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Taxonomic revision of the cryptic ant genus *Probolomyrmex* Mayr (Hymenoptera, Formicidae, Proceratiinae) in Madagascar

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Abstract

The alpha taxonomy of the ant genus *Probolomyrmex* in Madagascar is revised on the basis of the worker caste. Two new species are described: *P. curculiformis* **sp. n.** and *P. zahamena* **sp. n.** and the previously known *P. tani* is re-described. All three species are members of the *P. greavesi* species group. The species descriptions include diagnoses, taxonomic discussions, high quality montage images, and distribution maps. In addition, we provide an illustrated species level identification key.

Key Words

Malagasy region
Proceratiinae
Probolomyrmex
P. greavesi species group
taxonomy

Introduction

The rare ant genus *Probolomyrmex* is distributed throughout most of the world's tropics and subtropics, and contains 24 valid species at present (Bolton 2014). Based on current knowledge, *Probolomyrmex* are cryptic ants that live in small (around 20 workers), subterranean colonies in a variety of forest habitats (Taylor 1965, Shattuck et al. 2012). If encountered alive in the field they move very fast in straight movements with stretched out antennae (Agosti 1994). Due to their cryptic lifestyle they are seldom collected and only very little information about the biology of these peculiar ants exists (Taylor 1965, Agosti 1994, Shattuck et al. 2012). The Oriental species *P. dammermani* Wheeler turned out to be a specialised predator of polixenid millipeds (Ito 1998), but whether this prey choice is universal within *Probolomyrmex* or restricted only to *P. dammermani* remains to be studied.

The taxonomy of the genus is in a fairly good condition. Taylor (1965) monographed the genus, provided a global taxonomic revision and recognized nine species. Since then a number of authors published isolated species descriptions and updated, taxonomic revisions for several regional faunas (Neotropical: Agosti 1994, O'Keefe and Agosti 1997, Oriental: Tanaka 1974, Terayama and Ogata 1988, Xu and Zeng 2000, Eguchi et al. 2006, Malagasy: Fisher 2007, Australia and Melanesia: Shattuck et al. 2012). Recently, Eguchi et al. (2006) tried to divide the genus into smaller subsets for the Oriental and Indo-Australian regions and created two species groups: the *P. longinodus* group, which is characterised by a low, long petiole with reduced subpetiolar process,

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and the *P. greavesi* group, which contains species with a stouter petiole with very well developed subpetiolar process. Until a few years ago *Probolomyrmex* was unknown from the Malagasy region. Fisher (2007) provided the first record and described the first species from Madagascar: *P. tani* Fisher. Despite not having been associated to any species group yet, *P. tani* can be placed in the *P. greavesi* species group sensu Eguchi et al. (2006) on the basis of the only slightly longer than high petiole with well-developed ventral process.

In this study we revise the alpha taxonomy of the ant genus *Probolomyrmex* for Madagascar. We describe the two new species *P. curculiformis* and *P. zahamena* and re-describe *P. tani*. All descriptions include diagnoses, taxonomic discussions, and high quality montage images. In addition, we provide an illustrated identification key to species, as well as maps showing the known distribution ranges.

Abbreviations of depositories

The collection abbreviations follow Evenhuis (2014). The material upon which this study is based is located and/or was examined at the following institutions:

BMNH The Natural History Museum (British Museum, Natural History), London, U.K.

CASC California Academy of Sciences, San Francisco, California, U.S.A.

MCZC Museum of Comparative Zoology, Cambridge, Massachusetts, U.S.A.

Material and methods

The material examined in this study is based on ant inventories carried out on Madagascar from 1992 to 2011 which included more than 6,000 leaf litter samples, 4,000 pitfall traps, and 9,000 additional hand collecting events (see Fisher 2005 for additional details). Despite such an intensive sampling effort throughout the whole island, *Probolomyrmex* ants were only rarely collected. This is reflected in the just 40 specimens available for this study.

All new type material and all imaged specimens can be uniquely identified with specimen-level codes affixed to each pin (e.g. CASENT0078328). In the presented descriptions we list all of the available specimen-level codes for the whole type series. It should be noted, however, that the number of stated paratype workers does not necessarily match the number of listed specimen-level codes because pins can hold more than one specimen. Digital colour images were created using a JVC KY-F75 digital camera and Syncroscopy Auto-Montage software (version 5.0), or a Leica DFC 425 camera in combination with the Leica Application Suite software (version 3.8). All images presented are available online and can be seen on AntWeb (http://www.antweb.org). The distribution maps provided at the end of the study (Fig. 6) were generated with the software R (R Core Team 2014). The measurements were taken with a Leica MZ 12.5 equipped with an orthogonal pair of micrometers at a magnification of 100×. Measurements and indices are presented as minimum and maximum values with arithmetic means in parentheses. In addition, all measurements are expressed in mm to two decimal places. The measurements and indices used in this study are mostly based on Taylor (1965), Eguchi et al. (2006), Fisher (2007), and Shattuck et al. (2012):

HL Head length: in full-face view maximum longitudinal length of head from anterior-most portion of projecting clypeus to midpoint of line across back of head

HW Head width: in full-face view maximum width of head

SL Scape length: maximum length of antennal scape excluding basal constriction and condylar bulb

WL Weber's length: diagonal length of mesosoma measured in profile from posteroventral corner of mesosoma to the farthest point on anterior face of pronotum, excluding the neck

