

Two new species of *Bennaria* Melichar, 1914 (Hemiptera, Fulgoromorpha, Cixiidae, Bennini) from Papua New Guinea

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Abstract

Received 30 June 2011
Accepted 4 August 2011
Published 17 November 2011

Key Words

Taxonomy
Southeast Asia
Island endemism
Bennaria damisa sp n.
Bennaria mareagnesia sp n.

Species of the cixiid tribe Bennini are characterized by a pair of lateral rod-like appendages at the base of the abdomen which are present in both sexes. Hitherto, 22 Bennini species have been described in the genera *Benna*, *Bennaria* and *Celebenna* from throughout Southeast Asia, two of which occur in New Guinea. Recent field studies carried out in native forest ecosystems in Madang Province, East Papua New Guinea, provide evidence that the number of Bennini species is – as in many other insect taxa – higher than previously assumed. Here, we describe two new *Bennaria* species from Papua New Guinea and give preliminary notes on their ecology.

Introduction

During a recent survey of forest ecosystems in Papua New Guinea conducted in the framework of her master's thesis dissertation ("Community structure of Auchenorrhyncha (Hemiptera: Insecta) along an altitudinal gradient in Papua New Guinea") Francesca Dem collected several representatives of the cixiid tribe Bennini from various localities near Madang, Papua New Guinea. Bennini species are characterized by conspicuous rod-like lateral appendages arising from the base of the abdomen which are distally produced into an egg-cup-shaped dilation, the latter being slightly concave and bearing wax-covered sensillae. Superficially, these appendages resemble the halteres of Diptera (Hoch et al. 2011, this issue). So far, 22 species of Bennini have been described from throughout Southeast Asia: Singapore, the Philippines, Borneo, New Guinea, Buru, Taiwan, Sula, Amboina, Sumba, Western Caroline Islands, Palau, the Solomon Islands and Sulawesi (see Hoch et al. 2011, this issue), and assigned to three genera *Benna* Walker, *Bennaria* Melichar, and *Celebenna*

Hoch & Wessel. From New Guinea, two Bennini species are known: *Bennaria guttata* (Walker) (Walker 1870) and *Bennaria cyclopina* Nast (Nast 1950). A taxonomic revision of the whole group is in preparation (by H. Hoch) which will raise the number of species to more than 100. The Bennini specimens collected in the course of the survey at Madang, Papua New Guinea, are interpreted here as representatives of two species, and cannot be assigned to any of the known *Bennaria* species from New Guinea, or elsewhere. Consequently, they are described here as new to science. Due to their morphological configuration, both new species are preliminarily placed into the genus *Bennaria* Melichar (Melichar 1914).

Material and methods

Collecting, preservation, permanent storage. The specimens were collected by sweeping, and transferred immediately into vials containing 70% ETOH. For permanent storage, after dissection and examination, genitalia and the abdomen were transferred to polyethylene vials, and individually associated with the specimen vial.

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Morphological examination techniques, visualization. Measurements and examinations of external body features were made from specimens in alcohol without further manipulation. Measurements of body length pertain to the distance between the apex of the head and the distal margin of the tegmina. As in many specimens tegmina were distally damaged, thus preventing accurate measurement, body length measurements in both sexes were taken as the distance between the apex of the head and the tip of the anal segment. The latter are given in brackets.

Genital capsules were removed from the specimens, then macerated in 10% KOH (24 h) at room temperature, washed in water, transferred to glycerine for storage, or to glycerine-jelly for drawings. Dissections were made using stainless steel insect pins (no 3). Examinations and drawings were made using a Leitz stereomicroscope with a camera lucida.

Abbreviations. NGBRC = New Guinea Binatang Research Centre, Madang, Papua New Guinea; MfN = Museum für Naturkunde, Berlin, Germany.

SU = sampling unit; RS = random sampling (i.e. taken directly from the plant with an aspirator).

Taxonomy

Bennaria damisa sp. n.

Figures 1–5

Description

Body length. Male. 8.0–8.5 mm ($n = 3$), (5.0–5.5 mm; $n = 4$). Female. 9.1–9.2 mm ($n = 2$), (4.8–5.5 mm; $n = 6$). Habitus generally as in other *Bennini* (Hoch et al. 2011: fig. 3).

