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Taxonomic Status of *Bambusaspis miliaris*, *B. robusta*, and *B. pseudomiliaris* (Hemiptera: Coccoidea: Asterolecaniidae)

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Abstract: Based on an assessment of 50 morphological characters from 110 specimens of *Bambusaspis miliaris* (Boisduval 1869), *B. robusta* (Green 1908), and *B. pseudomiliaris* (Green 1922) from different geographic regions around the world, we conclude that these specimens represent the same species. Therefore, the taxa *B. robusta* and *B. pseudomiliaris* are considered junior subjective synonyms of *B. miliaris*.

Key words: Bamboo pit scales, Asterolecaniidae, *Bambusaspis*, *Bambusaspis miliaris*, *Bambusaspis robusta*, *Bambusaspis pseudomiliaris*

Introduction

Pit scale species are often serious pests of bamboo in both native and ornamental stands (Boisduval 1869, Russell 1941, Hamon 1980). Damage to the host is in the form of sap extraction and the production of honeydew that serves as a substrate for development of sooty mold, which decreases photosynthesis. Correct species identification is essential before implementing any control procedure against pests, especially when parasitoids and predators are used. During a revision of the pit scale family Asterolecaniidae, it was observed that 3 species on bamboo, *Bambusaspis miliaris* (Boisduval), *B. robusta* (Green), and *B. pseudomiliaris* (Green), were frequently found infesting the same host plants. From a study of the pit scales of North and South America, it was discovered that specimens identified as 3 separate species were morphologically similar or identical. Consequently, measurements of 50 morphological characters from 110 adult females (including type specimens) representing each of the 3 species were made to elucidate the status of these species.

Taxonomic History: *Chermes miliaris*, described by Boisduval (1869), was found infesting cultivated bamboo from the garden of Hamma, Algiers, Algeria. Since its discovery, this species has gone through an interesting history of misidentifications spanning a century. Targioni-Tozzetti (1892), in his critique of 2 newly discovered species of *Asterolecanium*, recognized the species and its transfer by Signoret (1870) to the genus *Asterolecanium*. Green (1896) described *Planchonia miliaris longa*, which was later recog-

nized as *A. longum* by Russell (1941) in her revision of the genus *Asterolecanium*. Cockerell (1896) included *A. miliaris* var. *longum* in his checklist of Coccidae, and later (Cockerell 1902a), recorded *A. miliaris* in his catalogue of the South American Coccidae. Cockerell (1902b) then established *Bambusaspis* as a new section of *Asterolecanium* to include species on bamboo and palms, but did not designate it as a new genus. This section was accepted by Sanders (1906) who named *miliaris* as its type. In 1908, Green described *A. miliaris robustum* as a variety of *A. miliaris*. He (Green 1909) included a redescription of *A. miliaris longum* which was later recognized as a misidentification of *A. miliaris robustum* by Russell (1941). Green (1909) stated that "while *A. miliaris* appears more frequently on the stems and branches of the plant, the variety *A. longum* appears to be confined to the foliage". The material described by Green (1915) as *A. miliaris longum* was later determined to be *B. robusta* by Williams & Watson (1990). During this period, Green described *A. pseudomiliaris* (1922) and *A. charmoyi* (1924) from the foliage of *Bambusa* sp. Takahashi (1930) recognized a new variety, *A. pseudomiliaris bambusifoliae*, but later synonymized it with *A. charmoyi* (Takahashi 1933). Russell (1941) recognized the varieties *A. miliaris miliaris* and *A. miliaris robustum* along with the species *A. pseudomiliaris*, and synonymized *A. charmoyi* and *A. pseudomiliaris bambusifoliae* with *A. pseudomiliaris*. Borchsenius (1950) recognized the genus *Bambusaspis*, which was independently repeated by Bodenheimer (1951). Ferris (1955) raised *A. miliaris robustum* to species status as *A. robustum*. Kozár & Walter (1985) placed *B. pseudomiliaris* as new nominal combination, and

