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STUDIES ON THE MORPHOLOGY AND TAXONOMY OF THE MALE OF *BEESONIA NAPIFORMIS* (KUWANA) (COCCOIDEA: BEESONIIDAE)

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ABSTRACT

Sexual dimorphism is reported for the first time in species of *Beesonia* (Beesoniidae), occurring on plants of the Fagaceae. *Beesonia brevipes* Takagi is shown to be a junior synonym of *B. napiformis* Kuwana, since the former has been described from the male form of the first-instar larvae. All the instars of the male of *B. napiformis* are described and illustrated based on collections taken in China. Morphological differentiation of the sexes develops at the beginning of hatching of first instars. Males develop through first instar, second instar, prepupa and pupa followed by the adult male. All the stages of *B. dipterocarpi* (occurring on Dipterocarpaceae) are compared with those of *B. napiformis* and reinterpreted. The adult male of *Beesonia* is compared with that of *Mangalorea,* the only other genus of the Beesoniidae.

KEY WORDS: Beesoniidae, *Beesonia napiformis,* male, morphology, taxonomy, new synonym.

INTRODUCTION

Green proposed the genus *Beesonia* in 1926 for *B. dipterocarpi,* a gall-making coccoid on *Dipterocarpus* (Dipterocarpaceae) from Burma, without assigning it to any of the recognized families at that time. Ferris (1950) discovered another species, *B. quercicola,* from China occurring on oaks (Fagaceae) and erected the family Beesoniidae for the genus *Beesonia.* Hu and Li (1986) described *Beesonia albohirta* from oaks in China. Takagi (1987) examined the descriptions of all species in the genus and suggested that the two species occurring on fagaceous plants in China are synonyms of *Xylococcus napiformis* Kuwana, 1914, a species occurring on Fagaceae in Japan. He also described *B. brevipes* on oaks from Nepal. Takagi (1992) established a second genus, *Mangalorea,* for *M. hopeae,* described from *Hopea* (Dipterocarpaceae) in southern India. So far, this family includes two genera and three species, which are distributed only in south and east Asia: *Beesonia* Green with *B. dipterocarpi* Green from Dipterocarpaceae and *B. napiformis* Kuwana from Fagaceae; *Mangalorea* with *M. hopeae* Takagi from Dipterocarpaceae.

The two Dipterocarpaceae-associated species are known to be bisexual. However, our knowledge on *Beesonia* is incomplete and confused. In particular, there is neither information on males of the species living on oaks nor information on sexual dimorphism in the first instar

of species living on Dipterocarpaceae. Improved data on these topics is essential for a comparison of Beesoniidae with other families and in establishing its phylogenetic relationships.

This publication presents the results of a comprehensive study, including detailed redescriptions and illustrations of all male stages of *B. napiformis*, the species which occurs on oaks.

RESULTS

Beesonia napiformis (Kuwana, 1914)
(Figs. 1–4)

Xylococcus napiformis Kuwana, 1914:1.
Trichococcus napiformis (Kuwana); Kanda, 1941:3.
Beesonia quercicola Ferris, 1950:1; synonymized by Takagi, 1987.
Beesonia albohirta Hu and Li, 1986:4; synonymized by Takagi, 1987.
Beesonia brevipes Takagi, 1978:37, ***n. syn.***

First-instar males prefer to settle near the surface of bark in crevices. Second-instar males crawl to the surface of the host plant and construct white flat cocoons from wax filaments secreted from pores and ducts in the body. The cocoon is open at its posterior end. Molting to the prepupal, pupal, and adult stage takes place within the cocoon.

Usually many individuals of first instars and all the female stages are found crowded together, causing roughened and cracked swellings of infested twigs and branches and

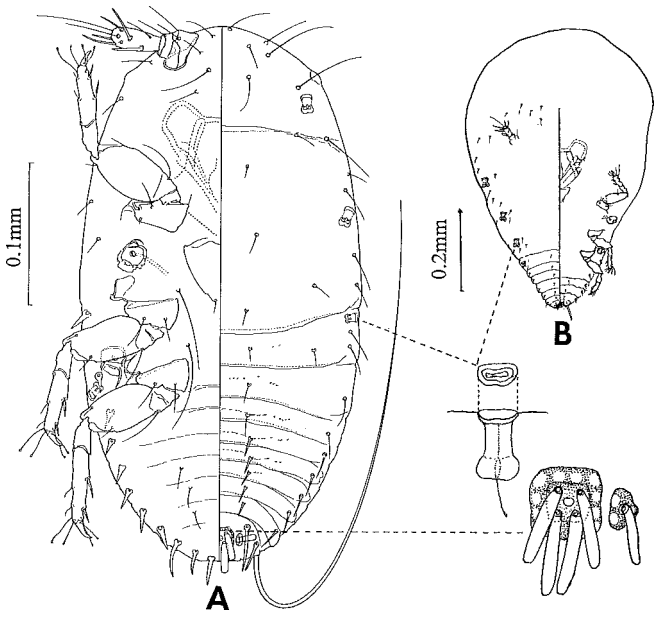

Fig. 1. *Beesonia napiformis* (Kuwana). A, free-living first-instar male (after Takagi, 1987, *B. brevipes*, ***n. syn.***); B, settled first-instar male.

inhabiting pits formed in response to clustered female feeding. Females live in the galls with their posterior extremity exposed outwards, secreting fine, long white waxy threads, and with the anterior apex attached to the host tissue of the cavity. Second-instar males secrete white threads forming cocoons close to the females on the surface of the host.