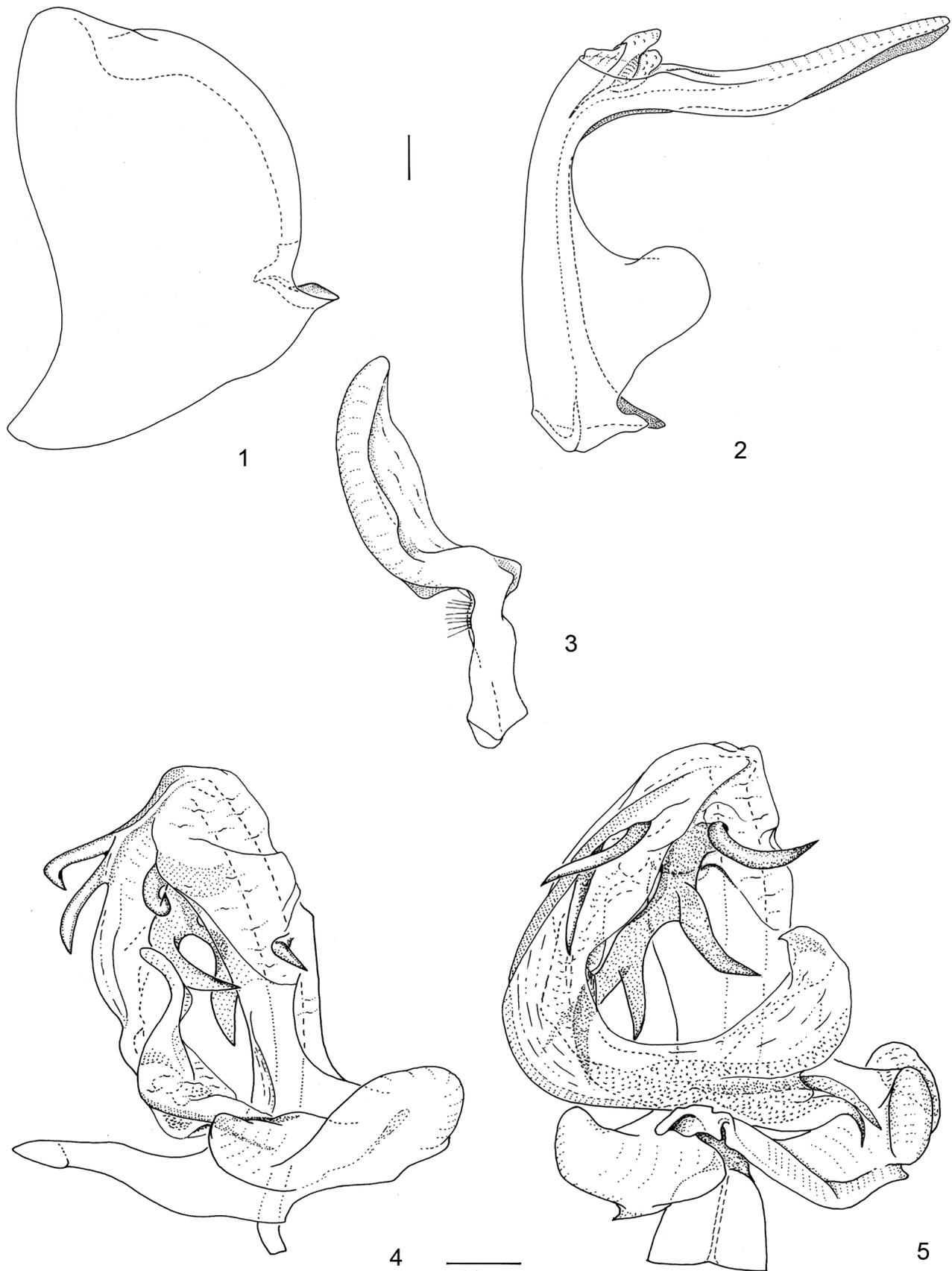
Head. Vertex short, posterior compartments together ca. 6.8 times wider than medially long; anterior compartment of vertex separated from frons by an obsolete concave transverse carina. Frons nearly smooth, with a very faint median longitudinal carina vanishing towards apex of frons, lateral carinae strongly ridged, on anterior side regularly notched. Frons long, narrow, widest slightly below level of antennae; medially 1.7 times longer than maximum width; slightly shorter (0.86) than post- and anteclypeus together. Frontoclypeal suture nearly straight, only very slightly arched. Post- and anteclypeus each with distinct median longitudinal carinae vanishing towards frontoclypeal suture. 3 ocelli present; antennae with scape short, ring-like, pedicel cylindrical, ca. 2.5 times as long as wide.