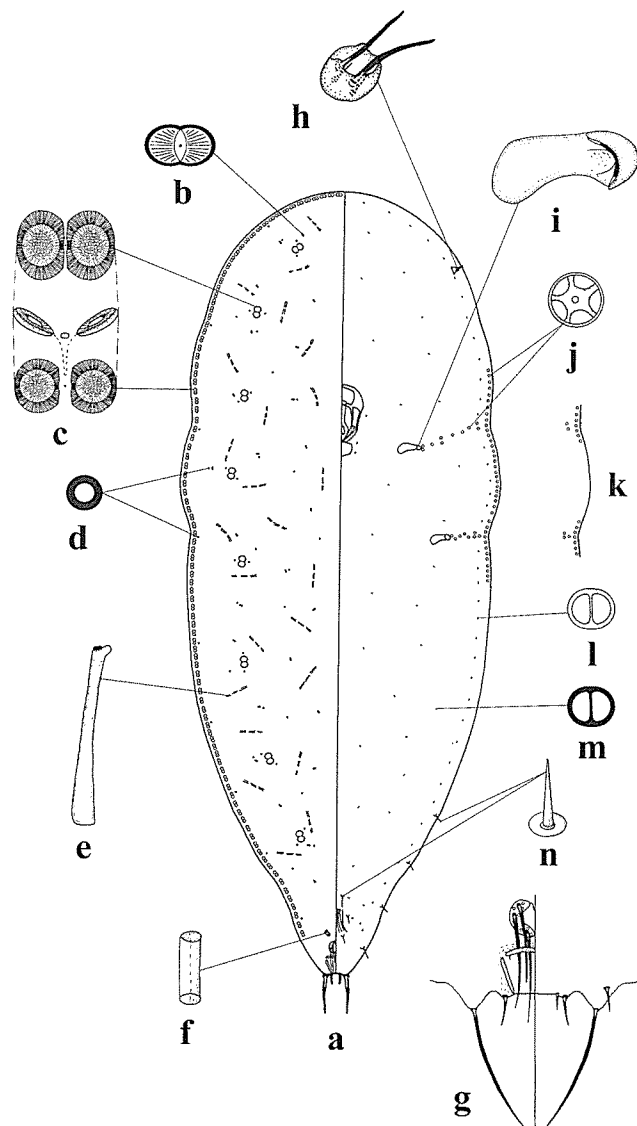


Figure 1. *Bambusaspis miliaris* (Boisduval): a, dorsal (left) ventral (right) view; b, small 8-shaped pore; c, large 8-shaped pore (bent), pores in submarginal row may or may not be present; d, simple disk pore; e, tubular duct; f, dorsal tube; g, anal region; h, antenna; i, spiracle; j, quinquelocular pore; k, variation in marginal distribution of quinquelocular pores; l, marginal bilocular pore; m, dark-rimmed bilocular pore; n, tacklike setae.

Williams & Watson (1990) did the same with *B. robusta*.

Materials and Methods [number of slides (specimens in parenthesis)]: **Type material:** U.S. National Museum (USNM), 2(24) first instars and 2(2) adult females; *Asterolecanium miliaris* (Bdv.), Type, det. Sign., det. Löw, auf *Bambusa* spec.?, Algerium, USNM access# 45 770, 45 771; 1(6) first instars and (2) adult females; *Asterolecanium miliaris robusta*

Green, Type, on *Bambusa* sp. stem, India, Pusa, Bengal, IV 1906, rec'd Dec. 1933, ex Coll. E.E. Green (left label), *Asterolecanium miliaris miliaris* (Bdv.) (right label), 45 878, 37 9466; 1(8) first instars and (2) adult females; *Asterolecanium miliaris*, Type, on *Bambusa oliveriana*, Perideniya, Ceylon, Dec. 1898, E.E. Green (left label), *Asterolecanium miliaris robustum* Gr. (right label); 1(3) second instars and (1) adult female, and 1(2) first instars and (3) adult females; *Asterolecanium pseudomiliaris* Green, Syn-type, bamboo, Perideniya, Ceylon, III 1910 McKenzie Coll., 1(5) adult females: on *Bambusa* sp., Mauritius, de Charmoy, Coll., Reed 1925 (left label), *Asterolecanium pseudomiliaris* Gr., *Asterolecanium longum* (Green), Type, 45 1255, 45 1254 (right label).

