SYSTEMATICS, MORPHOLOGY AND PHYSIOLOGY

A New Species of Ant-Tended Soft Scale of the Genus *Cryptostigma* Ferris (Hemiptera: Coccidae) Associated with Bamboo in Peru

TAKUMASA KONDO AND PENNY J. GULLAN

Dept. Entomology, University of California, 1 Shields Avenue, Davis, CA 95616-8584, USA
E-mail: tkondo@ucdavis.edu, pjgullan@ucdavis.edu

Neotropical Entomology 33(6):717-723 (2004)

Uma Nova Espécie de Coccídeo do Gênero *Cryptostigma* Ferris (Hemiptera: Coccidae) Associada a Formigas de Bambu no Peru

RESUMO - Os coccídeos do gênero *Cryptostigma* Ferris (Coccidae: Myzolecaniinae) ocorrem somente na região Neotropical e normalmente vivem em ninhos de formigas, ou raramente de abelhas, dentro de troncos, ou raízes de plantas. Neste trabalho, descreve-se pela primeira vez uma espécie de *Cryptostigma* coletada no Peru. A descrição de *Cryptostigma guadua* sp.n. é baseada na fêmea adulta e em ninfas do primeiro ínstar. Foram coletados em ninhos de *Camponotus* (*Myrmostenus*) *longipilis* Emery, *C.* (*Myrmostenus*) *mirabilis* Emery e *Camponotus* (*Pseudocolobopsis*) sp. (Formicidae: Formicinae), encontrados dentro de bambus vivos do gênero *Guadua* (Poaceae) planície de mata tropical do Parque Nacional del Manu, no sudeste do Peru. A fêmea adulta e a ninfa do primeiro ínstar de *C. guadua* sp.n. são comparadas com outras espécies próximas na taxonomia do grupo.

PALAVRAS-CHAVE: *Camponotus* (*Myrmostenus*), *Camponotus* (*Pseudocolobopsis*), *Guadua*, Myzolecaniinae

ABSTRACT - Soft scale insects of the genus *Cryptostigma* Ferris (Coccidae: Myzolecaniinae) occur only in the Neotropical region and usually live in the nests of ants, or rarely bees, inside plant stems, or feed on plant roots. Here we provide the first report of *Cryptostigma* from Peru. We describe *Cryptostigma guadua* sp.n. based on the adult female and the first-instar nymph. These coccids have been collected only from the nests of *Camponotus* (*Myrmostenus*) *longipilis* Emery, *C.* (*Myrmostenus*) *mirabilis* Emery and *Camponotus* (*Pseudocolobopsis*) sp. (Formicidae: Formicinae) from inside live bamboos of *Guadua* sp. (Poaceae) in lowland tropical forest in Parque Nacional del Manu, in southeast Peru. The adult female and the first-instar nymph (crawler) of *C. guadua* sp. n. are compared to closely related species.

KEY WORDS: *Camponotus* (*Myrmostenus*), *Camponotus* (*Pseudocolobopsis*), *Guadua*, Myzolecaniinae

Mutualistic interactions between ants (Formicidae) and scale insects (Coccoidea, also called coccoids) typically involve the scale insects providing sugary excreta, called honeydew, to tending ants whose presence improves coccoid survival by interfering with natural enemies and/or by reducing honeydew and fungal contamination (Buckley 1987a,b; Gullan 1997; Delabie 2001). These trophobiotic associations range from facultative to obligate. The most specialized interactions usually occur in tropical regions and involve ants and coccoids associated with ant-plants (myrmecophytes), which have pre-formed cavities, such as hollow stems, tubers or spines, that provide nesting spaces to ants (Beattie 1985, Benson 1985, Hölldobler & Wilson 1990, Ward 1991, Davidson & McKey 1993).

Most plant-ants cultivate mealybugs (Pseudococcidae) and/or soft scale insects (Coccidae, or coccids) within the cavities of the myrmecophyte host (Longino 1991, Ward 1991, Gullan 1997, Gaume *et al*. 1998, Moog *et al*. 2003). A few ant-plant taxa preferentially cultivate mealybugs (e.g. most *Cladomyrma* ants; Moog *et al*. 2003), whereas a few others only cultivate coccids (e.g. ants of the genus *Crematogaster* Lund in the hollow stems of *Macaranga* Thouars; Heckroth *et al*. 1998). In the Neotropics, the coccids most frequently associated with specialist plant-ants, or with other ants nesting inside plant cavities, belong to the genera *Akermes* Cockerell, *Cryptostigma* Ferris, *Cyclolecanium* Morrison, *Megasaissetia* Cockerell, *Neolecanium* Parrott and *Toumeyella* Cockerell of the subfamily Myzolecaniinae