PH Pronotum height: maximum height of pronotum in lateral view

PW Pronotum width: maximum width of pronotum in dorsal view

HTL Length of the hind tibia: measured in dorsolateral view, from the articulation with the femur, excluding the proximomedial condyle, to the distal extremity of the tibia

PeW Dorsal petiolar width: maximum width of the petiole in dorsal view

PeH Petiole height: height of petiole in lateral view, measured vertically from the ventral margin of the posteroventral convexity/angle/projection of subpetiolar process to the level of the highest point of petiolar node

PeNH Petiolar node height: maximum height of petiolar node in lateral view, measured vertically from a line tangent to the posterior and anterior-most points of the tergosternal suture to the level of the highest point on the node

PeNL Petiole node length: in dorsal view, maximum length of the node, measured from the anterior margin of the node (excluding articulation with propodeum) to the posteriormost dorsal margin of node. If anterior or posterior margin is concave, the length is measured from the midpoint of a line drawn across the margin

CI Cephalic index: HW/HL × 100

SI Scape index: SL/HW × 100

LMI Lateral mesosoma index: PH / WL × 100

HTLI Hind tibial length index: HTL / HW × 100

DPeI Dorsal petiolar node index: PeW/PeNL × 100

PeNI Dorsal petiole index: PeW/PW × 100

LPeI Lateral petiolar index: PeNL/PeH × 100

LPeNI Lateral petiolar node index: PeNL/PeNH × 100

Taxonomy

Genus *Probolomyrmex* Mayr

http://species-id.net/wiki/Probolomyrmex

Probolomyrmex Mayr 1901: 2. Type species: *Probolomyrmex filiformis* Mayr, by monotypy.
Escherichia Forel 1910: 245. Type species: *Escherichia brevirostris* Forel, by monotypy. [synonymised by Taylor 1965: 346]

Notes. Detailed diagnoses were given by Taylor (1965), Bolton (2003), Eguchi et al. (2006), and Keller (2011). The material from Madagascar treated herein matches them almost perfectly with one exception. The lack of any sutures or grooves on the mesosoma of *Probolomyrmex* is a widely accepted genus-specific character, but we observed the presence of a small but noticeable metanotal groove in two of the three Malagasy species. *Probolomyrmex* ants are always easily recognisable from other ants on the basis of their long and slender bodies, almost complete lack of pilosity, the long sting, and especially the frontoclypeal shelf bearing the antennal insertions (Taylor 1965, Agosti 1994). Taylor (1965) pointed out that the structural reduction in *Probolomyrmex* is extreme, which leaves only a few, useful diagnostic characters, such as dimensions and proportions of head, antennae, petiole, as well as surface sculpture. Based on the material from Madagascar, however, we do not consider surface sculpture to be too important for species diagnostics. We observed some noticeable variation within species. Consequently, we tried to avoid using surface sculpture as primary diagnostic character, and used it only as supporting character.

All three species treated in this study are placed in the *P. greavesi* species group sensu Eguchi et al. (2006), mostly on the basis of the well-developed ventral process. The two species groups hypothesised by Eguchi et al. (2006) work very well for the Oriental and Indo-Australian regions, and there is no reason to create a new group for the three species from Madagascar. As already pointed out by Fisher (2007) for *P. tani*, the Afrotropical species, which can also be placed in the *P. greavesi* species group, appear morphologically close to the three species from Madagascar suggesting a close relationship. At the moment however, it is not possible to assess the phylogenetic relationships of the Malagasy species with the species from other regions in a comprehensive way due to the high morphological uniformity and lack of diagnostic characters. A highly desirable multi-gene molecular phylogenetic analysis might provide insights into the subgeneric relationships within *Probolomyrmex*.

Synoptic list of *Probolomyrmex* species from Madagascar

Probolomyrmex curculiformis Hita Garcia & Fisher, sp. n.
Probolomyrmex tani Fisher, 2007
Probolomyrmex zahamena Hita Garcia & Fisher, sp. n.

Identification key to *Probolomyrmex* species from Madagascar (workers)

1 Petiole relatively longer, lower, and less arched, in profile (without ventral process) around 1.3 to 1.5 times longer than high (LPNel 127–150), and in dorsal view around 1.4 to 1.6 times longer than broad (DPel 63–69) (Fig. 1A) ..... *P. tani*
– Petiole shorter, higher and stronger arched, in profile (without ventral process) between 1.0 to 1.2 times longer than high (LPNel 103–116); in dorsal view petiole around 1.2 to 1.3 times longer than broad (DPel 76–86) (Fig. 1B, C) 2
2 Head shorter, in full-face view around 1.4 to 1.5 times longer than broad (CI 67–70); antennal scapes longer (SI 99–102); mesosoma with weak but distinct metanotal groove; surface sculpture much stronger developed throughout whole body; body colour usually darker than above, usually dark, reddish brown (Fig. 2A, B) ..... *P. zahamena*
– Head longer, in full-face view around 1.5 to 1.6 times longer than broad (CI 62–65); antennal scapes shorter (SI 91–94); mesosomal outline straight without any groove; surface sculpture much weaker developed throughout whole body; body colour light orange brown (Fig. 2C, D) ..... *P. curculiformis*