Other material studied: USNM, 1(2) adult females: *Asterolecanium miliare miliare* (Boisduval), ex. *Bambusa* sp. stem, Barbados, 21 IV 81, L. Gary, JFKIA 38944, V81; 1(5) adult females: *Asterolecanium miliaris miliaris* (Bdv), *Asterolecanium miliaris robustum* Green, on bamboo, Salazar, Angola, 3 II 1973, Dina Almeida, Reg. 9781; 1(4) adult females: *Asterolecanium miliaris miliaris* (Bdv), *pseudomiliaris* Green, on *Bambusa* sp., Casablanca, Morocco, 10 June 1945, Sanders, coll., 45 1587, 45 1588; 1(11) adult females: *Asterolecanium miliaris miliaris* (Bdv.), *Asterolecanium miliaris robustum* Green, *Asterolecanium pseudomiliaris* Green, on *Bambusa* sp., Colonia, Ponape: at Hawaii, Jan. 17.30, 1949, M.M. Ross, coll., Hawaii 5384, 49 1250, 49 1251, 49 1252, Florida State Collection of Arthropods (FSCA); 5(5) adult females: *Asterolecanium miliaris* (Boisduval), *Bambusa* sp., Hawaii: via Boynton Beach, Florida, 7 III 1991, D. Leone, det. A. Hamon; 1(1) adult females: *Asterolecanium robustum* (Green), on *Bambusa* sp., Bradenton, Fla., 26 VIII 1980, G.O. Quin, det. A. Hamon '80; 1(1) adult female: *Asterolecanium robustum* Green, on *Bambusa* sp., Immokalee, Fla., 16 V 1980, det. A. Hamon '80; 1(1) adult female: *Asterolecanium robustum* Green, on *Bambusa* sp., Estero, Fla., 14 X11 1979, K. Delate, det. A. Hamon '80; 2(2) adult : *Asterolecanium robustum* Green, on *Bambusa multiplex*, Florida: Miami, 12 IX 1983, J. Frankel, G. Gwin, det. A. Hamon; 1(1) adult female: *Asterolecanium robustum* Green, on *Bambusa* sp., Florida: Arcadia, 7 VIII 1987, J. Bennett, det. A. Hamon; 3(3) adult females: *Asterolecanium robustum* Green, on *Bambusa* sp., Melbourne, Fla., 25 VII 1980, F.A. Smith, det. A. Hamon '80; 1(1) adult female: *Asterolecanium robustum* Green, on *Bambusa* sp., Florida: Ft. Lauderdale, 24 XI 1989, S. Fazli, det. A. Hamon '89; 1(1) adult female: *Asterole-*

Table 1. Measurements of morphological characters in the 3 variants of *B. miliaris*.