(Hodgson 1994, Kondo & Williams 2002). The natural history of these coccids has been noted only by myrmecologists interested in the biology of the ants (e.g., Wheeler 1942), although recent work (Camargo & Pedro 2002a,b) reported a new species of Amazonian stingless bee, *Schwarzula coccidophila* Camargo & Pedro, that houses coccids of an undescribed *Cryptostigma* species inside its nest tree and tends them for honeydew and wax. Five of the six described species of *Cryptostigma* are either known, or inferred, to live exclusively in ant nests (Qin & Gullan 1989, Kondo 2003).

Recently, Dr. D.W. Davidson and colleagues, who have been conducting long-term studies of Neotropical ants associated with bamboo, provided specimens of an undescribed *Cryptostigma* species from the nests of *Camponotus* (*Myrmostenus*) *longipilis* Emery, *C.* (*Myrmostenus*) *mirabilis* Emery and *C.* (*Pseudocolobopsis*) sp. (Formicidae: Formicinae) from inside live bamboos of *Guadua* sp., possibly *G. weberbaueri* Pilger (Poaceae). All ants and coccids were collected in lowland tropical forest (approximately 11° 54' S, 71° 22' W and 350-400 m a.s.l.) at Estación Biológica Cocha Cashu, Parque Nacional del Manu, Madre de Dios, in southeast Peru (http://www.duke.edu/~manu/index.html). *Cryptostigma* has not previously been collected from bamboo or any other species of Poaceae (Ben-Dov *et al*. 2003).

Dr. Davidson and her research assistants provided the following information on the association between the ants and this soft scale insect. Both *C. mirabilis* and *C. longipilis* are specialist associates of live bamboo, and their colonies appear to be highly dependent on the cultivation of this same coccid species. This observation is supported by the nitrogen isotope ratios for these two *Camponotus* species that suggest that they acquire their nitrogen from plant sources and trophobionts, rather than from predation or scavenging (Davidson *et al*. 2003). In floodplain forests surrounding Estación Biológica Cocha Cashu, coccids are most often associated with *C. mirabilis*, which is the commonest ant in the bamboo there. In live culms inhabited by these ants, the coccids are present on the internal culm walls, on the external surfaces of rhizomes, and rarely, on the internodal septa. Progressively younger and smaller coccids occur at higher internodes, perhaps because the ants transport them into the newest growth. Coccids have never been seen inside culms without ants. It is likely that, within bamboo clones, coccids colonize new culms by spreading along rhizomes, and that the ants assist in their dissemination. However, it is not known how the ants acquire the coccids when new ant nests are established. None of several alate queens of *C. mirabilis* or *C. longipilis* examined carried a coccid nymph on their nuptial flights. Ants of the third species, *C.* (*Pseudocolobopsis*) sp., collected with apparently dwindling populations of the same coccids, are frequently, but not exclusively, found in bamboo.

Here we formally recognize this ant-associated coccid from *Guadua* as a new species of *Cryptostigma.* We describe and illustrate the adult female and the first-instar nymph and discuss the relationships of this new species to other *Cryptostigma* species. This is the first published record of *Cryptostigma* from Peru. Despite the rich biodiversity of Peru, which is recognized as one of 17 "megadiversity" countries and contains parts of two biodiversity "hotspots" (Mittermeier & Mittermeier 1997, Myers *et al*. 2000, Myers 2001, Sarukhán & Dirzo 2001), only eight species of soft scale insects have been recorded in the literature (Ben-Dov *et al*. 2003). This dearth of recognized Peruvian soft scale insects is unlikely to reflect coccid diversity in nature because the Coccidae is the third largest scale insect family, with approximately 1130 described species, and it is well represented in the Neotropics (Ben-Dov *et al*. 2003).

Materials and Methods

Specimens were slide mounted according to the method given by Williams & Granara de Willink (1992), and were studied under an Olympus BX40 phase contrast compound microscope. One specimen was mounted on each slide. Illustrations of the insects follow the typical style adopted for scale insects, with the dorsal side drawn on the left and the ventral side drawn on the right. Enlargements of important characters are placed around the illustration, however, these enlargements are not in direct proportion to each other. Measurements of slide-mounted specimens were made using an ocular micrometer. Measurements of total body length are presented in millimeters whereas all other measurements are presented in micrometers (µm) as a range.