Thorax. Pronotum as in other *Bennini* short, tricarinate, ca. $1.55 \times$ wider than maximum width of head (incl. eyes). Mesonotum subpentagonal, dorsally tricarinate, ca. as wide as medially long, lateral portions steeply oblique. Metatibiae laterally with 1 distinct and a varying number (4–6) of smaller spines, distally with 6 large spines, arranged in two groups. Metabasis distally with 8 teeth, 2nd metatarsal joint distally with 9 teeth. Tegmina narrow proximally, distally widening; 2.2 times longer than maximum width, surpassing tip of abdomen with ca. $1/3$ their total length; venation as described for *Bennini* by Emeljanov (2002).

Colouration. Frons medially and laterally – except for a narrow median longitudinal yellow stripe – sordid

brown; clypeus, genae and antennae brown, rostrum yellowish brown. Pronotum medially dark brown, anterior lateral portions yellowish. Tegulae dark brown. Mesonotum sordid brown, carinae accompanied by dark brown longitudinal stripes. Legs brownish, yellowish near joints. Abdominal tergites in both sexes dark brown, pregenital sternites light brown, with dark brown lateral portions, caudal margins whitish. Lateral abdominal appendages dark brown. In the male, genital segment sordid yellowish brown, anal segment and distal portion of parameres dark brown. In the female, sternite VII in proximal $2/3$ brownish, distally as well as base of ovipositor yellowish, ovipositor otherwise as well as IX segment and anal segment dark brown. Tegmina subhyaline, yellowish brown, veins dark brown. Tegmen in proximal half with several small dark brown spots with irregular outline: 4 in subcostal cell, one in radian cell just distally of apex of anterior subapical cell, 2 in median cell, one in cubital cell and one in claval cell, extending into the Y-vein furcation. Tegmen near apex of posterior subapical cell with a larger, dark brown irregular shaped spot. Median and distal transverse veinlets accompanied by dark brown bands; distal cells irregularly laced with brownish bands enclosing lighter portions.

Male genitalia (Figs 1–5). Genital segment (Fig. 1) bilaterally symmetrical, in lateral aspect more or less trapezoidal; caudal margin laterodorsally rounded, medioventral process wide at base, distally irregularly tapering, apically rounded, dorsal surface smooth. Anal segment (Fig. 2) bilaterally distinctly asymmetrical, long, narrow, distal half bent ventrally in a ca. 90° angle; proximal portion in dorsal aspect ca. $3.3 \times$ as long as wide at base, right lateral margin straight, left lateral margin with a conspicuous rounded lobe; anal segment distally of anal style tongue-shaped, gradually tapering, in caudal aspect slightly sinuate, tip rounded; anal segment ventrally concave. Parameres (Fig. 3) narrow, sub-tubular at base, in apical half expanding into a narrowly triangular, spatula-shaped dilation which is apically tapering and caudally concave. Aedeagus (Figs 4–5). Shaft tubular, stout, base distinctly bilaterally asymmetrical: left laterally, near base, with a comparatively large, ear-shaped protrusion extending ventrally which connects at its base with that of the left lateral basal projection; left lateral basal projection slightly smaller than right lateral basal projection, both distinctly separated from shaft base, erect, apically rounded. Shaft laterally and dorsally strongly sclerotized; distal margin of sclerotized portion dorsally differentiated into a conspicuous rigid quadrispinose process, the branches of which pointing left laterally, ventrally to the left side, basally and ventrally to the right side, respectively. Shaft left laterally at ca. midlength with a short, slender, terete spine-like process. Flagellum movable, in repose bent right laterally; long, in repose attaining base of shaft, more or less semicircularly curved left laterally; flagellum tubular, dorsally and right laterally with a strongly sclerotized taeniform portion which is apically produced into a compress velum; membranous



Figures 1–5. *Bennaria damisa* sp. n., male genitalia. **1.** Genital segment, left lateral aspect; **2.** Anal segment, left lateral aspect; **3.** Left paramere, maximal aspect; **4.** Aedeagus, left lateral aspect; **5.** Aedeagus, dorsal aspect. Scale bar: 0.1 mm.