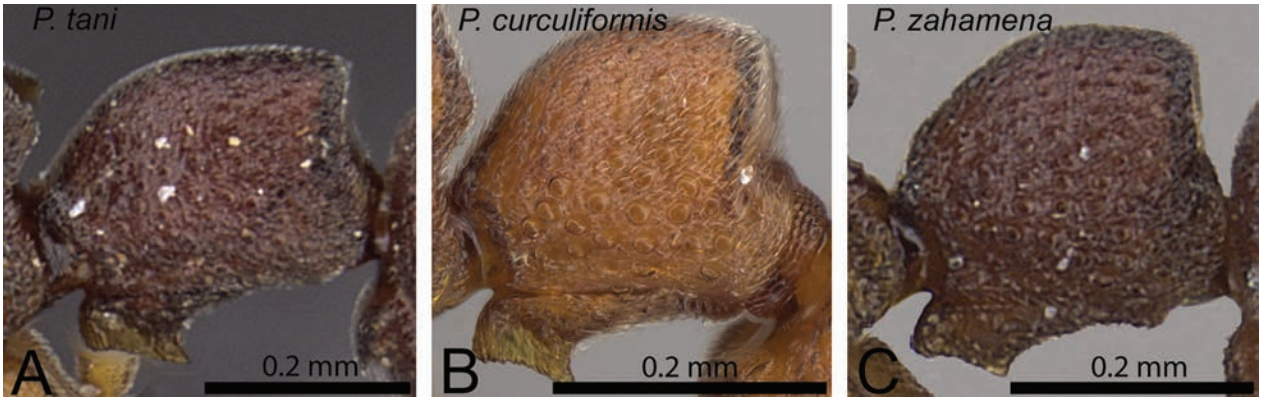

Figure 1. Petiole in profile view. **A** *P. tani* (CASENT0243185) **B** *P. curculiformis* (CASENT0469570) **C** *P. zahamena* (CASENT0914279).

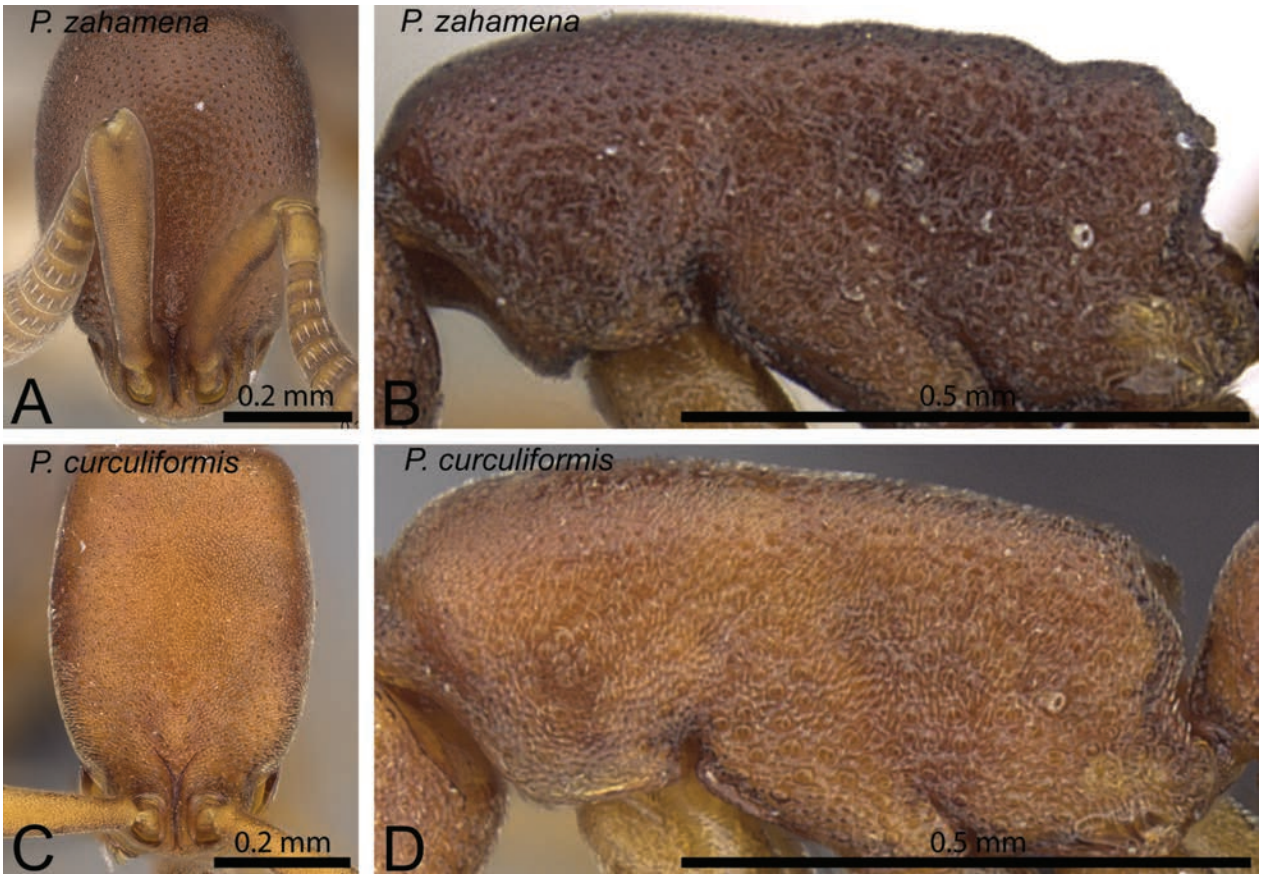

Figure 2. Head in full-face view and mesosoma in profile. **A, B** *P. zahamena* (CASENT0914279) **C, D** *P. curculiformis* (CASENT0469570).