Abbreviations for the depositories are as follows: Museo de Historia Natural, Lima, Peru (MHLP); Museo de Entomologia, Universidad Nacional Agraria, Apartado 456, La Molina, Lima, Peru (UNAD); Bohart Museum of Entomology, Department of Entomology, University of California, Davis, California, U.S.A. (BME); and The National Museum of Natural History Coccoidea Collection, Beltsville, Maryland, U.S.A. (USNM).

Results and Discussion

Cryptostigma guadua sp. n.

(Figs. 1 and 2)

Diagnosis. The adult female of *C. guadua* sp. n. can be diagnosed by the following features: (i) numerous small sclerotic plates on the dorsum, (ii) a deep, cone-shaped spiracular sclerotization, (iii) tubercle-like preopercular pores, (iv) presence of 10-16 setae on each anal plate, and (v) multilocular disc-pores present on all abdominal segments, surrounding the spiracles and including a group which forms a line from each mesothoracic leg towards the posterior spiracle. *Cryptostigma biorbiculus* Morrison, *C. reticulolaminae* Morrison, *C. silveirai* (Hempel) and an undescribed species from Venezuela on citrus also have dorsal sclerotic plates (Kondo 2003) and may be confused with *C. guadua* sp. n. However, the other species mentioned above have 4-5 setae per anal plate, with the exception of *C. biorbiculus* which has about 10 setae per plate. *Cryptostigma biorbiculus* can be distinguished from *C. guadua* sp. n. by the possession of two characteristic orbicular pores on the mid area of the head and thorax.

Adult Female
(Fig. 1)

Unmounted Material. Color of insects variable, live specimens often reddish with a yellow tinge. Dorsum of specimens preserved in alcohol pale orange to yellowish-brown, ventral surface pinkish in color. Dorsal surface covered by a thin waxy layer, easily detached in alcohol, wax of a flaky texture. Spiracular cleft and anal cleft very deep; spiracular sclerotizations and anal plates clearly marked, light brown to dark brown in color.

Mounted Material. Body outline broadly oval, margins smooth or irregular, 3.8-10.1 mm long, 4.0-9.0 mm wide (n = 12).

Dorsum. Derm membranous, with numerous circular or constricted sclerotic plates (Fig. 1B, E); abundant towards body margin; each plate 13-100 µm wide, associated with a central duct or seta, plates near body margin generally larger and often with constricted margins (enlargement of dorsal derm shown in Fig. 1B.); density of dorsal sclerotic plates highly variable between specimens, ranging from very scarce to dense, but always fewer on mid dorsum. Dorsal body setae (Fig. 1A) sharply or bluntly spinose, 7-18 µm long, each seta on a small dorsal sclerotic plate, 5-18 µm wide, present evenly on dorsum. Submarginal tubercles absent. Preopercular pores (Fig. 1D) present, tubercle-like, about 10-15 µm wide, present on mid-dorsum on area anterior and laterad to anal plates. Dorsal microducts (Fig. 1C) with orifice appearing bilocular, about 3 µm wide, numerous, scattered on dorsum, with a very long and usually slightly sclerotized outer ductule; those near margin often longer; inner ductule about as long as or longer than outer ductule. A sclerotic crescent present around anal plates. Anal plates (Fig. 1F) together pyriform, occasionally quadrate, with rounded angles; each plate 133-183 µm long, 55-80 µm wide, anterolateral margin 103-145 µm wide, posterolateral margin 75-103 µm wide; with 10-16 setae on dorsal surface of each plate, located at about 1/3-1/4 of body length from posterior margin. Anal ring (Fig. 1H) with 10 setae. Eyes absent.

Margin. Marginal setae not differentiated. Spiracular clefts very deep, forming a conical spiracular sclerotization; length 480-680 µm, opening 270-460 µm wide. Spiracular setae usually hard to detect, however, three short conical swellings often present on outer margin of spiracular plate.