part of flagellum distally produced into 2 slender, feebly sclerotized spinose processes, both in repose directed left latero-basally. Flagellum left laterally in proximal third with 2 slender, terete spinose processes arising from the margin of the strongly sclerotized taeniform portion, in repose both directed basally, and right laterally in proximal half with two processes: one – arising near flagellum base – ventrally rounded and its surface beset with fine teeth, dorsally irregularly serrate; the other – arising slightly distally of it – slender, terete, spine-like, slightly sinuate, in repose directed right laterally. Phallosome exposed left laterally, flanked dorsally by the base of the velum-like process and laterally by the two slender apical spinose processes. Visible part of ejaculatory duct in flagellum rugose.

Female genitalia. As in other *Bennini* IX. tergite truncate, wax-producing area well developed, anal segment short, rectangular, ovipositor ensiform. Anal segment short, in dorsal aspect rectangular, lateral margins parallel, straight; ca. 1.5 times longer than wide, caudal margin rounded.

Diagnosis. In size and general habitus similar to *Bennaria mareagnesia* sp. n. (see below), but distinguishable from *B. mareagnesia* sp. n. by the specific colour pattern, especially the longitudinal dark stripes on the mesonotum and the pigmentation pattern of the tegmen (distribution of dark irregular spots in proximal part; posterior margin dark brown), and the specific configuration of the male genitalia (anal segment long, narrow, with a lobate process left laterally near base and bent at midlength at a ca. 90° angle; spine configuration of the aedeagus).

Etymology. *Bennaria damisa* sp. n. is named in honour of Francesca Dem's niece, Damisa Dameau.

Distribution. Endemic to Papua New Guinea; known from 3 localities within Madang Province, from 700–1,200 m altitude (see ecology).

Material examined. Holotype ♂. PAPUA NEW GUINEA, Madang Province, Bobrai – Kumi, 700 m, 12.XII.2009, SU # 5 (RS), F. Dem and A. Gibson leg., NGBRC.

Paratypes. Same locality as holotype except dates: 2 ♂♂, 1 ♀, 2.VI.2009, SU # 10, NGBRC; 5 ♂♂, 5 ♀♀, 10.XII.2009, (RS), NGBRC; 2 ♂♂, 2 ♀♀, 18.XII.2009, SU # 20 (RS), NGBRC; 1 ♀, 10.XII.2009, SU # 4 (RS), NGBRC; 2 ♂♂, 1 ♀, 18.XII.2009, SU # 22 (RS), MfN; 1 ♂, 18. XII.2009, SU # 19 (RS), NGBRC; 1 ♀, 1.VI.2009, SU # 8, MfN; 1 ♀, 1.VI.2009, SU # 9, MfN; 1 ♀, 16.XII.2009, SU # 14 (RS), NGBRC. – Madang Province, Bananumbu, 700 m, F. Dem and A. Gibson leg., NGBRC: 1 ♂, 6.VI.2009, SU # 20. – Madang Province, Koviamarai-Kumi, 1,200 m, F. Dem and A. Gibson leg., NGBRC: 1 ♂, 7.XI.2009, SU # 12; 1 ♀, 11.XI.2009, SU # 24.

Bennaria mareagnesia sp. n.

Figures 6–10

Description

Body length. Male. 9.1 mm (n = 2), (6.0–6.2 mm; n = 3). Female. (6.2–6.7 mm; n = 5).

Head. Vertex short, posterior compartments together ca. 8 times wider than medially long; anterior compartment of vertex separated from frons by a faint transverse carina. Frons with a faint median longitudinal carina, vanishing towards apex of frons at level of lateral ocelli. Frons long, narrow, widest slightly below level of antennae; medially 1.88 times longer than maximum width; slightly shorter (0.9) than post- and anteclypeus together. Frontoclypeal suture more or less straight. Post- and anteclypeus with a distinct median longitudinal carinae vanishing towards frontoclypeal suture. 3 ocelli present; antennae with scape short, ring-like, pedicel cylindrical, ca. 2.5 times as long as wide.