Character	<i>miliaris</i> *	<i>robusta</i>	<i>pseudomiliaris</i>
Body length	717±92 (600-840)**	990±137 (800-1200)	751±159 (600-1000)
Body width	397±65 (300-510)	403±72 (320-540)	356±109 (200-560)
Clypeolabral shield length	96.8±9.3 (80.5-113.8)	97.8±7.5 (85.1-109.2)	89.7±11.4 (74.7-106.9)
Clypeolabral shield width	66.7±6.4 (58.6-79.3)	64.0±4.6 (56.3-70.1)	59.5±11.1 (42.5-74.7)
Labial length	24.1±1.7 (21.8-27.6)	22.3±3.3 (18.4-29.9)	21.4±4.1 (17.2-29.9)
Labial width	28.6±4.3 (23.0-35.6)	27.9±3.9 (24.1-36.4)	27.2±3.4 (23.0-32.2)
Spiracle length	24.2±2.3 (20.1-28.7)	23.1±1.7 (20.4-25.9)	21.6±2.6 (19.0-25.9)
Spiracular peritreme width	9.6±1.3 (7.5-11.5)	9.0±0.7 (8.0-10.7)	8.4±1.5 (6.1-11.2)
Antennal length	6.8±1.3 (5.7-8.6)	8.3±5.2 (3.4-18.4)	4.9±0.9 (3.4-5.7)
Antennal base width	7.5±1.3 (5.7-9.8)	7.4±1.2 (4.6-9.2)	7.3±1.4 (5.7-10.3)
Apical setal length	55.4±8.0 (41.4-60.9)	59.3±3.7 (52.9-63.2)	56.1±5.5 (49.4-65.5)
Anal ring length	11.8±2.2 (9.2-14.9)	12.1±2.1 (10.3-14.4)	8.9±1.3 (6.9-10.9)
Anal ring width	17.9±2.3 (14.9-21.8)	16.4±1.1 (13.8-17.2)	15.9±1.8 (13.8-19.5)
Arched anal bar length	23.2±1.8 (20.7-25.3)	21.9±2.4 (18.4-26.4)	22.1±2.0 (17.2-24.1)
Lateral anal bar length	11.9±2.4 (8.0-16.1)	11.2±1.2 (9.2-12.6)	12.4±2.3 (6.9-15.5)
Marginal 8-shaped pore length	6.8±0.4 (5.7-6.9)	6.2±0.2 (5.7-6.3)	5.8±0.7 (4.6-6.9)
Submarginal bilocular pore length	1.6±0.2 (1.1-1.7)	2.0±0.4 (1.7-2.9)	1.7±0.3 (1.1-2.3)
Quinquelocular pore diameter	2.2±0.5 (1.7-3.4)	2.0±0.3 (1.7-2.3)	2.1±0.5 (1.1-2.9)

* Measurements performed on 10 specimens of each variant

** Numbers represent the mean and standard variation (um) followed by the range in parentheses.

canium robustum Green, on *Bambusa* sp., West Palm Beach, Fla., 17 V 1979, R. Buchholz & J. Bennett, det. A. Hamon '79; 2(2) adult females: *Asterolecanium robustum* Green, on *Bambusa* sp., Cocoa, Fla., 10 XII 1979, R.E. Burns, det. A. Hamon; 2(2) adult females: *Asterolecanium miliaris longum* Green, host - bamboo, Tarpon Springs, Fla., 4 IX 1922, coll. F.M. O'Byrne, det. GBM, 13374; 5(5) adult females: *Asterolecanium miliaris longum* Green, host: *Bambusa* sp., Miami, Fla., 30 VIII 22, E.L. Kelly, det. H. Morrison & G.B. Merrill, 13130; 3(3) adult females: *Asterolecanium miliaris robustum* Green, on *Bambusa* sp., Winter Haven, Fla., 7 VIII 1970, W.P. Henderson, det. S. Nakahara '71, 1595, 125364; 3(3) adult *Asterolecanium miliaris robustum*

Green, on bamboo, Vero Beach, Fla., 22 V 1946, Coll. O.W. Calkins, G.B.M., 92387; 15(2) second instars and (13) adult females: *Asterolecanium miliaris* var. *robustum* Green, on *Bambusa* sp., Vero Beach, Fla., 24 VIII 1977, S.P. Beidler, det. A. Hamon '79, NY. K-746; 3(3) adult females: *Asterolecanium miliaris* var. *robustum* Green, on *Bambusa* sp., Winter Haven, Fla., 3 178, C. Roberts, det. A. Hamon '78, L-17; 1 (1) adult female: *Asterolecanium pseudomiliaris* Green, on *Bambusa* sp., Coconut Grove, Fla., 23 111970, J.F. Dillon, det., A. Hamon '80, 1-450; 3(3) adult females: *Asterolecanium pseudomiliaris* Green, on *Bambusa* sp., Okeechobee, Fla., 26 IX 1978, S.P. Beidler, det. A. Hamon '80; 2(2) adult females: *Asterolecanium miliaris robustum* Green, on *Bambusa* sp., Stuart, Fla.,

Table 2. Presence or absence of morphological characters in the 3 variants of *B. miliaris*.