***Probolomyrmex curculiformis* Hita Garcia & Fisher, sp. n.**

http://zoobank.org/ABC95DCB-B3CF-428B-BE9F-D112B77D7159
http://species-id.net/wiki/Probolomyrmex_curculiformis
Figs 1B, 2C, D, 3C, 6

Type material. Holotype, pinned worker, MADAGASCAR, Mahajanga, Parc National d'Ankarafantsika, Ampijoroa Station Forestière, 5.4 km 331° NW Andranofasika, 16.29889°S, 46.813°E, 70 m, tropical dry forest, sifted litter (leaf mold, rotten wood), collection code BLF03571, 26.III.–1.IV.2001 (*Rabeson et al.*) (CASC: CASENT0469570). **Paratypes**, nine pinned workers with same data as holotype (BMNH: CASENT0469574; CASC: CASENT0469571; CASENT0469572; CASENT0469573;CASENT0469575;CASENT0469576; CASENT0469577; CASENT0469579; MCZ: CASENT0469578); and one pinned worker from Mahajanga, Parc National d'Ankarafantsika, Ampijoroa Station Forestière, 40 km 306° NW Andranofasika, 16.32083°S, 46.81067°E, 130 m, tropical dry forest, sifted litter (leaf mold, rotten wood), collection code BLF03522, 26.III.–1.IV.2001 (*B.L. Fisher et al.*).

Non-type material. MADAGASCAR: Antsiranana, Forêt d'Anabohazo, 21.6 km 247° WSW Maromandia, 14.30889°S, 47.91433°E, 120 m, tropical dry forest, 11.–16.III.2001 (*B.L. Fisher et al.*) (CASC: CASENT0458322; CASENT0458323); Mahajanga, Parc National d'Ankarafantsika, Ampijoroa Station Forestière, 40 km 306° NW Andranofasika, 16.32083°S, 46.81067°E, 130 m, tropical dry forest, 26.III.–1.IV.2001 (*B.L. Fisher et al.*) (CASC: CASENT0465467; CASENT0465863); Mahajanga, Forêt de Tsimembo, 8.7 km 336° NNW Soatana, 19.02139°S, 44.44067°E, 20 m, tropical dry forest, 21.–25.XI.2001 (*B.L. Fisher et al.*) (CASC: CASENT0080550); Mahajanga, Parc National Tsingy de Bemaraha, 3.4 km 93° E Bekopaka, Tombeau Vazimba, 19.14194°S, 44.828°E, 50 m, tropical dry forest, 6.–10.XI.2001 (*B.L. Fisher et al.*) (CASC: CASENT0477984; CASENT0477985; CASENT0477986); Toliara, Tulear, Berenty, 12 km N.W. Amboasary, 24.251889°S, 45.860894°E, 5.–15.V.1983 (*J.S. Noyes & M.C. Day*) (BMNH: CASENT0102226); Toliara, Parc National de Tsimanampetsotsa, Forêt de Bemanateza, 20.7 km 81° E Efoetse, 23.0 km 131° SE Beheloka, 23.99222°S, 43.88067°E, 90 m, 22.–26.III.2002 (*B.L. Fisher et al.*) (CASC: CASENT0004401).

Diagnosis. *Probolomyrmex curculiformis* is easily distinguishable from the other Malagasy congeners on the basis of the following character combination: head in full-face view around 1.5 to 1.6 times longer than broad (CI 62–65); SI 91–94; mesosomal outline straight without metanotal groove; hind tibia around 1.1 to 1.2 times

shorter than head width (HTLI 83–92); petiole shorter, higher and stronger arched, in profile (without ventral process) between 1.0 to 1.2 times longer than high (LPNeI 107–116), in dorsal view petiole around 1.2 to 1.3 times longer than broad (DPeI 76–82).

Worker measurements (N=15). HL 0.57–0.60 (0.59); **HW** 0.37–0.39 (0.38); **SL** 34–37 (0.35); **WL** 0.71–0.76 (0.74); **PH** 0.24–0.26 (0.25); **PW** 0.27–0.32 (0.30); **HTL** 0.32–0.35 (0.33); **PeH** 0.27–0.32 (0.29); **PeNH** 0.20–0.23 (0.21); **PeNL** 0.22–0.25 (0.24); **PeW** 0.18–0.19 (0.19); **CI** 62–65 (0.64); **SI** 91–94 (93); **LMI** 33–35 (0.34); **HTLI** 83–92 (88); **DPeI** 76–82 (79); **LPeI** 76–86 (80); **LPeNI** 107–116 (110); **PeNI** 60–67 (63).