Thorax. Pronotum as in other *Bennini* short, tricarinate, ca. 1.88 times wider than maximum width of head (incl. eyes). Mesonotum subpentagonal, dorsally tricarinate, ca. as wide as medially long, lateral portions steeply oblique. Metatibiae laterally with 2 distinct and a varying number (4–6) of smaller spines, distally with 6 large spines, arranged in two groups. Metabasis distally with 8 teeth, 2nd metatarsal joint distally with 9 teeth.

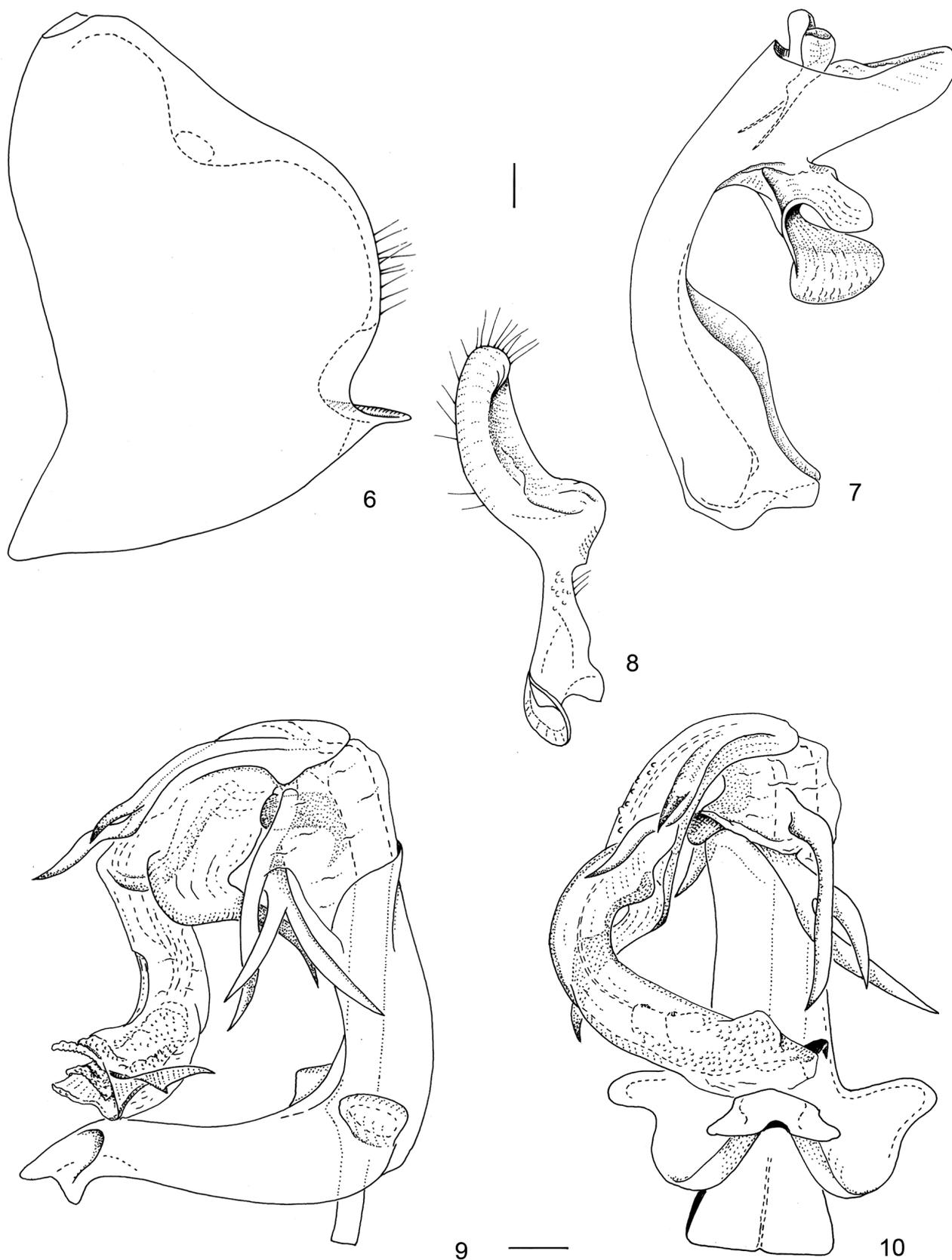
Tegmina narrow proximally, distally widening; 2.16 times longer than maximum width, surpassing tip of abdomen with ca. 1/3 their total length; venation as described for *Bennini* by Emeljanov (2002).