Character	<i>miliaris</i> *	<i>robusta</i>	<i>pseudomiliaris</i>
Fleshy antennal setae	2 (2-3)**	2 (2-3)	2
Slender antennal setae	2 (2-3)	2 (1-3)	2
Large dorsal 8-shaped pores	0	0	17 (2-48)
Quinquelocular pores in each spiracular furrow	12 (8-17)	11 (8-14)	12 (8-16)
Submarginal setae on each side of abdomen	4 (2-6)	4 (2-6)	4 (2-4)
Inner pores on anal ring	6	6	6
Outer pores on anal ring	12 (10-14)	12 (12-14)	14 (12-16)

* Measurements performed on 10 specimens of each variant

** Numbers represent the mean and standard variation (μm) followed by the range in parentheses.

21 V 1978, S.P. Beidler, det. D.R. Miller '78, DPI# 126273a; 5(5) adult females: *Asterolecanium miliaris robustum* Green, on *Bambusa* sp., Gainesville, Fla., 28 XII 1981, A. Beck, det. A. Hamon '82; 3 (3) adult females: *Asterolecanium milaris* (Boisduval), on *Bambusa vulgaris*, Corozal, Puerto Rico, 4 11197 1, det. D.R. Miller '73, acc. # 101-71; 2(2) adult females: *Asterolecanium milaris* (Boisduval), on *Bambusa* sp., Florida: Delray Beach, Palm Beach Co., 28 XI 1988, E. Tannehill, det. A. Hamon; 2(2) adult females: *Asterolecanium robustum* Green, on *Bambusa* sp., Punta Gorda, Fla., 17 III 1980, A. Gambill, det. A. Hamon '80; 2(2) adult females: *Asterolecanium pseudomiliaris* Green, on *Bambusa* sp., Miami, Fla., 25 IX 1980, K. Martin, det. A. Hamon '80; 3(3) adult females: *Asterolecanium pseudomiliaris* Green, on *Bambusa* sp., Bonita Springs, Fla., 30 VII 1980, K. Delate, det. E. Mercer, conf. A. Hamon '80; 3(3) adult females: *Asterolecanium pseudomiliaris* Green, on *Bambusa* sp., Ft. Lauderdale, Fla., 6 III 1980, M. McCulloch, det. A. Hamon '80.

Linear measurements of 18 characters (Table 1) and counts of 7 characters (Table 2) were obtained from 30 specimens. The presence or absence of 25 characters (Table 3) was recorded from 110 specimens. All data were taken from adult females from the USNM and FSCA using a phase contrast microscope equipped with a micrometer.

Results and Discussion: Traditionally, 3 diagnostic characters have been used to separate these 3 species. They included the presence of large dorsal 8-shaped

pores (Fig. 1c, Tables 2, 3) and a marginal row of simple disk pores (Fig. 1d, Table 3) to distinguish *B. pseudomiliaris*, and the presence of a gap in the row of marginal quinquelocular pores (Fig. 1k, Table 3) to separate *B. robusta* from *B. miliaris*. We found these characters too variable to reliably separate the species. With the exception of the occasional appearance of large dorsal 8-shaped pores (Table 3) and slight differences in body shape in 35 of the 110 specimens, no substantial differences were observed or measured from the characters evaluated. The presence of large dorsal 8-shaped pores is considered the most important diagnostic character for the identification of *B. pseudomiliaris*. In specimens with such pores, the numbers range from 2 to 48. The presence or absence of large dorsal 8-shaped pores among specimens may be a result of host-induced variations as recorded in other scale insect species (Danzig 1970, Knipscher et al. 1976, Liu et al. 1989, Lupo 1943, Stafford and Barnes 1948, Takagi 1985, 1988, Takahashi 1952, Tippins and Beshear 1970). Because of the inconsistency in numbers of large dorsal 8-shaped pores and the erratic distribution pattern when present, the presence or absence of these pores alone is not a reliable key diagnostic character to distinguish *B. pseudomiliaris* from *B. robusta* and *B. miliaris*. Marginal 8-shaped pores (Fig. 1c, Table 3) occur in the same arrangement in all 3 species, which is consistent with the pattern exhibited in other pit scale species. In addition, Russell (1941) distinguished *B. pseudomiliaris* based on the presence of a complete marginal row of simple disk pores. Without exception, this character was found in each of the 110 specimens examined,

Table 3. Counts of morphological characters in the 3 variants of *B. miliaris*.