Worker description. In full-face view head between 1.5 to 1.6 times longer than broad (CI 62–65), posterior head margin more or less flat; lateral margins of head convex, broadest medially, posterolateral corners rounded; clypeus and anterior part of frons strongly protruding anteriorly as narrow frontoclypeal, subrectangular shelf or socket; antennal sockets exposed and closely approximated, separated by a thin, vertical lamella formed by fused frontal carinae; mandibles small, triangular to elongate-triangular, masticatory margin armed with one larger apical tooth and a series of six smaller denticles, in full-face view mandibles obscured by frontoclypeal shelf; palp formula 4,2; eyes absent; antennae 12-segmented, funicular antenommeres growing in size and width towards apex without forming well defined antennal club, apical antennomere much larger than remaining funicular antenommeres, antennal scape short (SI 91–94), far from reaching posterior head margin. Mesosoma slender, long, and relatively low (LMI 33–35), in profile mesosomal outline flat; propleurae enlarged and projecting ventrally; promesonotal suture and metanotal groove absent; declivitous face of propodeum margined by low, obtuse, and concave lamella on each side, propodeal lamella posterodorsally and posteroventrally with small, blunt tooth or rounded lobe; posterior declivity of propodeum weakly concave in dorsal view. Legs long and slender; all tibiae with single, pectinate spur; pretarsal claws simple without median tooth; hind tibia around 1.1 to 1.2 times shorter than head width (HTLI 83–92). In profile petiole with subpetiolar process around 1.2 to 1.3 times higher than long (LPeI 76–86), petiole without subpetiolar process around 1.1 to 1.2 times longer than high (LPNeI 107–116), petiolar dorsum strongly arched, much higher posteriorly, anterior face curving smoothly onto dorsum without well developed anterodorsal margin, posterior face vertical and concave, enclosed laterally and dorsally by low, thick carina; in dorsal view petiole around 1.3 to 1.3 times longer than broad (DPeI 76–82); pronotum between 1.5 to 1.7 times longer than petiolar width (PeNI 60–67); subpetiolar process well developed and lamelliform, ventral face weakly concave, anteroventral portion rounded to moderately angled, posteroventral portion sharper and stronger angled, projecting backwards, usually as small acute tooth. Abdominal segment III in profile narrowed anteriorly, broadest posteriorly. Sting well developed and very long. Surface sculpture generally weakly to moderately foveolate overlaying conspicuous very fine, more or less dense, coriaceous microsculpture, usually foveolate sculpture better developed and more conspicuous on cephalic dorsum, lateral mesosoma, and lateral petiole than remainder of body. Pilosity strongly reduced throughout and virtually absent, except for few short hairs below frontoclypeal shelf, some longer hairs on mandibles, and some short, fine hairs around metapleural gland orifice. Pubescence whitish, extremely fine, very short, and appressed, present over most of body, funicular antenommeres with such pubescence overlaid by much scattered, much longer, appressed hairs. Colour dark reddish brown, appendages light brown. Pilosity strongly reduced throughout and virtually absent, except for few short hairs below frontoclypeal shelf, some longer hairs on mandibles, and some short, fine hairs around metapleural gland orifice. Pubescence whitish, extremely fine, very short, and appressed, present over most of body, funicular antenommeres with such pubescence overlaid by much scattered, much longer, appressed hairs. Colour orange to light brown, appendages yellowish.

Etymology. The name of the new species is a combination of the Latin noun “curculio”, which means weevil, and the suffix “formis”, which means alike. The long and narrow head with its anteriorly projecting frontoclypeal shelf resembles the elongated head shape of a weevil.

Distribution and biology. *Probolomyrmex curculiformis* is widely but patchily distributed in western Madagascar (Fig. 6). Its known distribution ranges from the southernmost localities Tsimanampetsotsa and Amboasary to Anabohazo in the northwest. The localities are all tropical dry forest or spiny forest habitats situated at very low elevations of 20 to 130 m. Even though the new species was entirely collected by sifting litter, we suspect it is not a genuine leaf litter inhabitant. Instead, *P. curculiformis* is likely to be a hypogaeic species and the available material was sampled accidentally through the collection of soil for leaf litter sifting. A hypogaeic lifestyle would also explain the patchy distribution pattern. If true, intensive soil sampling in western Madagascar will likely yield more material of this species. The natural history of *P. curculiformis* is unknown.

Discussion. *Probolomyrmex curculiformis* is unlikely to be confused with the other two Malagasy *Probolomyrmex* species. The shape of the petiole is fairly distinct and separates the western *P. curculiformis* from the northern *P. tani* since the latter species has a much lower and longer petiole than the first. The third species, *P. zahamena*, from eastern Madagascar shares a higher and stouter petiole with *P. curculiformis*. However, *P. zahamena* possesses a small, but distinct metanotal groove, which is absent in *P. curculiformis*. In addition, the two species also differ in head shape, which is slightly broader in *P. zahamena* (CI 67–70) than in *P. curculiformis* (CI 62–65). Nevertheless, the last difference is sometimes hard to observe and requires measuring.

