

New records of the carabidicolous Laboulbeniales (Ascomycetes) of Japan (II)

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Six carabidicolous species of Laboulbeniales are reported as new for the Japanese mycoflora. They are *Laboulbenia finitima*, *L. separata*, *L. borneensis*, *L. manubriolata*, *Dimeromyces caribaeus*, and *Dixomyces ornatus*. In Japan, the former three species are parasitic on *Mochtherus luctuosus* and the latter three species on *Perigona nigriceps*. *Laboulbenia finitima* occurs on the left legs (tarsi and tibiae); *L. separata* on the left elytral margin; *L. borneensis* on the pronotum; *L. manubriolata* on the pronotum and elytra; *Dimeromyces caribaeus* on the right inferior posterior surface of the prothorax (pronotal hypomeron); and *Dixomyces ornatus* on the outer margin of the right elytron. Comments and photographs are given for each fungus.

Key Words—Carabidae; *Dimeromyces*; *Dixomyces*; Japan; *Laboulbenia*.

As a continuation of my previous study (Terada, 1998), six additional species of Laboulbeniales, four in *Laboulbenia* and one each in *Dimeromyces* and *Dixomyces*, are reported from Japan. The species were originally described from tropical Asia and tropical America (Thaxter, 1899, 1902, 1915, 1920). The present report extends the known ranges of these species to Japan.

Abbreviations used here are based on those of Benjamin and Shanor (1950) and Tavares (1985).

Laboulbenia finitima Thaxter, Proc. Amer. Acad. Arts Sci. **35**: 176. 1899. Type: On *Pericalus guttatus* Chevrolat, Java (see Thaxter, 1908, p. 466). Figs. 1–3
Specimens examined: On *Mochtherus luctuosus* Putzeys. KT-866, 869, 870, 22-IV-1978, K. Terada leg., Tanoshiri, Tsutsuga, Hiroshima Pref.; KT-1440, 10-X-1998, Y. Kurosa leg., Sasuna, Tsushima, Nagasaki Pref.

Measurements: Total length to tip of perithecium 200–230 μm ; perithecia (excluding cell VII) 100–105 \times 30–40 μm ; appendages 115–150 μm long.

This fungus is characterized by the color combination and the arrangement of the receptacle cells. The receptacle is dark brown except for hyaline cell I. Cell V is wedge-shaped, with the lower end very close to, but not touching, the upper end of cell III. Cell VI is triangular (wedge-shaped), located beside cell II, with the lower end touching the upper end of cell I. The outer appendage is single and filamentous (simple), extending somewhat beyond the perithecial apex, almost colorless except for the basal cell, whose outer side is blackened. The inner appendage consists of a basal cell and two filamentous branches on either side; the basal cell is half as tall as the basal cell of the outer appendage. The perithecium is dark brown, but usually paler in the upper half,

almost parallel-sided (cylindrical), and with blunt, rounded apical lobes. One or two slender antheridia and a relatively short simple trichogyne with colorless septa are formed in young thalli (Fig. 1, tr).

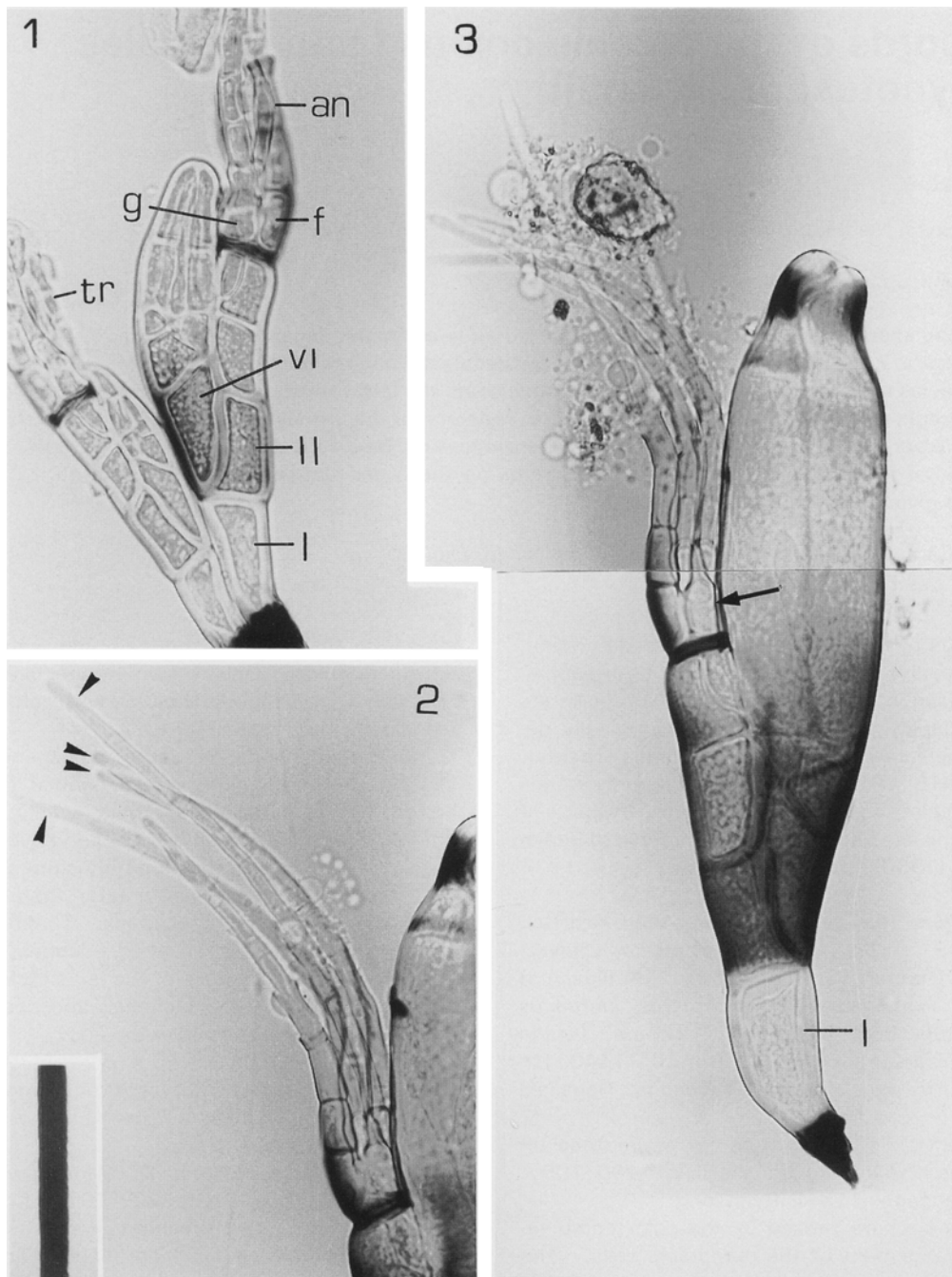
In the original description of this species by Thaxter (1899), the perithecium was described as “olivaceous brown, lighter distally, becoming wholly dark brown”, but no olivaceous shades were observed in the Japanese specimens. The size of the perithecium given by Thaxter (1899) was somewhat greater than the measurements of the Japanese specimens. Thaxter (1908) published three full drawings of this fungus, in which the thallus, with the exception of the receptacle cell I and the appendages, is wholly blackened and opaque, and the perithecium is barely lobed at the apex.