Colouration. Frons medially in upper part, vertex, upper part of frons, pro- and mesonotum medially as well as posterior margins of tegmina yellow; lower part of frons and clypeus sordid brown; genae, antennae, rostrum, pro- and mesonotum laterally as well as tegulae dark brown. Legs brownish, tarsal joints brownish, with proximal and distal margins yellowish. Abdominal tergites of pregenital segments brownish, sternites of segments III and IV dark brown, sternites V and VI brownish with dark brown lateral portions. Lateral abdominal appendages brownish. In the male, genital segment and anal segment sordid dark brown.

In the female, sternite VII in proximal 2/3 brownish, distally as well as base of ovipositor yellowish, ovipositor otherwise as well as IX segment and anal segment dark brown.

Tegmina subhyaline, yellowish brown, with vivid pattern of dark brown markings; veins except posterior margin dark brown. Basal cell brown, 3 short, dark brown stripes in proximal half of subcostal cell, a dark brown roundish spot between apex of anterior subapical cell and media, a roundish dark spot at ca. midlength of Cu; clavus dark brown except for portion between posterior branch of Y-vein and posterior margin of tegmen, a small, spot-like area just caudally of basal cell; apex of posterior subapical cell and distal transverse veinlets accompanied by dark brown bands; distal cells dark brown, distally laced with irregular roundish or oval light spots.

Male genitalia (Figs 6–10). Genital segment (Fig. 6) bilaterally symmetrical, in lateral aspect more or less trapezoidal; caudal margin laterodorsally rounded, medioventral process wide at base, distally irregularly tapering, apically rounded, dorsal surface smooth. Anal segment (Fig. 7) bilaterally strongly asymmetrical, in



Figures 6–10. *Bennaria mareagnesia* sp. n., male genitalia. **6.** Genital segment, left lateral aspect; **7.** Anal segment, left lateral aspect; **8.** Left paramere, maximal aspect; **9.** Aedeagus, left lateral aspect; **10.** Aedeagus, dorsal aspect. Scale bar: 0.1 mm.

dorsal aspect long, narrow, lateral margins with slight rounded ventral lobes, ventrally – slightly proximally of anal style – equipped with a unpaired bilobate process directed ventrally. Parameres (Fig. 8) narrow, sub-tubular at base, in apical half expanding into a tongue-shaped dilation which is apically rounded and caudally concave; concave portion ceriferous. Aedeagus (Figs 9–10). Shaft tubular, stout, base more or less bilaterally symmetrical; lateral basal projections well separated from shaft base, comparatively small, directed laterally, apically rounded. Shaft laterally, dorsally and in ventral half strongly sclerotized; distal margin of sclerotized portion dorsally in left half differentiated into a rigid bifurcate process, the branches of which pointing left laterally and basally, respectively, and dorsally in right half into a small, ear-shaped protrusion directed right laterally. Shaft left laterally near aedeagal joint with a slender, terete, spine-like process directed straight basally. Flagellum movable, in repose bent right laterally; long, in repose attaining base of shaft, more or less semicircularly curved left laterally; flagellum tubular, in proximal third strongly sclerotized and dorsally beset with irregularly distributed tubercles. Flagellum with 5 spinose processes: two arising left laterally in proximal half (short, slender, terete, in repose directed dorsally), one arising ventrally from a wide, rounded base, apically rapidly tapering and directed right laterally, its tip pointing basally, one arising right laterally near aedeagal joint (short, in repose directed straight basally) and one arising at the tip of flagellum, compressed, spine-like, in repose directed ventrally. Phallosome exposed left laterodorsally; visible part of ejaculatory duct in flagellum rugose.

Female genitalia. As in other Bennini IX. tergite truncate, wax-producing area well developed, anal segment long, narrow, ovipositor ensiform. Anal segment long and narrow, in dorsal aspect rectangular, lateral margins parallel, straight; ca. 5 times longer than wide, caudal margin ventrally produced into two short acute processes, slightly asymmetrical.

Diagnosis. In size and general habitus similar to *Bennaria damisa* sp. n., but distinguishable from *B. damisa* sp. n. by the specific colour pattern, especially the conspicuous yellow dorsal longitudinal stripe (with body otherwise dark and tegmina with vivid dark colour pattern), and the specific configuration of the male genitalia (anal segment ventrally with bilobate process, spine configuration of the aedeagus) and female genitalia (anal segment ca. 5 times as long as wide at base).