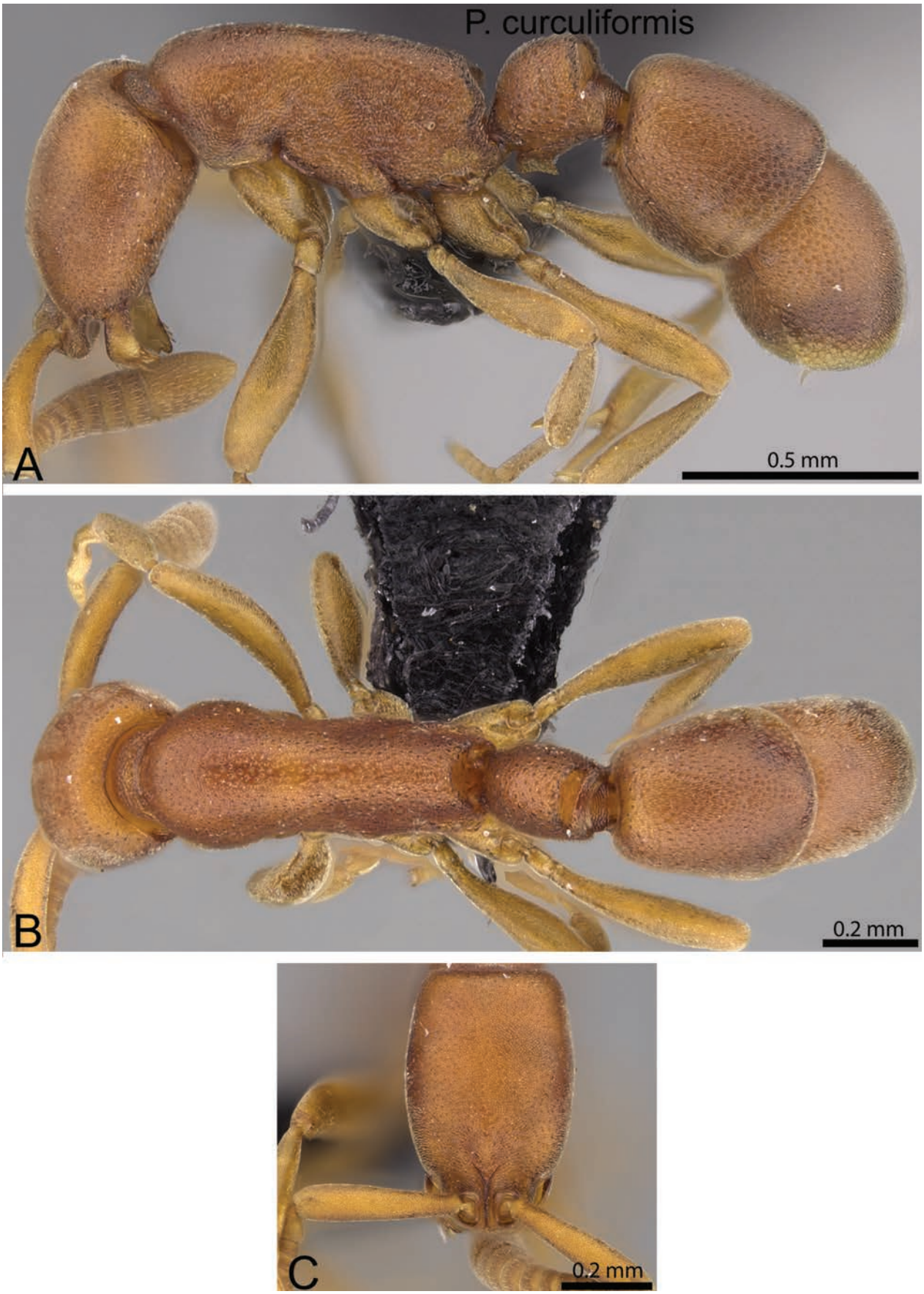

Figure 3. *Probolomyrmex curculiformis* sp. n. holotype worker (CASENT0469570). **A** Body in profile **B** Body in dorsal view **C** Head in full-face view.

Variation. Despite a very broad distribution pattern in western Madagascar, we could not observe any significant intraspecific variation except for surface sculpture. There is some moderate variation in density and depth of foveolate sculpture throughout the material examined here. Some specimens display very little sculpture while sculpture is very well developed in others.

Probolomyrmex tani Fisher, 2007

http://species-id.net/wiki/Probolomyrmex_tani%5Caccording_to_Hita_Garcia_et_al_2014
Figs 1A, 4, 6

Probolomyrmex tani Fisher 2007: 146.

Type material. Holotype, pinned worker, MADAGASCAR, Antsiranana, Forêt d'Analabe, 30.0 km 72° ENE Daraina, 13.08333°S, 49.90833°E, 30 m, littoral rainforest, collection code BLF9426, 27.XI.2003 (*B.L. Fisher et al.*) (CASC: CASENT0041505). **Paratypes**, one pinned worker (CASC: CASENT0041507) and one dealate queen (CASC: CASENT0041506) with same data as holotype.

Non-type material. MADAGASCAR: Antsiranana, Ambondrobe, 41.1 km 175° Vohemar, 13.71533°S, 50.10167°E, 10 m, littoral rainforest, 29.XI.2004 (*B.L. Fisher*) (CASC: CASENT0056575; CASENT0057032); Antsiranana, Forêt de Binara, 9.4 km 235° SW Daraina, 13.26333°S, 49.6°E, 1100 m, montane rainforest, 5.XII.2003 (*B.L. Fisher*) (CASC: CASENT0043467; CASENT0043468; CASENT0043471); Antsiranana, Montagne des Français, 7.2 km 142° SE Antsiranana, 12.32278°S, 49.33817°E, 180 m, tropical dry forest, 22.–28.II.2001 (*B.L. Fisher et al.*) (CASC: CASENT0004400); Antsiranana, Makirovana forest, 14.16666°S, 49.95°E, 715 m, rainforest, 1.–2.V.2011 (*B.L. Fisher et al.*) (CASC: CASENT0243171; CASENT0243185); Antsiranana, Makirovana forest, 14.17066°S, 49.95409°E, 225 m, rainforest, 4.–6.V.2011 (*B.L. Fisher et al.*) (CASC: CASENT0231492).