Venter. Derm membranous. Ventral setae (Fig. 1I) slender, straight or slightly bent, those on abdominal segments usually longer, 20-43 µm; those near margins shorter, 7-15 µm long. Interantennal setae about three pairs. Ventral microducts (Fig. 1K) scattered evenly on venter, about 3 µm wide. Tubular ducts completely absent. Clypeolabral shield 305-335 µm wide. Labium with four pairs of setae. Multilocular disc-pores (often called perivulvar or pregenital pores) (Fig. 1G) with 3-8 loculi, mostly with 6-7 loculi, 7-10 µm wide, abundant around vulvar area and present on all abdominal segments; pores also present around metathoracic legs in a line that connects to area of posterior spiracle. Spiracular pores (Fig. 1L) with 3-8 loculi, mostly 5-locular, 6-8 µm wide, some extending anteriorly towards mesothoracic legs. Antennae (Fig. 1M) very small, 45-65 µm long, apparently 1-segmented, represented by flattened segment bearing about 14-15 setae. Legs (Fig. 1J) greatly reduced, represented by a rudimentary claw, several setae, and associated pores, total length 45-65 µm. Spiracles much larger than legs, located far from body margin; anterior spiracular peritreme 113-143 µm wide, posterior peritreme 125-160 µm wide.

First-Instar Nymph
(Fig. 2)

Diagnosis. The first-instar nymph of *C. guadua* sp. n. can be diagnosed by the combination of the following features: (i) 5-segmented antennae, (ii) presence of mid-ventral setae on all abdominal and thoracic segments, (iii) dorsal setae arranged in two parallel longitudinal lines, (iv) presence of two types of marginal setae, those on dorsal side sharply spinose, those on ventral side flagellate, and (v) the presence of numerous ventral microducts arranged in a transverse row just posterior to the mouthparts and anterior coxae. First-instar nymphs with 5-segmented antennae also occur in most members of the *Toumeyella*-group, and also are found in *C. reticulolaminae*, *C. silveirai* and two undescribed species, but these other species do not have the combination of features listed above for *C. guadua* sp. n. Williams & Kondo (2002) described the crawlers of *C. biorbiculus* as having 5-segmented antennae, however, this was a misidentification of *C. reticulolaminae* because specimens were mixed up with those of *C. biorbiculus* which have the common number of six antennal segments.

Mounted Material. Slide mounted material elongate oval (Fig. 2), recently eclosed or early settled nymphs 1.2-1.6 mm long, 0.9-1.4 mm wide (n = 4), fully grown nymphs 1.8-2.2 mm long, 1.6-1.9 mm wide (n = 4).

Dorsum. Dorsal derm membranous, tesselated in some specimens, with segmentation delineated by membranous folds (enlargement of dorsal derm shown in Fig. 2A). Dorsal setae (Fig. 2C) present in two submedian parallel rows, each seta about 15 µm long, setae on head region usually present, other dorsal setae often broken off or undetectable. A trilocular pore (Fig. 2B) present on each side of head near margin close to eye. Dorsal microducts (Fig. 2E) with orifice appearing bilocular, about 2 µm wide, numerous over dorsum. Simple disc pores (Fig. 2H) about 3-5 µm wide, those closer to body margin slightly smaller. Anal plates with shingled surface texture, together pyriform, each plate 165-180 µm long, 70-80 µm wide, anterolateral margin 138-163 µm long, posterolateral margin 48-85 µm long, dorsal surface with one seta on anterior part of plate and four apical setae, ventral surface with one fringe seta. Anal ring (Fig. 2J) with six setae and an irregular row of translucent wax pores.

Margin. Outline smooth. Marginal setae of two types; those found just dorsally sharply spinose (Fig. 2G), total number