Etymology. *Bennaria mareagnesia* sp. n. is named in honour of Francesca Dem's mother, Mare Agnes.

Distribution. Endemic to Papua New Guinea. Known from one locality in Madang Province, at 1,700 m altitude.

Material examined. Holotype ♂. PAPUA NEW GUINEA, Madang Province, Bananumbu, 1,700 m, 24.VI.2009, SU # 13, F. Dem and A. Gibson leg., NGBRC.

Paratypes. Same data as holotype except 1♂, 27.VI. 2009, SU # 20; 1♂, 23. VI. 2009, SU # 10; 2♂♂, 3♀♀, 27.VI.2009, SU # 17 (1♂, 1♀, MfN); 1♀, 24.VI.2009, SU# 12; 1♀, 27.VI.2009, SU # 8.

Ecology

The two new Bennini species were found at three altitudinal levels: *Bennaria damisa* from various localities between 700–1,200 m altitude, while *Bennaria mareagnesia*



Figures 11–13. Forest at study site in Madang Province; 11. at 700 m a.s.l.; 12. at 1,200 m a.s.l.; 13. at 1,700 m a.s.l.

nesia from only one location at 1,700 m altitude. At 700 m, there is lowland rainforest with tall canopy trees, understorey and forest floor less densely vegetated (Fig. 11), while at 1,200 m there is a mixture of lowland rainforest and scrub (Fig. 12), understorey and forest floor are loosely vegetated, but partly occupied by crawling bamboo and partly by seedlings and saplings on a slope (V. Novotny, personal communication). No specific host-plant has yet been identified.

At 1,700 m, there is montane rainforest with mosses on the branches and stems and on every tree and sapling, and also on logs lying on the ground. Generally the forest floor is covered by ground ferns (Fig. 13). The forest is wet and damp most of the time (V. Novotny, personal communication). Also for *Bennaria mareagnesia* no specific host-plant could be identified yet. These data indicate that the ranges of *B. damisa* and *B. mareagnesia* are separated along an altitudinal gradient. Unfortunately, nothing is known about the species-specific habitat requirements. Further investigations are needed to reveal which factors may drive altitudinal zonation and perhaps niche differentiation in the Bennini, e.g., host plant preference, life history traits, climatic parameters (temperature, humidity). The morphological hypertrophies observed in the genital characters of the two new Bennini species from New Guinea suggest that sexual selection acts strongly on characters of the male and female copulatory organs. Gaining in-depth knowledge of the reproductive system within the Bennini – from a combined phylogenetic, behavioural and functional morphological approach – may help unveil the evolutionary history of these “Insects of Paradise”.

Acknowledgements

We would like to express our sincere thanks to Scott E. Miller, USNM, Washington, for bringing us in contact with each other, to Vojta Novotny for supervising Francesca Dem's research project on the Hemiptera survey in Madang, and to the New Guinea Binatang Research Centre and its staff for their support and assistance to Fran-

cesca Dem throughout the study period. We also thank various land-owners for providing access to their forests, and Alois Koane (Senior) and his family for their time and support in the field. Special thanks are also due to Amos Gibson, Valentine Kunda, Zechery Peter, and Alois Koane (Jr), Madang, for assistance in the field, to Juliane Gaestel, Eva Patzschke, and Jason Dunlop, all Museum für Naturkunde, Berlin, for image processing, editorial assistance and linguistic corrections respectively. We also thank the Managing Editor of Deutsche Entomologische Zeitschrift, Manfred Asche, Museum für Naturkunde, Berlin, for valuable advice, and two anonymous reviewers for constructive comments on the manuscript. Financial support of Francesca Dem's study was provided by grants of the Christensen Institute, Centre for International Forest Research (CIFOR) and the Mama Graun Conservation Trust Fund. Francesca Dem is especially indebted to her husband, Eric Brus, for his support and understanding.

Author contribution

F. D. collected the Bennini specimens and provided information on the ecology of the field sites as well as the habitat photographs. H. H. contributed background information on the taxonomy and morphology of the Bennini, the species descriptions incl. line drawings of male genitalia and wrote the manuscript.

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