Laboulbenia separata Thaxter, Proc. Amer. Acad. Arts Sci. **35**: 200. 1899. Type: On *Pericalus guttatus* Chevrolat, No. 571, Java. Figs. 4–7

Specimens examined: On *Mochtherus luctuosus* Putzeys. KT-867, 870, 22-IV-1978, K. Terada leg., Tanoshiri, Tsutsuga, Hiroshima Pref.; KT-1407, 1-VI-1997, K. Terada leg., Uchiguro-yama, Togouchi, Hiroshima Pref.; KT-1439, 10-X-1998, Y. Kurosa leg., Sasuna, Tsushima, Nagasaki Pref.

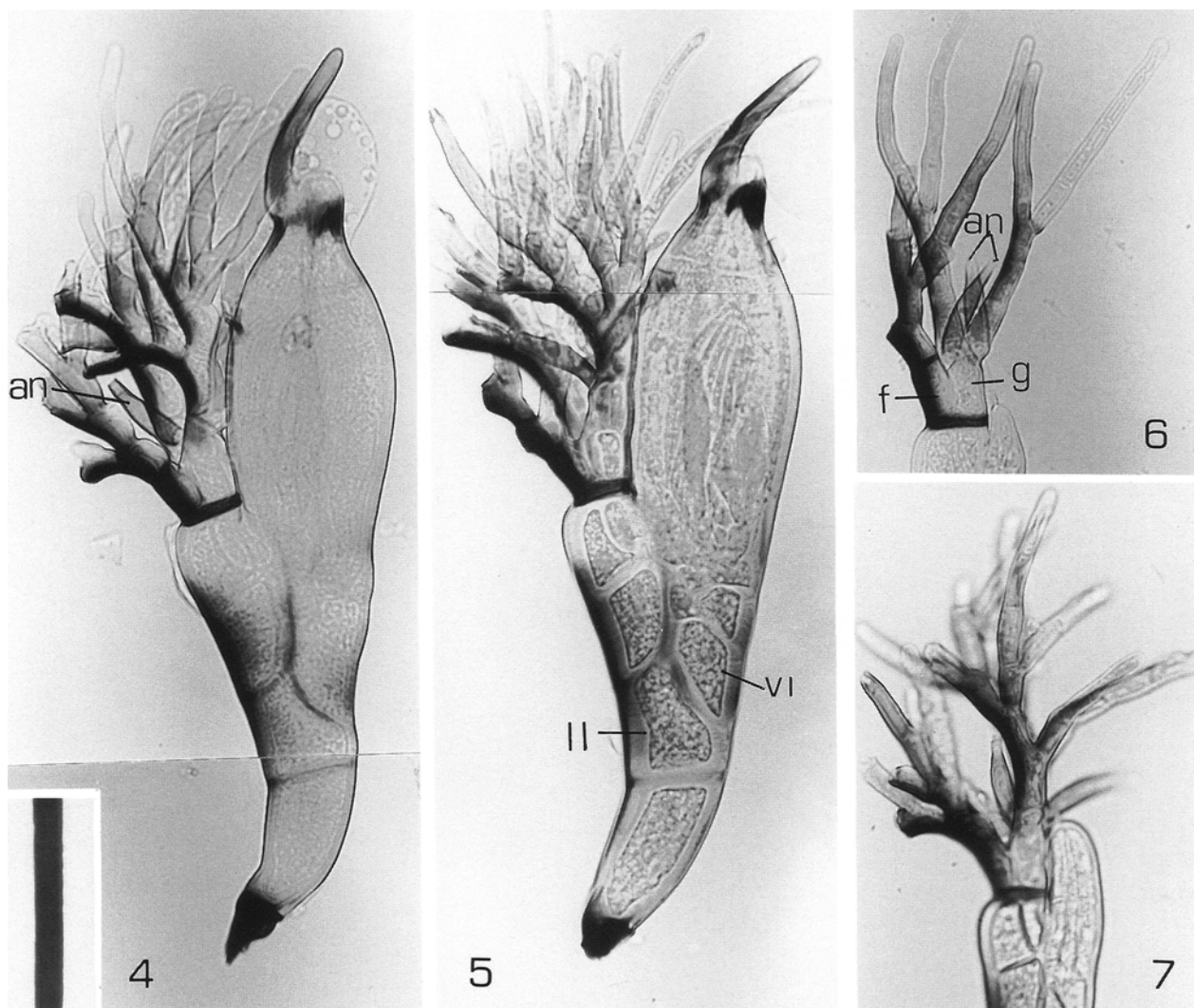
Measurements: Total length to tip of perithecium 180–190 μm ; perithecia (excluding cell VII) 90–100 \times 35–40 μm ; perithecial projection 30–40 \times 4.5 μm ; appendages 110–125 μm long.