Diagnosis. The following character set distinguishes *P. tani* from its congeners in Madagascar: head in full-face view between 1.5 to 1.6 times longer than broad (CI 64–66); SI 92–103; in profile mesosomal outline flat to very weakly convex, metanotal groove usually absent, but rarely weakly developed; hind tibia around 1.0 to 1.1 times longer than head width (HTLI 100–111); petiole relatively longer, lower, and less arched, in profile (without ventral process) around 1.3 to 1.5 times longer than high (LPNeI 127–150), and in dorsal view around 1.4 to 1.6 times longer than broad (DPeI 63–69).

Worker measurements (N=10). HL 0.56–0.65 (0.60); **HW** 0.37–0.42 (0.39); **SL** 35–43 (0.39); **WL** 0.73–0.91 (0.80); **PH** 0.25–0.30 (0.27); **PW** 0.27–0.35 (0.30); **HTL** 0.39–0.47 (0.42); **PeH** 0.26–0.31 (0.28); **PeNH** 0.19 –0.23 (0.21); **PeNL** 0.26–0.34 (0.29); **PeW** 0.17–0.22 (0.19); **CI** 64–66 (65); **SI** 92–103 (0.98); **LMI** 33–37 (35); **HTLI** 100–111 (104); **DPeI** 63–69 (67); **LPeI** 97–110 (103); **LPeNI** 127–150 (137); **PeNI** 60–66 (63).

Worker description. In full-face view head between 1.5 to 1.6 times longer than broad (CI 64–66), posterior head margin flat or weakly concave; lateral margins of head convex, broadest medially, posterolateral corners rounded; clypeus and anterior part of frons strongly protruding anteriorly as narrow frontoclypeal, subrectangular shelf or socket; antennal sockets exposed and closely approximated, separated by a thin, vertical lamella formed by fused frontal carinae; mandibles small, triangular to elongate-triangular, masticatory margin armed with one larger apical tooth and a series of six smaller denticles, in full-face view mandibles obscured by frontoclypeal shelf; palp formula 4,2; eyes absent; antennae 12-segmented, funicular antenommeres growing in size and width towards apex without forming well defined antennal club, apical antennomere much larger than remaining funicular antenommeres, antennal scape short (SI 92–103), far from reaching posterior head margin. Mesosoma slender, long, and relatively low (LMI 33–37), in profile mesosomal outline flat to very weakly convex; propleurae enlarged and projecting ventrally; promesonotal suture absent; metanotal groove usually absent, rarely present but very weak; declivitous face of propodeum margined by low, obtuse, and concave lamella on each side, propodeal lamella posterodorsally with small, blunt tooth, posteroventrally with rounded lobe or very blunt tooth; posterior declivity of propodeum weakly concave in dorsal view. Legs long and slender; all tibiae with single, pectinate spur; pretarsal claws simple without median tooth; hind tibia around 1.0 to 1.1 times longer than head width (HTLI 100–111). In profile petiole with subpetiolar process around 1.0 to 1.1 times longer than high (LPeI 97–110), petiole without subpetiolar process around 1.3 to 1.5 times longer than high (LPNeI 127–150), petiolar dorsum strongly arched, much higher posteriorly, anterior face curving smoothly onto dorsum without well developed anterodorsal margin, posterior face vertical and concave, enclosed laterally and dorsally by low, thick carina; in dorsal view petiole around 1.4 to 1.6 times longer than broad (DPeI 63–69); pronotum between 1.5 to 1.7 times longer than petiolar width (PeNI 60–66); subpetiolar process well developed and lamelliform, ventral face weakly concave, anteroventral portion rounded to moderately angled, posteroventral portion sharper and stronger angled, projecting backwards, variably developed, ranging from right angle to a elongate-triangular tooth. Abdominal segment III in profile narrowed anteriorly, broadest posteriorly. Sting well developed and very long. Surface sculpture generally weakly to moderately foveolate overlaying conspicuous very fine, more or less dense, coriaceous microsculpture, foveolate sculpture better developed and more conspicuous on cephalic dorsum and lateral mesosoma than remainder of body. Pilosity strongly reduced throughout and virtually absent, except for few short hairs below frontoclypeal shelf, some longer hairs on mandibles, and some short, fine hairs around metapleural gland orifice. Pubescence whitish, extremely fine, very short, and appressed, present over most of body, funicular an-