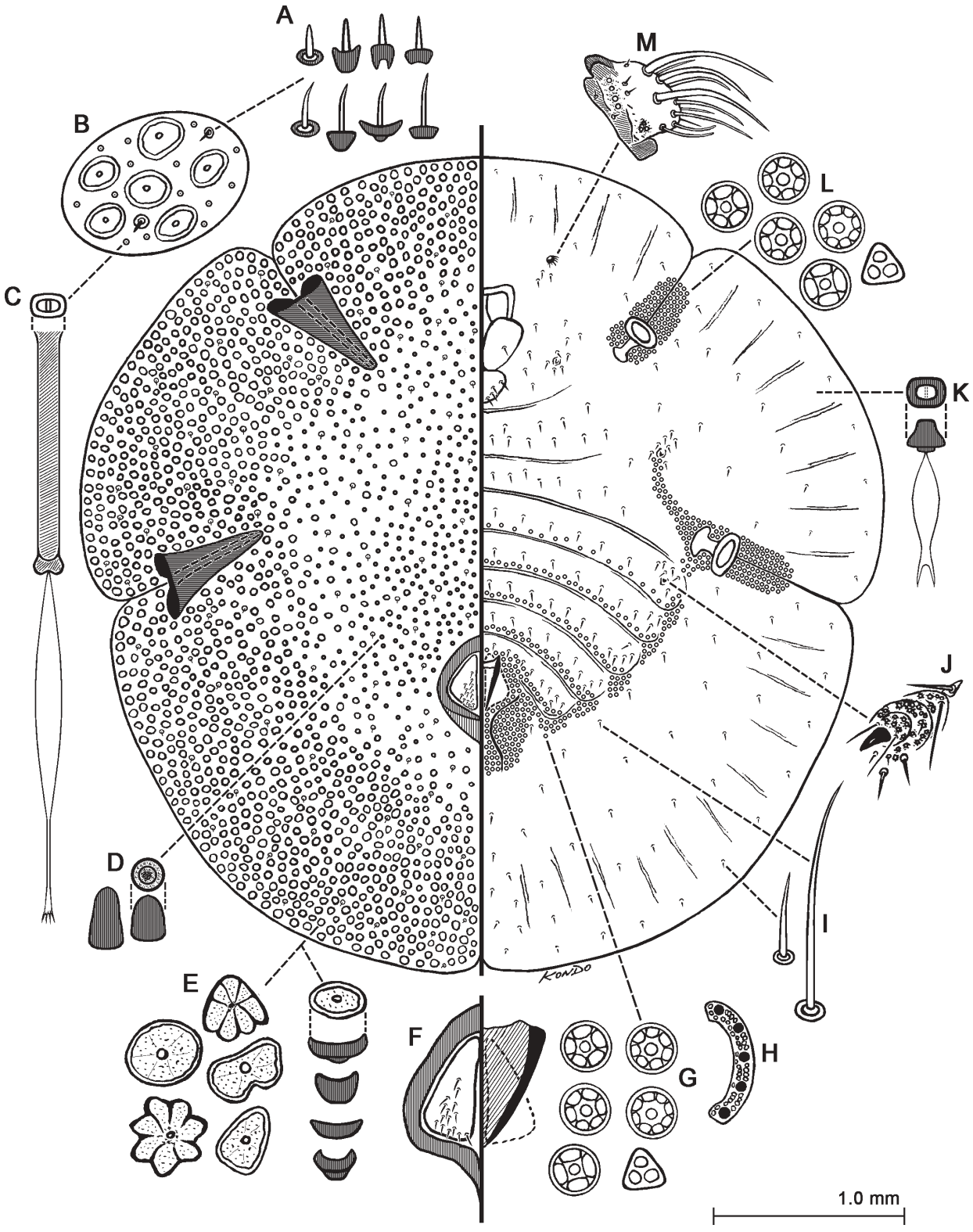

Figure 1. *Cryptostigma guadua* sp. n. Adult female. A. Dorsal setae; B. Enlargement of dorsal derm; C. Dorsal microduct; D. Preopercular pores; E. Sclerotic plates; F. Anal plate; G. Perivulvar pores; H. Anal ring (right half); I. Ventral setae; J. Leg; K. Ventral microduct; L. Spiracular pores; M. Antenna. Scale = 1.0 mm for insect body.