This fungus is characterized by a perithecium bearing a finger-like elongation at the apex and appendages that are frequently branched and blackened externally. The receptacle is pale yellowish brown except for a darker middle portion. Cell II is very short. Cell V is wedge-shaped, with the lower end very close to, and almost



Figs. 1-3. *Laboulbenia finitima* (on *Mochtherus luctuosus*).

(1) Pair of young thalli showing arrangement of receptacle cells in which cell VI was separated from side of cell II and its lower end touches cell I. Basal cell (g) of inner appendage is half as tall as outer basal cell (f). Single slender antheridium (an) arises from branch of inner appendage. Relatively short, simple trichogyne (tr) has hyaline septa. KT-870. (2) Appendages with hyaline filamentous branches; basal cell of outer appendage is blackened externally; basal cell of inner appendage bears two filamentous branches on either side. Each arrowhead indicates tip of inner appendage branch. KT-1440. (3) Mature thallus showing perithecium with blunt apex and with parallel sides, and receptacle with hyaline cell I. Arrow indicates position of septum between basal cell and suprabasal cells of inner appendage. KT-1440. Bar=50 μ m.



Figs. 4-7. *Laboulbenia separata* (on *Mochtherus luctuosus*).

(4) Mature thallus with much-branched and externally blackened appendages and dark slender antheridium (an); receptacle partly suffused with dark color; perithecium with dark finger-like projection at apex and with slightly convex sides. KT-1407. (5) Mature thallus showing arrangement of receptacle cells in which cell II is very short and cell VI extends downward. KT-867. (6) Appendages of young thallus, with branches dichotomously branched and with dark slender antheridia (an). Basal cell (g) of inner appendage is almost same height as outer basal cell (f). KT-866. (7) Appendages of young thallus in more advanced stage, with branches successively branched. KT-1407. Bar=50 μ m.

touching, the upper end of cell III. Cell VI is pointed downward (wedge-shaped), with the lower end very close to, but not touching, the upper end of cell I. Appendages extend somewhat beyond the perithecial apex; basal cells of the outer and inner appendages are equal in height. The perithecium is pale yellowish brown, slightly convex laterally, and bears a finger-like projection at the apex. Dark slender antheridia are formed in both young and mature thalli (Figs. 4 and 6, an).

In the original description of this species by Thaxter (1899), the perithecium was described as "pale olivaceous" and the receptacle was described as "dull olivaceous", but no olivaceous color was observed in my specimens. The finger-like projection was described as

"almost hyaline", whereas in my specimens, it is dark as shown in Figs. 4 and 5. The total length of the thallus given by Thaxter (1899) was greater than my measurements, but the finger-like projection is shorter. Thaxter (1908) published two full drawings of this fungus, in which the receptacle cell II is longer than in the Japanese material, so that receptacle cell VI is rather distant from receptacle cell I, and the perithecium is nearly straight on the outer side in Thaxter's illustration (sub-cylindrical).

Laboulbenia borneensis Thaxter, Proc. Amer. Acad. Arts Sci. 38: 28. 1902. Type: On *Thyreopterus* (?) sp., No. 1201, Borneo. Figs. 8-12

Specimens examined: On *Mochtherus luctuosus*



Figs. 8–10. *Laboulbenia borneensis* (on *Mochtherus luctuosus*).

