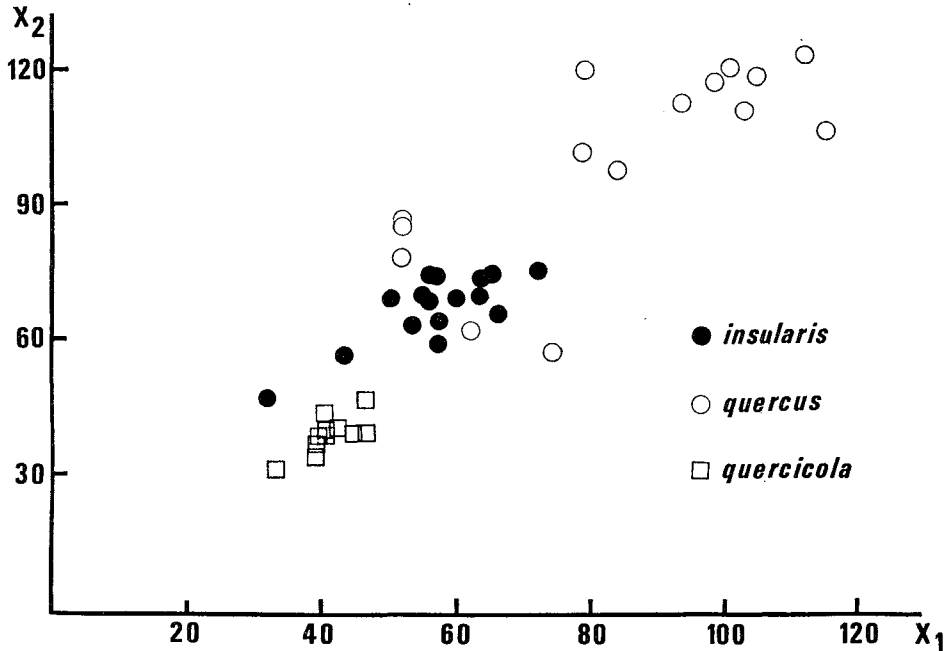


Fig. 13. Number of perivulvar disc pores (X_1) against number of gland spines (X_2) in some specimens of adult female *Quernaspis quercus*, *Q. insularis* and *Q. quercicola*.

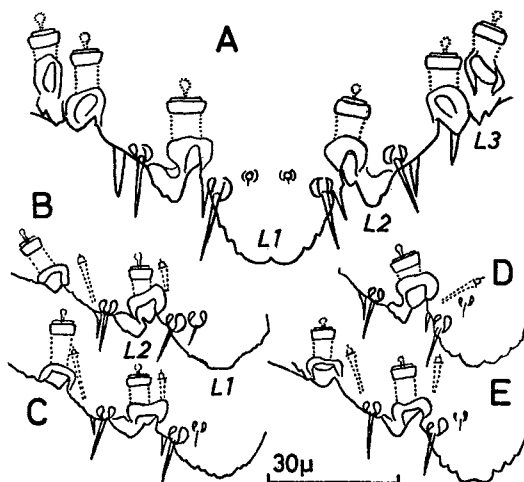
other than the marginals have a strong tendency to be reduced in size, whereas in the Asian species the tendency is less pronounced.

In the 2nd instar males the American species in comparison with the Asian species are characterized by dorsal and ventral ducts mostly much reduced in size. This may be another manifestation of the tendency shown in the duct system of the adult females. In the Asian species definite "cup-like ducts" are not seen and the marginal processes of the pygidium are well developed. In these features the American group itself is variable as stated above. At a glance the 2nd instar males appear fairly different among the species, and they may be grouped into 3 types: *Q. quercus* and *Q. insularis*; *Q. quercicola*; and *Q. nepalensis* and *Q. chiulungensis*. It is not sufficient for us merely to make a formal comparison among these types, but we need to try giving evolutionary explanations for them and finding connections among them. However, our knowledge of this stage of development, as well as of the 1st instar larva and adult male, is still very poor. We only want to point out here that we are getting an increasing number of cases where the 2nd instar males are strikingly different among species which appear to be related in the adult females.

The 1st instar larvae also show a difference between the groups. In both groups the antennae are 6-segmented, but the terminal segment is relatively much shorter in the American species.

We are inclined to the opinion that the differences between the American and Asian species in the larval stages and adult females are due to divergence, rather

Fig. 14. *Quernaspis quercus* (Comstock). Adult female: apex of pygidium (A). Second instar female, exuvial cast: apex of pygidium (B-E). A, D, and E: Palo Alto, San Francisco, California, on *Quercus agrifolia*. B and C: Mt. Wilson, California, on "oak branch". (In A the pore prominence of the 7th abdominal segment is visible on the right side in the figure, between the median and 2nd lobes. It is visible in B and C, but quite reduced in D and E.)



than to the opposite that the apparent resemblance between the adult females is due to convergence. For we do not think that we have any positive evidence in support of the latter opinion. All these species are associated with *Quercus* and allied genera (*Lithocarpus*; *Castanopsis*) of Fagaceae. The body plans of the adult females are fairly close between the American and Asian species, remarkably differing only in the accentuated 2nd lobe or pore prominence combined with the reduced pore prominence or 2nd lobe. For this reason all these species should tentatively be lumped together under *Quernaspis*. As other species are found, we may revise our thinking accordingly. In any event, we believe that we have evidence to support a possible Asio-American bicontinental connection between these two groups of scale insects.

No other North American scale insects seem to be related to *Quernaspis*. In the Old World certain genera, e.g., *Contigaspis*, show some resemblance to *Quernaspis*, but may not particularly be related with the latter. "*Pinnaspis lithocarpi* var. *siamensis*" described by Takahashi (1942) and associated with *Lithocarpus* in Thailand may have nothing to do with *Q. lithocarpi*.

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