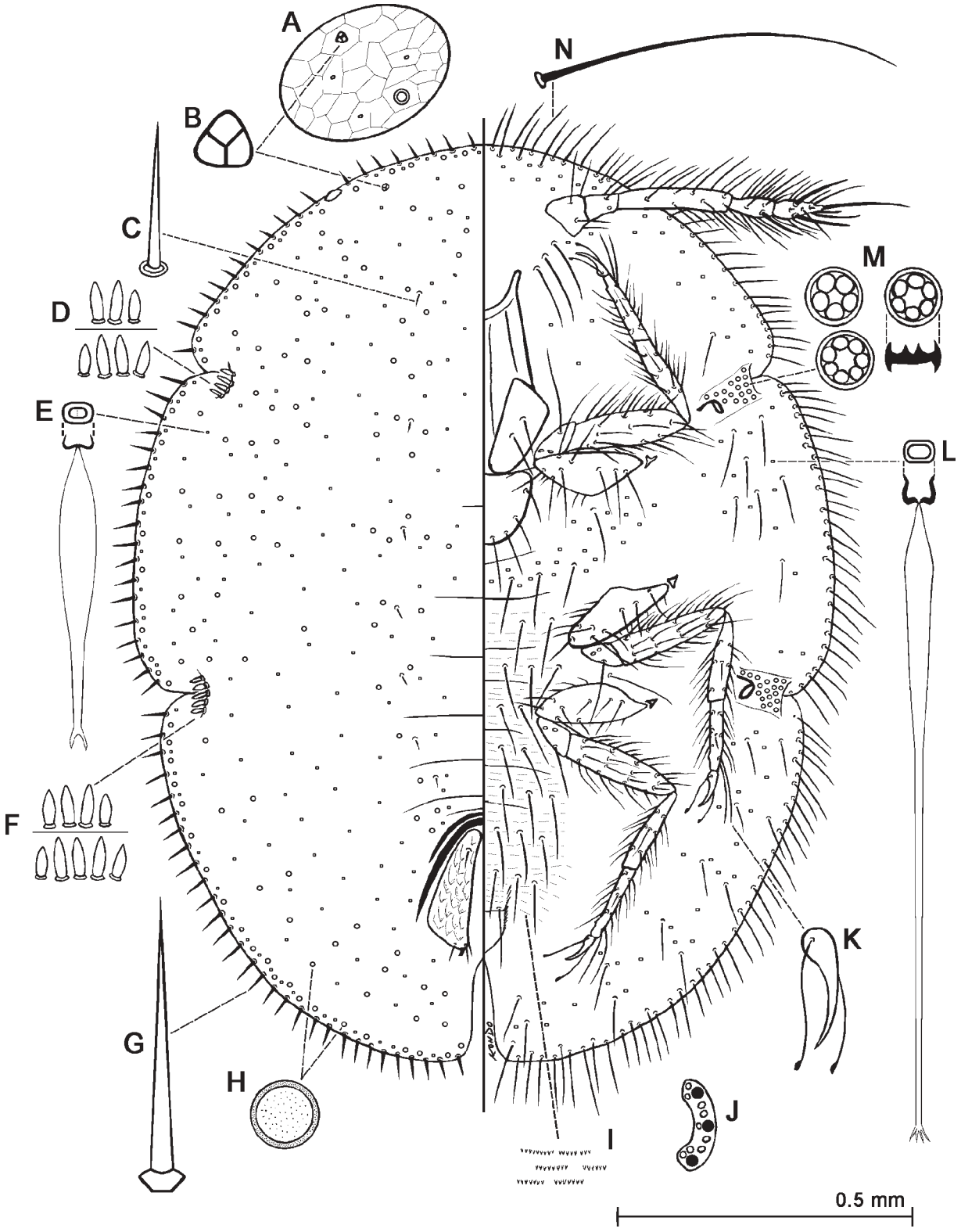

Figure 2. *Cryptostigma guadua* sp. n. First-instar nymph. A. Enlargement of dorsal derm; B. Trilocular pore; C. Dorsal seta; D. Anterior spiracular setae; E. Dorsal microduct; F. Posterior spiracular setae; G. Marginal seta; H. Simple disc pore; I. Microtrichia; J. Anal ring (right half); K. Claw; L. Ventral microduct; M. Spiracular pores; N. Ventral marginal seta. Scale = 0.5 mm for insect body.

133-160, numbering 15-20 anteriorly between eyes, 10-15 between each eye and anterior spiracular setae, 16-23 between each group of anterior and posterior spiracular setae, and 29-49 between posterior spiracular setae and body apex; those found just ventrally (Fig. 2N) flagellate, more numerous than dorsal marginal setae, 63-90 µm long; submarginal ventral setae similar to ventral marginal setae, in six pairs on each side of abdomen, about seven setae between each anterior and posterior spiracle, and one seta between antennal scape and anterior spiracular furrow. Spiracular setae sharply spinose, subequal in length, short, each seta 15-20 µm long; anterior spiracular setae (Fig. 2D) in a group of 3-4 setae, posterior spiracular setae (Fig. 2F) in a group of 4-5 setae.

Venter. Ventral derm membranous, with microtrichia (Fig. 2I) present on abdominal segments. Mid-ventral setae present on all segments posterior to mouthparts, with 4-8 setae per segment, each seta flagellate, 75-100 µm long. Interantennal setae in 3-4 pairs. Ventral microducts (Fig. 2L) with a very long ductule, numerous around body margin and area posterior to mouthparts and hind coxae. Spiracular pores (Fig. 2M) with 5-7 loculi, mostly 5-locular, about 5 µm wide, with 12-18 pores per spiracular furrow. Clypeolabral shield 180-214 µm wide, with 4-5 setae. Labium with four pairs of setae. Legs well developed, with numerous setae; trochanter + femur 215-245 µm long, tibia + tarsus 235-265 µm long, microctenidia not visible on tibial apex. Tarsal digitules similar, spiniform. Claw (Fig. 2K) slender, without a denticle; claw digitules slender, with knobbed apices. Antennae 5-segmented, total length 390-440 µm, third antennal segment longest.