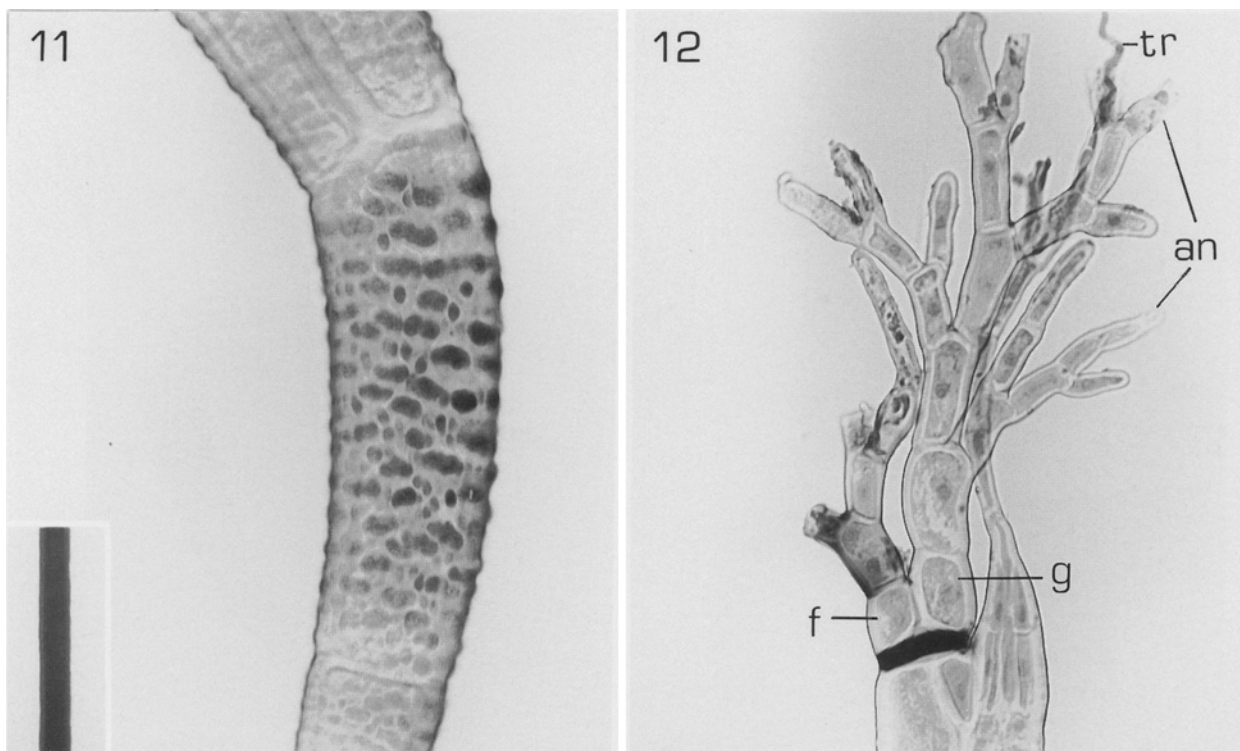
(8) Mature thallus with somewhat stout perithecium in which blackish hump is indicated by arrow. Receptacle is covered with dark brown warts on surface. Appendages are almost broken off. KT-380. (9) Mature thallus with long perithecium; outer appendage with two dark-colored superposed cells; inner appendage with two pale-colored superposed cells subtending much-branched appendage. KT-1439. (10) Mature thallus with somewhat slender perithecium. KT-1439. Bar = 100 μm .

Putzeys. KT-1444, 25-VIII-1997, T. Kosaka leg., Sandankyo, Togouchi, Hiroshima Pref.; KT-1439, 1440, 10-X-1998, Y. Kurosa leg., Sasuna, Tsushima, Nagasaki Pref.; KT-380, 26-III-1976, K. Terada leg., Kujukawa, Yakushima, Kagoshima Pref.

Measurements: Total length to tip of perithecium 450–520 μm ; perithecia (excluding cell VII) 140–215 \times 35–60 μm ; appendages 150–200 μm long.

This fungus is characterized by a perithecium with a blackish hump and a receptacle with dark brown warts and ridges spreading over the surface. The receptacle is pale yellowish brown except for “smoky brown” warts as described by Thaxter (1902). Cell V is wedge-shaped. Cell VI is oblong, located beside cell III, and as tall as the

latter cell. Appendages are dichotomously branched several times and extend beyond the perithecial apex; repeated branching results in formation of many short branchlets. The outer appendage consists of dark-colored superposed cells at the base (basal and suprabasal cells) and paler branches from the suprabasal cell. The inner appendage is similar in shape to the outer appendage, but basal and suprabasal cells are pale-colored and larger than those of the outer appendage. The perithecium is pale yellowish brown (“pale dull straw yellow, transparent with brownish suffusions” in the original description by Thaxter, 1902); the sides of the perithecium are almost parallel (cylindrical); one apical lobe projects distally. A long, branched, apically twisted



Figs. 11–12. *Laboulbenia borneensis* (on *Mochtherus luctuosus*).

(11) Warts on surface of cell II. KT-1439. (12) Appendages of young thallus, of which inner appendage is successively branched from suprabasal cell. Basal cell (g) of inner appendage is taller than outer basal cell (f). Some of branchlets bear antheridia (an). Long, branched, and apically twisted trichogyne (tr) has hyaline septa. KT-1439. Bar = 50 μm .

trichogyne with hyaline septa and several antheridia which arise singly at apices of branchlets are formed in young thalli (Fig. 12). The total length of the thallus and the size of the perithecium given by Thaxter (1902) are smaller than my measurements. Thaxter (1908) published a drawing of this fungus (as *L. thyreopteri*, pl. LV, Fig. 15), but his specimen had broken outer appendages.

Laboulbenia thyreopteri Thaxter has similar characters to *L. borneensis*. However, in *L. thyreopteri*, the outer appendage is unbranched and filamentous (simple) and the basal cell of the inner appendage produces a simple branch on either side (Thaxter, 1899, 1908). Thaxter (1908) considered *L. borneensis* as a synonym of *L. thyreopteri* from Africa (see pl. LXIV, Fig. 15), but he did not mention the difference in the shape of the appendages of the two species.

Laboulbenia manubriolata Thaxter, Proc. Amer. Acad. Arts Sci. 51: 44. 1915. Type: On a small carabid allied to *Tachys*, No. 2081 d, Java. Figs. 13–18
Specimens examined: On *Perigona (Trechicus) nigriceps* (Dejean). KT-1405, 1406, 1419, 1445, 16-VIII-1998, K. Terada leg., Mushiki-no-toge, Togouchi, Hiroshima Pref.