First-instar male (Fig. 1): The dimorphism of newly hatched crawlers can be distinguished only in slide-mounted specimens (Fig. 1A): dorsal setae of head and thorax hairy; dorsal derm without distinct circular patches; tarsus 50–56 μm long and 2.0–2.2 times as long as hind tibia. After settling, males and females develop differently and can be separated. The male nymphs settle near the surface of bark in crevices; expanded at their frontal area into the shape of an ovoid balloon, about 0.5–0.8 mm long and 0.3–0.5 mm wide (Fig. 1B).

Second-instar male (Fig. 2): The body is about 1.0–1.3 mm long and 2.5 times as long as wide (in slide-mounted specimens), with a roseate color, membranous derm, well-developed antennae, eyes, spiracles, legs and stylets.

Antennae 3-segmented, with slender setae and fleshy setae the same as in first instar. Labium triangular shaped, one-segmented. Stylets looped and extend to metathorax. Leg slender, tibia and tarsus somewhat fused. Anal opening located between partially sclerotized anal lobes, retracted into terminal end of body; 3 pairs of cylindrical anal setae with rounded and truncated apices.

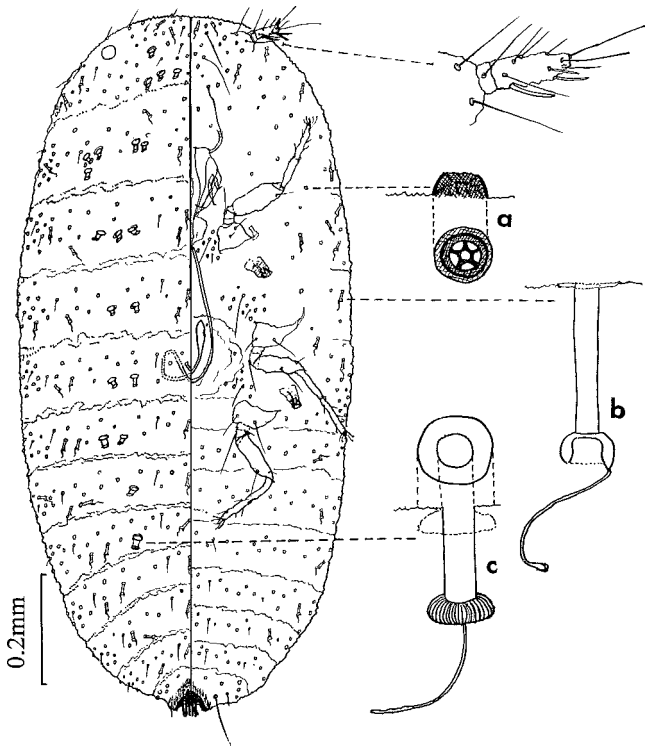

Fig. 2. *Beesonia napiformis* (Kuwana), second-instar male (a, quinquelocular disc pore; b, small duct; c, large duct).

Quinquelocular disc pores (Fig. 2, a) numerous, distributed ventrally and dorsally, more densely near the coxae and along dorsal margin. Tubular ducts of two types present on dorsum; the small duct (Fig. 2, b) consists of a membranous tube with a slightly sclerotized, cup-shaped inner end and a membranous filament; distributed in medial, submarginal and marginal rows on the dorsal derm; the large duct (Fig. 2, c) is composed of shorter tube and more heavily sclerotized, stouter inner end than those of the small duct, arranged in submedial rows on dorsal surface. Abdomen dorsally with 6 rows of setaceous setae and 4 rows ventrally. Other longer setaceous setae near coxal and antenna bases.

Prepupa (Fig. 3A): Body ovate, tapering posteriorly, with the head, thorax and abdomen fused, antennae and legs unsegmented and wings just as lateral protuberances. Spiracle well formed. A few small ducts (a) present on head. Microspines (b) of derm found on abdominal segments.

Pupa (Fig. 3B): Antennae and legs segmented, with femur protruded. Genital segment elongated greatly, subequal in length to the abdomen. A pair of eyes present.