Etymology. The species epithet of this bamboo coccid is derived from the genus of the host plant: *Guadua* (a noun in apposition).

Distribution. Neotropical Region: Peru

Host Plants. Poaceae: bamboo (*Guadua* sp.)

Associated Ants. Formicinae: *Camponotus* (*Myrmostenus*) *longipilis*, *C.* (*M.*) *mirabilis* and *C.* (*Pseudocolobopsis*) sp.

HOLOTYPE (MHLP). Adult female, Peru, Estación Biológica de Cocha Cashu, Parque Nacional Manu, Madre de Dios, 11°54'S, 71°22'W, c. 350 m. a.s.l., VI-2003, coll. D.W. Davidson, ex bamboo (*Guadua* sp.), inside nest of *Camponotus mirabilis*. **PARATYPES.** Three adult females, five second-instar nymphs, five first-instar nymphs, same data as holotype (BME, UNAD, USNM); three first instar nymphs, Peru, Estación Biológica Cocha Cashu, Parque Nacional Manu, Madre de Dios, c. 400 m. a.s.l., 8-X-2001, coll. D.W. Davidson, No. cc-01-120, ex bamboo (*Guadua* sp.), inside nest of *Camponotus mirabilis* (UNAD, USNM); two adult females, one third-instar nymph, Peru, Estación Biológica de Cocha Cashu, Parque Nacional Manu, Madre de Dios, 11°54'S, 71°22'W, c. 350 m. a.s.l., 31-V-2003, coll. D.W. Davidson, No. 03-043, ex bamboo (*Guadua* sp.), tended by *Pseudocolobopsis* sp. (BME, UNAD); four adult females, Peru, Estación Biológica de Cocha Cashu, Parque Nacional Manu, Madre de Dios, 11°54'S, 71°22'W, c. 400 m. a.s.l., 13-XI-2001, No. cc-01-140 & cc-01-157, coll. D.W. Davidson, ex bamboo (*Guadua* sp.), inside nest of *Camponotus longipilis* (UNAD); one adult female + one pharate adult female, Peru, Tambopata Research Center on Rio Tambopata, II-2002, coll. D.W. Davidson, No. 01-TRC-01, ex bamboo (UNAD).

Acknowledgments

We are thankful to Dr. Diane W. Davidson from the Department of Biology, University of Utah, for providing the material studied as well as information on the ant associations. Also Mr. J.A. Arias U. and Mr. J. Mann provided some field notes on the coccids. We acknowledge Peru's Instituto Nacional de Recursos Naturales (INRENA) for the research permit to Dr. Davidson for collection of the insects. Dr. Walter S. Leal kindly checked our Portuguese resumo. This material is based upon work supported by the U.S. National Science Foundation under Grant No. 0118718.

Literature Cited

Beattie, A.J. 1985. The evolutionary ecology of ant-plant mutualisms. Cambridge University Press, Cambridge, 182p.

Ben-Dov, Y., D.R. Miller & G.A.P. Gibson. 2003. ScaleNet: A database of the scale insects of the world. [Online] http://www.sel.barc.usda.gov/scalenet/scalenet.htm.

Benson, W.W. 1985. Amazon ant-plants, p. 239-266. In G.T. Prance & T.E. Lovejoy (eds.), Key environments: Amazonia. Pergamon Press, Oxford, 442p.

Buckley, R.C. 1987a. Ant-plant-homopteran interactions. Adv. Ecol. Res. 16: 53-85.

Buckley, R.C. 1987b. Interactions involving plants, Homoptera, and ants. Annu. Rev. Ecol. Syst. 18: 111-135.

Camargo, J.M.F. & S.R.M. Pedro. 2002a. A new species of *Schwarzula* from Amazon (Hymenoptera, Apidae, Meliponini). Iheringia, Sér. Zool. 92: 101-112.

Camargo, J.M.F. & S.R.M. Pedro. 2002b. Mutualistic association between a tiny Amazonian stingless bee and a wax-producing scale insect. Biotropica 34: 446-451.

Davidson, D.W. & D. McKey. 1993. The evolutionary ecology of symbiotic ant-plant relationships. J. Hymenoptera Res. 2: 13-83.