Measurements: Total length to tip of perithecium 215–330 μm ; perithecia (excluding cell VII) 90–120 \times 25–41 μm ; appendages ca. 135 μm long.

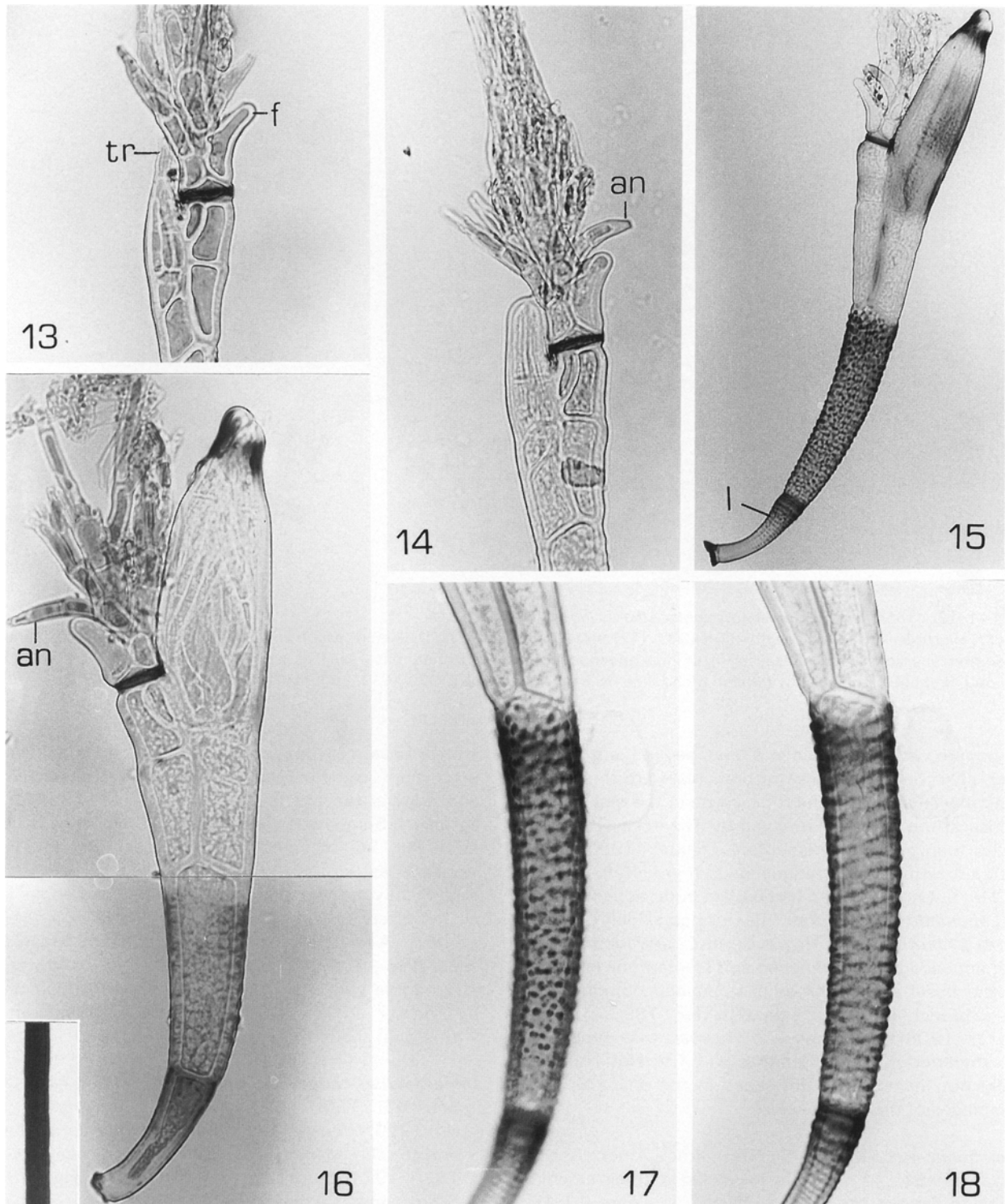
This fungus is characterized by an outer appendage

with a basal cell projecting backward (“the handle-like protrusion” in the original description by Thaxter, 1915) and a lower receptacle with dark-colored warts on the surface. Sometimes these warts are not conspicuous, as in Fig. 16, or completely disappear (Rossi, 1982). Appendages are several times branched and extend slightly beyond the perithecial apex. Antheridia arise singly, often turning outward as shown in Figs. 14 and 16 (an). A relatively short simple trichogyne has hyaline septa (Fig. 13, tr). In the color of the thallus, my specimens agree with the original description of this species by Thaxter (1915, “dirty straw-yellow throughout, or with brown shades”).

Dimeromyces caribaeus Thaxter, Proc. Amer. Acad. Arts Sci. 55: 260. 1920. Type: On *Perigona* sp., No. 2920, Grenada, West Indies (Orthographic correction for *D. caribbaeus* and *D. caribbeus*, see Thaxter, 1920, 1924). Figs. 19–24