Adult male (Fig. 4): Length 1.6–1.7 mm. The thorax and genital segment chitinised, remaining abdominal segments membranous. With 2 long, white, waxy filaments protruding from the eighth abdominal segment. Body setae hair-like.

Head with 2 dorsal and 2 ventral simple eyes subequal in diameter and a pair of lateral rudimentary ocelli. Antennae 3-segmented, the two basal segments short and with some slender setae on ventral surface, segment 2 with a sensory pore on dorsal anterior margin; the third segment very long and of irregular form, with numerous blunt setae being situated in large

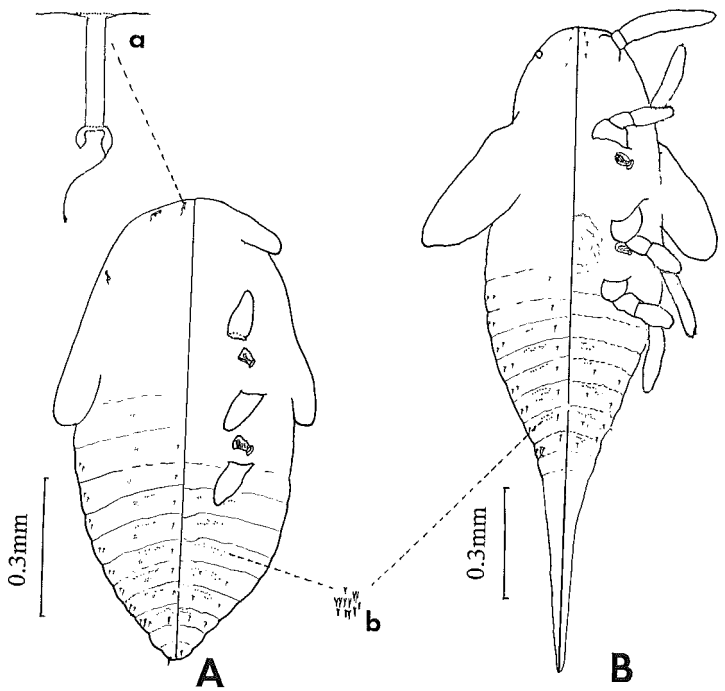

Fig. 3. *Beesonia napiformis* (Kuwana). A, male prepupa; B, male pupa.

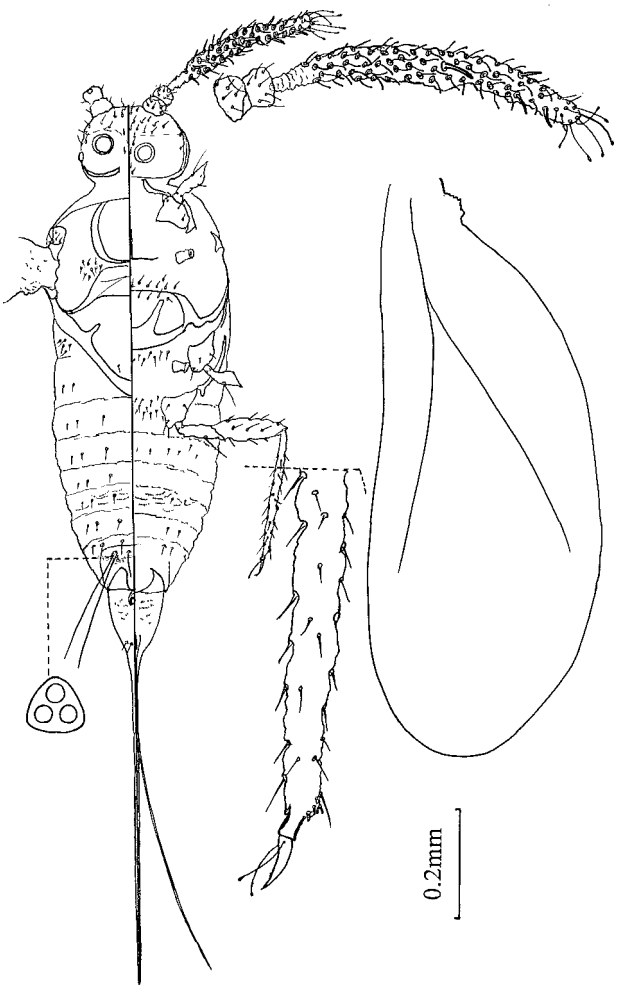

Fig. 4. *Beesonia napiformis* (Kuwana), adult male.

round basal depression except on base and apical section, 4–5 fleshy setae on upper ventral section and 5–6 long apical setae with slightly swollen end.

Scutum much shorter than prescutum. Scutellum transversely subrectangular. Setae always in cluster on thorax. Wings well developed, with indistinct alulae. Halteres absent. Legs relatively large; trochanter with 4 small sensory pores, a little shorter than femur; tibia and tarsus fused; many pointed setae on femur and fused tibia and tarsus, a few truncate short setae on apical lateral margin of the tarsus; claw digitules present, no tarsal digitules.