Davidson, D.W., S.C. Cook, R.R. Snelling & T.H. Chua. 2003. Explaining the abundance of ants in lowland tropical rainforest canopies. Science 300: 969-972.

Delabie, J.H.C. 2001. Trophobiosis between Formicidae and

Hemiptera (Sternorrhyncha and Auchenorrhyncha): an overview. Neotrop. Entomol. 30: 501-516.

Gaume, L., D. McKey & S. Terrin. 1998. Ant-plant-homopteran mutualism: How the third partner affects the interaction between a plant-specialist ant its myrmecophyte host. Proc. Roy. Soc. Lond. B 265: 569-575.

Gullan, P.J. 1997. Relationships with ants, p.351-373. In Y. Ben-Dov & C.J. Hodgson (eds.), Soft scale insects: Their biology, natural enemies and control, volume 7A. Elsevier Science, Amsterdam, 452p.

Heckroth, H.-P., B. Fiala, P.J. Gullan, A.H. Idris. & U. Maschwitz. 1998. The soft scale (Coccidae) associates of Malaysian ant-plants. J. Trop. Ecol. 14: 427-443.

Hodgson, C.J. 1994. The scale insect family Coccidae: An identification manual to genera. CAB International Institute of Entomology, London, UK, 432p.

Hölldobler, B. & E.O. Wilson. 1990. The ants. The Belknap Press of Harvard University Press, Cambridge, Massachusetts, 732p.

Kondo, T. 2003. A taxonomic review of the subfamily Myzolecaniinae (Homoptera: Coccoidea: Coccidae). Thesis Ph.D. Department of Entomology, Auburn University, Auburn, Alabama, USA, 302p.

Kondo, T. & M.L. Williams. 2002. The Myzolecaniinae (Hemiptera: Coccidae): Old World vs. New World. Boll. Zool. Agr. Bachicolt. Ser. II 33: 125-128.

Longino, J.T. 1991. *Azteca* ants in *Cecropia* trees: Taxonomy, colony structure, and behaviour, p. 271-288. In C.R. Huxley & D.F. Cutler (eds.), Ant-plant interactions. Oxford University Press, Oxford, 601p.

Mittermeier, R. & C. Mittermeier. 1997. Megadiversity: Earth's biologically wealthiest nations. CEMEX, Mexico City, 501p.

Moog, J., B. Fiala, M. Werner, A. Weissflog, S.L. Guan & U. Maschwitz. 2003. Ant-plant diversity in Peninsular Malaysia, with special reference to the Pasoh Forest Reserve, p. 459-494. In T. Okuda, N. Manokaran, Y. Matsumoto, K. Niiyama, S.C. Thomas & P.S. Ashton (eds.), Pasoh: Ecology of a lowland rain forest in Southeast Asia. Springer-Verlag, Tokyo, 634p.

Myers, N. 2001. Hotspots, p. 371-381. In S.A. Levin (ed.), Encyclopedia of biodiversity, vol. 3. Academic Press, San Diego, 870p.

Myers, N., R.A. Mittermeier, C.G. Mittermeier, G.A.B. da Fonseca & J. Kent. 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853-858.

Qin, T.K. & P.J. Gullan. 1989. *Cryptostigma* Ferris: A coccoid genus with a strikingly disjunct distribution (Homoptera: Coccidae). Syst. Entomol. 14: 221-232.

Sarukhán, J. & R. Dirzo. 2001. Biodiversity-rich countries, p. 419-436. In S.A. Levin (ed.), Encyclopedia of biodiversity, vol.1. Academic Press, San Diego, 943p.

Ward, P.S. 1991. Phylogenetic analysis of pseudomyrmecine ants associated with domatia-bearing plants, p. 335-352. In C.R. Huxley & D.F. Cutler (eds.), Ant-plant interactions. Oxford University Press, Oxford, 601p.

Wheeler, W.M. 1942. Studies of Neotropical ant-plants and their ants. Bull. Mus. Comp. Zool. 90: 1-262.

Williams, D.J. & M.C. Granara de Willink. 1992. Mealybugs of Central and South America. C.A.B. International, Wallingford, UK, 635p.

Williams, M.L. & T. Kondo. 2002. Characteristics of first-instar nymphs in the soft scale insects (Hemiptera: Coccidae): Surprising indicators of relationships. Boll. Zool. Agr. Bachicolt. Ser. II 33: 35-42.

Received 08/07/03. Accepted 10/05/04.