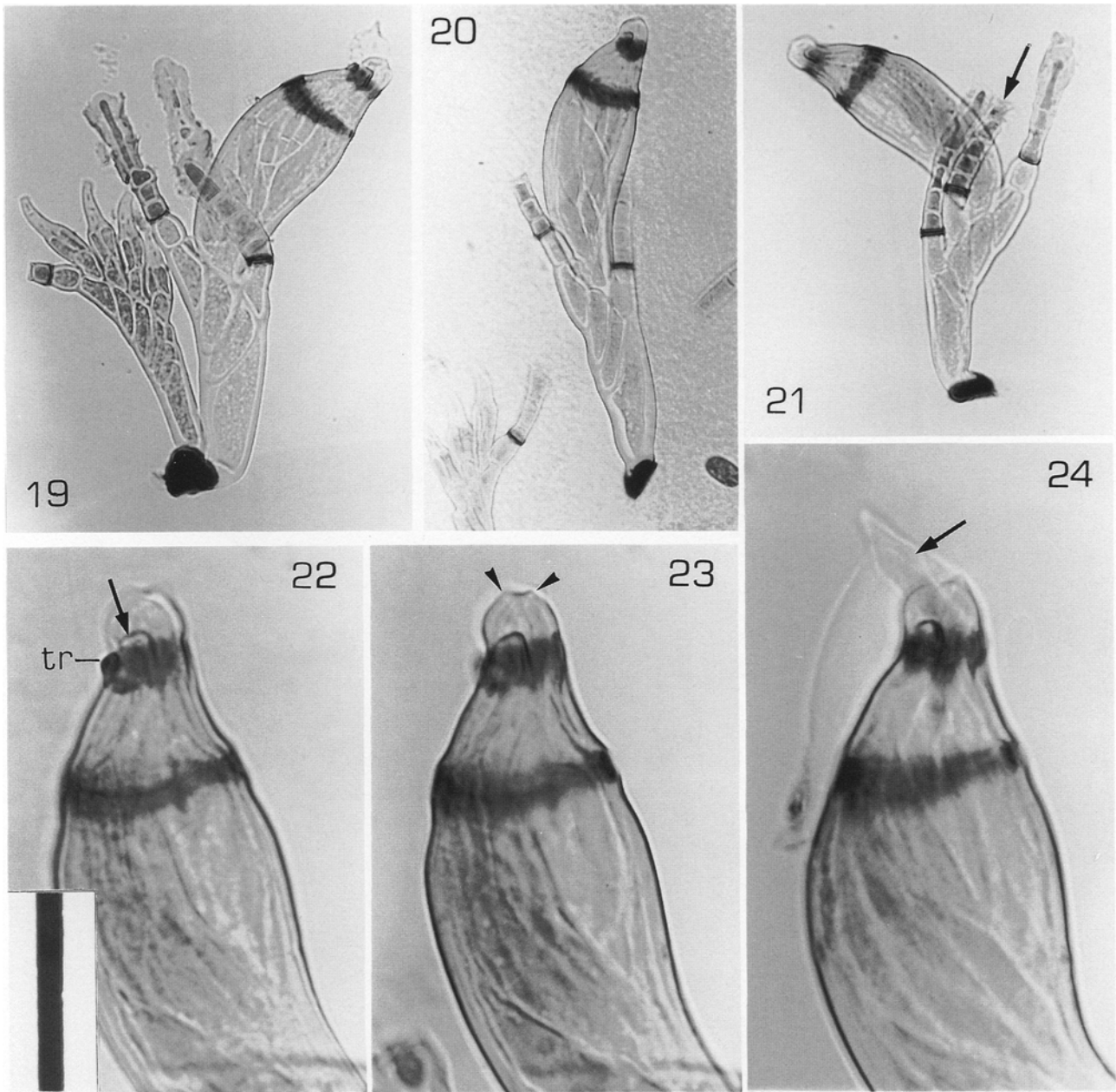
Specimens examined: On *Perigona (Trechicus) nigriceps* (Dejean). KT-1452, 13-IX-1998, Y. Nakamura leg., Udo-san, Oya, Shizuoka City, Shizuoka Pref.; KT-1405, 1406, 1445, 1450, 1451, 16-VIII-1998, K. Terada leg., Mushiki-no-toge, Togouchi, Hiroshima Pref.; KT-1466, 4-VII-1999, K. Terada leg., Nanatsuka, Shoubara, Hiroshima Pref.; KT-1467, 19-IV-1998, K. Terada leg., Miyajima, Hiroshima Pref.

Measurements: Total length to tip of perithecium



Figs. 13–18. *Laboulbenia manubriolata* (on *Perigona nigriceps*).

(13) Appendages of young thallus, with outer basal cell (f) forming “handle-like protrusion”. Relatively short trichogyne (tr) has hyaline septa. KT-1406. (14) Appendages of young thallus in which single antheridium (an) is bent outward. KT-1406. (15) Mature thallus with cylindrical perithecium and with long receptacle which consists of pale upper cells and dark warty lower cells. Receptacle cell I is narrowed. KT-1445. (16) Mature thallus showing inconspicuously warty surface of lower cells of receptacle and appendages with single antheridium (an). KT-1405. (17) Receptacle cell II with dark-colored warts spread over surface. KT-1419. (18) Same specimen in another focus. KT-1419. Bar = 50 μm (100 μm for Fig. 15).