Abdomen with setae regularly distributed. Terminal segment with a pair of dorsal gland pockets of trilocular pores, each bearing 2 long setae, which support waxy filaments in living insect. The genital segment extended into styliform, subequal to the thorax and abdomen combined in length. Microspines present on derm.

MATERIAL STUDIED. CHINA, Guizhou Province, Sichuan Province, Yunnan Province, Shandong Province and Liaoning Province: 53 first instars mounted on 13 slides; 39 second-instar males on 9 slides; 12 prepupae and 17 pupae on 8 slides; 24 male adults on 8 slides. 1–1650 m, on *Quercus acutissima* Carr., *Q. dentata* Thumb, *Q. variabilis* Bl., *Castanopsis delavayi* Fr., 10–20.iv.1990, 5–23.v.1990, coll. X.P. Hu and S.Z. Li. All materials are deposited in the Collection of the Forestry College, Shandong Agricultural University, China.

DISCUSSION

The new finding on sexual dimorphism of oak-associated species could contribute to a better understanding of this unusual coccoid group. In particular, it could clarify some confused interpretation on developing stages of *B. dipterocarpi*. So far, all the three known species of the family (*B. dipterocarpi, B. napiformis, Mangalorea hopeae*) are bisexual. Differentiation of the sexes appears at the hatching of the first-instar crawlers. The male develops through the stages of egg, first instar, second instar, prepupa and pupa before emerging into adult. After comparing *B. dipterocarpi* with *B. napiformis*, we believe that Green (1926, 1928) and Takagi (1987) presented the following stages of *B. dipterocarpi*: first-instar female (equals to Green's 2nd-stage female; Takagi's Form A), second-instar female (Green's 3rd- and 4th-stage females; Takagi's 2nd- and 3rd-stage females), first-instar male (Green's 2nd male exuviae; Takagi's Form B); second-instar male within the cast skin of the first-instar male (Green's embryonic larva; Takagi's Form C), free-living second-instar male (Green's 3rd-stage male, 1928, 3rd-stage female, 1926), and adult male. We are inclined to believe that Green mistook the 3rd-instar female for the adult female, so there might be an uncovered membranous, featureless form accommodated by the 3rd larval instar.

B. brevipes is a new synonym of *B. napiformis*. The first instar described by Takagi (1987) represents evidently the first-instar male. At the beginning of this study, we thought we were dealing with two coexisting species, because all our collections of newly hatched crawlers yielded dimorphism. One type was identical with *B. napiformis*, the other belonging to *B. brevipes*, with variable ratios of the two types among specimens from different provinces. The female instar stages vary morphologically along with developing levels. In addition, the infested host plants exhibit various types of symptoms. Besides the features we mentioned before, we observed roughly swollen galls at the bases of smaller branches on the tree(s) and at axillary angles of vegetative buds, causing twigs to break at the gall. After examining all instar stages and adults, we confirmed that there is only one species and that the morphological differences among first instars represent sexual dimorphism.

Takagi (1987) supposed that the generic name *Trichococcus* Kanda should be used for all the species associated with Fagaceae. In our opinion, *B. napiformis* and *B. dipterocarpi,* despite being associated with different host plants, share common characteristics of first instars, adult male and, maybe, adult female, and should be kept in the same genus, *Beesonia.* They have similar life habits with three free-living stages (first-instar male, second-instar male and adult male), causing woody galls in branches and twigs. We also found that more than a dozen adult females were crowded into a single gall (the same case in *B. dipterocarpi*). One swollen twig, 10 cm in length, might contain hundreds of fully developed females.

Two distinct genera are recognized in Beesoniidae. The galls caused by *Beesonia* species are diverse in their structure and are located at the extremity of the smaller branches of the tree, in

the bases of twigs, or in twigs and branches. The galls formed by *Mangalorea* species are shaped like a sea urchin, occur in leaf axils and rarely on shoot terminals, and are very similar to the galls induced by gall-makers belonging to *Reynvaania* Reyne (Kermesidae) (Hu and Li, 1993) and *Gallacoccus* Beardsley (Eriococcidae) (Beardsley, 1971). Concerning adult males, the following characters can be adopted as generic diagnosis. In the genus *Beesonia*, body setae are hair-like and pointed; tibia and tarsus are fused and genital segment is long and slender, at least longer than the other abdominal segments combined. In the genus *Mangalorea*, the body is covered with numerous papillae intermingled with pointed setae; tibia and tarsus are articulated; genital segment is very short (only a little longer than one abdominal segment). Green (1926) described the adult male of *B. dipterocarpi* as an alate, with both wings and halteres. If the halteres are really present, the feature can be used in identifying the two species in the genus *Beesonia*.

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