Character	<i>miliaris</i>	<i>robusta</i>	<i>pseudomiliaris</i>
Legs present	no*	no	no
Labium deltoid	yes	yes	yes
Labium without setae	yes	yes	yes
Marginal 8-shaped pores present	yes	yes	yes
Marginal 8-shaped pores end 2-4 pore lengths before anal lobe	yes	yes	yes
Large dorsal 8-shaped pores in submarginal row	no	no	yes
Small dorsal 8-shaped pores present	yes	yes	yes
Submarginal bilocular pores present	yes	yes	yes
Marginal row of quinquelocular pores complete	no	no	no
Marginal row of quinquelocular pores with gap between spiracular furrows	no	yes	yes (34) no (1)
Quinquelocular pores absent near antennal base	yes	yes	yes
Multilocular pores present on venter	no	no	no
Dorsal simple disk pores present	yes	yes	yes
Simple disk pores in row on margin	yes	yes	yes
Tubular ducts present	yes	yes	yes
Tubular ducts in 6 longitudinal rows	yes	yes	yes
Dorsal intersegmental setae present	no	no	no
3 pairs of ventral segmental setae present	yes	yes	yes
Dorsal tubes present	yes	yes	yes
Small anal cleft present	yes	yes	yes
Anal lobe with apical, subapical, and 2 pairs of ventral setae	yes	yes	yes
Anal ring complete	yes	yes	yes
Anal ring with 6 setae	yes	yes	yes
Arched anal bar present	yes	yes	yes
Lateral anal bar present	yes	yes	yes

* Characters evaluated from *B. miliaris* (16 specimens), *B. robusta* (59 specimens), and *B. pseudomiliaris* (35 specimens).

regardless of the presence or absence of large dorsal 8-shaped pores (Table 3). Furthermore, a row of quinquelocular pores (Fig. 1j, Table 2) extends from each spiracle (Fig. 1i, Table 1, 2) to the margin where it joins a marginal row of quinquelocular pores. The occurrence of a gap in this marginal row for *B. robusta* and the absence of such a gap in *B. miliaris* is generally used to separate these 2 species. The length of the gap within the row of quinquelocular pores is variable, ranging from no gap (17 specimens, 15.5%), a minute gap (9 specimens, 8.2%), or a wide gap (84 specimens, 76.4%). Of the 17 specimens without a gap, 16 (94.1 %) had previously been identified as *B. miliaris* and 1 (5.9%) as *B. pseudomiliaris* based on the presence of large dorsal 8-shaped pores. Of the 9 specimens with a minute gap, 4 (44.4%) had been determined as *B. robusta* and 5 (55.6%) as *B. pseudomiliaris*. From the 84 specimens with a wide gap, 55 (65.5%) had been identified as *B. robusta* and 29 (34.5%) as *B. pseudomiliaris*. In 1 specimen determined as *B. miliaris*, a minute gap was found on one side of the body and no gap on the other side. One type of *B. robusta* from the USNM contains 2 adult females that were identified as *B. miliaris*. In addition, different shapes have been used to illustrate *B. miliaris*, *B. robusta*, and *B. pseudomiliaris* (Russell 1941, Ferris 1955). However, body shape is often influenced by the specimen's location on the host, population density on the branch or leaf, or food source, and cannot be solely used for species identification purposes. Some morphological characters in pit scales appear to be more variable than previously considered. Location on the host plant may play an important role in morphological differentiation. For example, *Asterodiaspis minus* (Russell) and *A. quercicola* (Bouché) are host-induced variants of *A. variolosa* (Ratzeburg) (Podsiadlo 1990). In *Palmaspis urichi* (Cockerell), large dorsal 8-shaped pores may or may not be present (Russell 1941), although this species is usually described without these types of pores (Matile-Ferrero 1996).

All characters used in differential diagnoses of the 110 specimens examined either overlapped to varying degrees, or were not useful. No clear distinctions between the 3 species could be found. As a consequence, *B. robusta* and *B. pseudomiliaris* are considered junior subjective synonyms of *B. miliaris*.

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