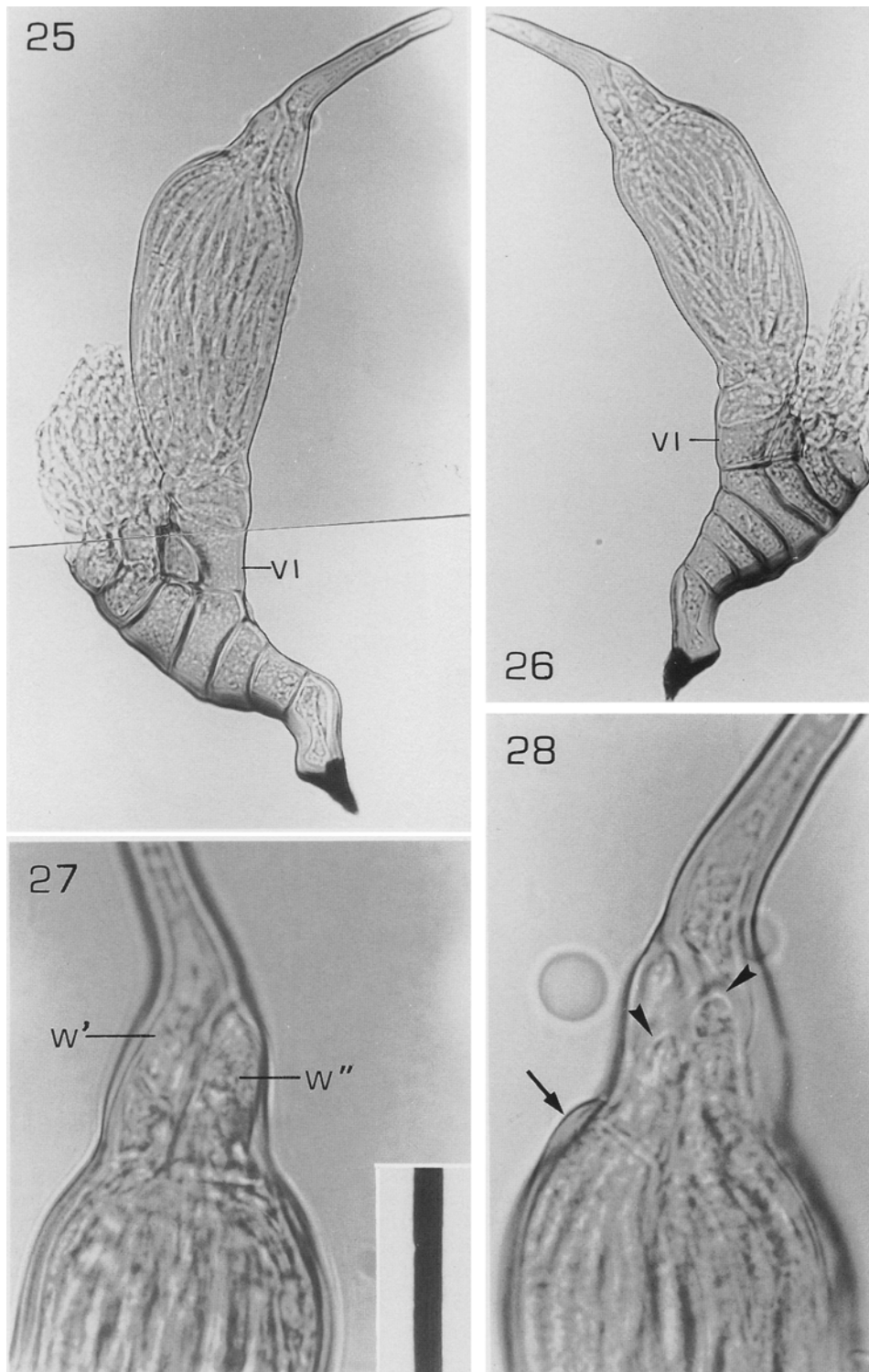
Figs. 19–24. *Dimeromyces caribaeus* (on *Perigona nigriceps*).

(19) Male (left) and female (right) thalli. KT-1405. (20) Female thallus showing erect form. This form is rare. KT-1405. (21) Female thallus with additional appendage (arrow). KT-1405. (22) Perithecium with remnant of trichogyne (tr) and with scale-like structure (arrow) in dark zone below apex. KT-1406. (23) Same specimen in another focus, in which remnant of trichogyne is out of focus and scale-like structure is in focus. Each arrowhead indicates minute papilla of hyaline lip cells. KT-1405. (24) Perithecium with discharged ascospore (arrow) from ostiole. KT-1405. Bar = 50 μm (20 μm for Figs. 22–24).

105.5–117.5 μm ; perithecia (including cell VI) 60–65 \times 20–22.5 μm ; appendages 45–50 μm long; antheridia ca. 25 \times 6 μm .

This fungus is dioecious. The female thallus is characterized by a peculiar form in which the perithecium is usually curved away from the axis of the four-celled receptacle, from which two filamentous appendages (rarely three in my specimens, as shown in Fig. 21) and a

subclavate perithecium arise. The perithecium has four lip cells unequal in height, of which two tall cells are hyaline and papillate (Fig. 23, arrowheads), with a dark zone below, where a small, scale-like structure is adjacent to a smaller dark structure, or the remnant of the trichogyne (Fig. 22, tr). The scale-like structure must be the top part of the trichophoric cell (Tavares, personal communication). The submedian portion of the perithecium is



Figs. 25–28. *Dixomyces ornatus* (on *Perigona nigriceps*).

(25) Mature thallus showing perithecium with apical outgrowth, geniculate receptacle with four superposed cells below cell VI, and compact appendage mass arising from two basal cells. (26) Mature thallus of similar form, but receptacle with five superposed cells below cell VI. (27) Upper portion of perithecium with posterior top cell (w'') connected with base of outgrowth (w'), together forming subapical bulge of perithecium. (28) Upper portion of perithecium with posterior hump (arrow) not remarkably developed. Another two top cells (arrowheads) of different height are at base of outgrowth (these cells may be undergoing division); ostiole is surrounded by all four terminal outer wall cells. YN-1159. Bar = 50 μm (20 μm for Figs. 27–28).

encircled by a dark band. The male thallus is hyaline throughout and is characterized by a six- or seven-celled receptacle from which a single terminal appendage and three to six lateral antheridia arise.

The female of this fungus is quite similar to that of *Dimeromyces patchii* Thaxt., but the species are distinguished by the following characters. 1) The thallus dimensions including the overall length are slightly smaller in *Dim. caribaeus* (see Thaxter, 1924, pp. 335–336). 2) The antheridia have blackened necks in *Dim. patchii*, whereas they are hyaline in *Dim. caribaeus* (cf. Thaxter, 1924, pl. VII, Figs. 190 and 194).

In my specimens the antheridia are wholly colorless (Fig. 19); the perithecia lack a noticeable constriction at the dark band on the second tier of the outer wall cell rows.

Dixomyces ornatus (Thaxter) I. I. Tavares, Mycologia Memoir 9: 209. 1985. Basionym: *Misgomyces ornatus* Thaxter, Proc. Amer. Acad. Arts Sci. 51: 47. 1915. Type: On *Perigona* sp., No. 2081, Java (see Thaxter, 1931, p. 294). Figs. 25–28

Specimens examined: On *Perigona (Trechicus) nigriceps* (Dejean). YN-1159. 30-VII-1989. Y. Nakamura leg. Udo-san, Oya, Shizuoka City, Shizuoka Pref.

Measurements: Total length to tip of perithecial appendage 165–190 μm ; perithecia above cell VII to ostiole 75–92 μm ; appendages 50 μm .

This fungus is amber-colored throughout and deeply suffused along the posterior margin of the receptacle. The color is very similar to that of *Misgomyces dyschirii* Thaxter. The receptacle below cell VI has four or five superposed cells and is abruptly bent just above cell I. Appendages form a compact mass of hyaline, short, ramified branches on the inner and outer basal cells. The perithecium has an apical outgrowth of variable length, which was determined by Tavares (1985) to be a free portion of the third tier cell in the anterior row of the outer wall cells. The long base of the outgrowth and the posterior top cell are united with each other to form a subterminal bulge on the perithecial apex (Fig. 27, w', w"). At the base of the outgrowth, another two apical cells shorter in height were observed in the Japanese specimens (Fig. 28). The two shorter cells appear to undergo cell division to become four-celled rows. An ostiole is formed where the four outer wall cell rows join apically (Fig. 28).

Thaxter (1931) published two full drawings of this fungus, based on the Java and the Philippine specimens, in which a tooth-like hump is shown on the posterior (inner) side of the perithecium, but in the Japanese specimens, this hump almost completely disappears, as shown in Figs. 25 and 26.

Host-fungus relationship

Laboulbenia finitima and *L. separata* were described on *Pericalus guttatus* Chev. from Java (Thaxter, 1899). Both bore the same collection number, no. 571. Thaxter (1899) reported that *L. finitima* was present on the legs,

and *L. separata* on the elytral margins. On the other hand, *L. borneensis* was described on *Thyreopterus* (?) sp. from Borneo (Thaxter, 1902); a more precise identification of the host was not published by Thaxter later. The position on the host was not given.

Mochtherus luctuosus Putzeys is a blackish carabid about 8 mm in length, which lacks patches or spots on the elytra. It is distributed in various parts of Japan (but is absent from Hokkaido) and mainly lives under bark of rotten wood. I have found three fungal species on this carabid: *L. finitima* on the legs (left tarsi and tibiae), *L. separata* on the lateral margin of the left elytron, and *L. borneensis* on the pronotum. The position of the first two species on *M. luctuosus* agrees quite well with Thaxter's description (Thaxter, 1899). Simultaneous parasitism on single host body were sometimes observed among the Japanese specimens of *L. finitima*, *L. separata*, and *L. borneensis*. *Mochtherus*, *Pericalus*, and *Thyreopterus* belong to the tribe Lebiini [Coleoptera, Carabidae].

Laboulbenia manubriolata, *Dim. patchii*, and *Dix. ornatus* were described on a small carabid allied to *Tachys* from Indo-Malayan region (Thaxter, 1915); collection no. 2081 (c, d, f) from Java was included under all three species. Thaxter (1931) reported no. 2081 as *Perigona* sp. later. *Laboulbenia manubriolata* was reported from elytra, *Dim. patchii* on the right inferior posterior surface of the prothorax, and *Dix. ornatus* on the outer margin of the right elytron. *Dimeromyces caribaeus* was described from Grenada, West Indies, on the legs and inferior anterior thorax of *Perigona* sp. (Thaxter, 1920). Thaxter (1924) later amended the "inferior anterior thorax" to "inferior anterior prothorax".

Perigona nigriceps (Dejean) is a small brownish carabid about 3 mm in length. It is distributed almost all over the world and lives under moist litter. I have found *L. manubriolata* on the elytra, including the elytral apices, and the pronotum; *Dim. caribaeus* occurred on the right ventral recurved part of the pronotum (pronotal hypomeron). The last species' position probably agrees with that of *Dim. patchii* reported by Thaxter (1915). The Japanese specimens of *L. manubriolata* and *Dim. caribaeus* were sometimes found on the same host individual.

Through the courtesy of Mr. Nakamura, I have observed *Dix. ornatus* on *P. nigriceps* collected by him in Shizuoka, Japan. This fungus is present on the outer margin of the right elytron as Thaxter (1915) described, but it also grows on legs and the ventral surface (Nakamura, personal communication). *Perigona* belongs to the tribe Perigonini [Coleoptera, Carabidae].

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