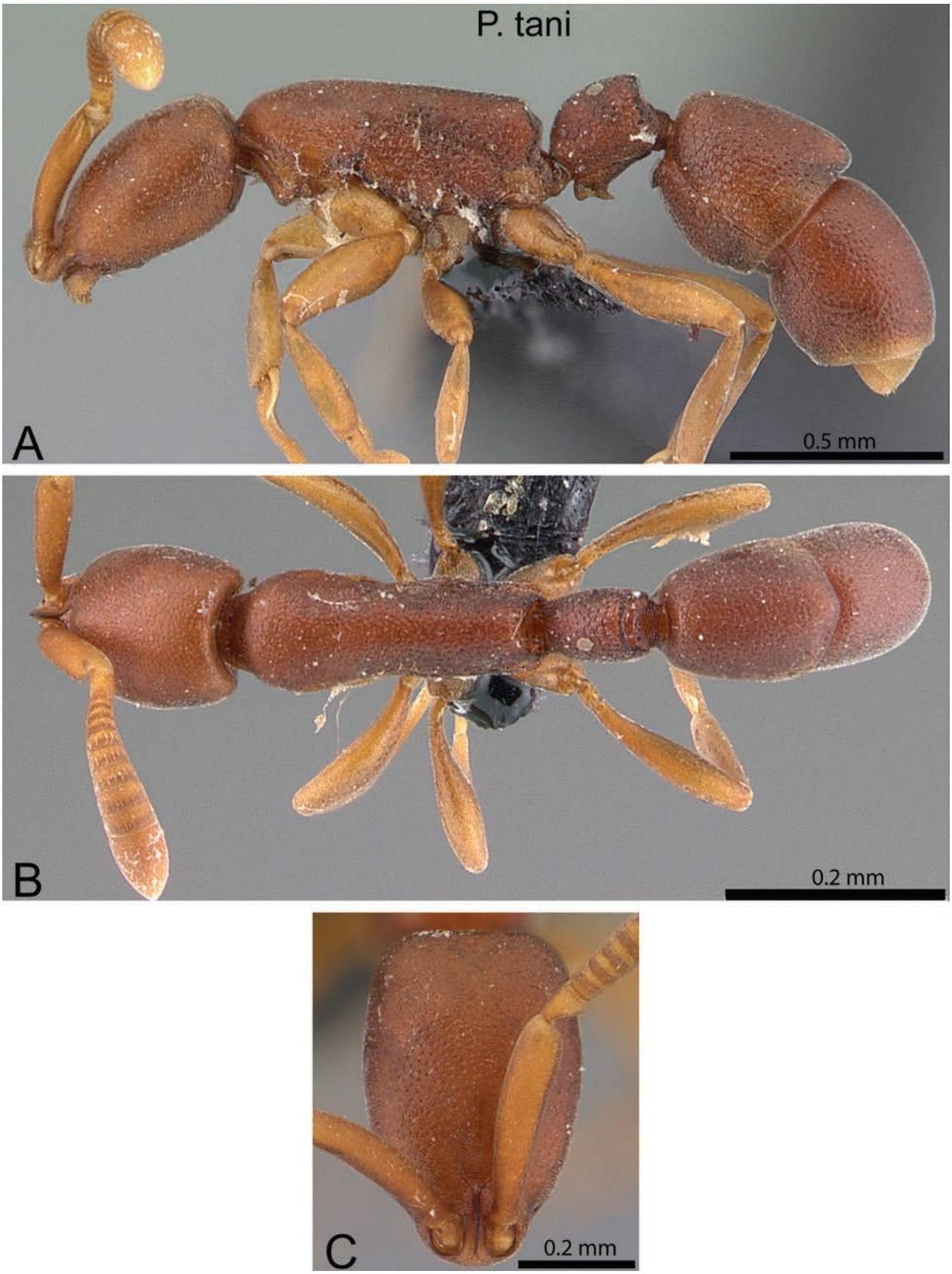

Figure 4. *Probolomyrmex tani* holotype worker (CASENT0041505). **A** Body in profile **B** Body in dorsal view **C** Head in full-face view.

tenommeres with such pubescence overlaid by much scattered, much longer, appressed hairs. Colour light reddish brown to darker brown, appendages lighter, yellowish to light brown.

Distribution and biology. It has to be pointed out that *P. tani* is much less broadly distributed as previously thought. Indeed, its distribution is restricted to a narrow strip in the northeast of Madagascar ranging from Makirovana and Ambondrobe north to Montagne des Français. Most of the remaining locality data listed under *P. tani* in the original description (Fisher 2007) are actually records of the new species *P. curculiformis*, except for Manongarivo. The only available specimen from the latter locality is damaged, and it cannot be assigned to any species. Therefore, we do not list this locality for *P. tani* nor any of the other two species treated here. *Probolomyrmex tani* is found in a variety of forest habitats, such as littoral rainforest, tropical dry forest, lowland rainforest, and montane rainforest, and has an altitudinal range of 10 to 1100 m. Despite that most of the material was collected from leaf litter, *P. tani* is more likely subterranean in lifestyle, very much like *P. curculiformis*.

Discussion. *Probolomyrmex tani* is the most distinctive species of the three treated herein. The shape of the petiole alone separates it very well from *P. curculiformis* and *P. zahamena*. In these two the petiole is shorter, higher and stronger arched, in profile (without ventral process) around 1.3 to 1.5 times longer than high (LPNeI 127–150), and in dorsal view around 1.4 to 1.6 times longer than broad (DPeI 63–69). By contrast, the petiole of *P. tani* is relatively longer, lower, and less arched, in profile (without ventral process) around 1.3 to 1.5 times longer than high (LPNeI 127–150), and in dorsal view around 1.4 to 1.6 times longer than broad (DPeI 63–69).

Variation. Despite being less variable than previously thought (Fisher 2007), *P. tani* still displays some noticeable intraspecific variation within a relatively small area in northern Madagascar. The specimens from Makirovana possess a much better developed and conspicuous foveolate surface sculpture than the rest of the material of *P. tani*. Most of the material from Makirovana also has a small but distinct metanotal groove, which is absent in the material from other localities, and longer antennal scapes (SI 99–102). These dissimilarities could be used to separate this series as different species. However, there are several good arguments against it. The length of the antennal scapes is always stable within localities, but shows some noticeable geographical variation. The specimens from the type locality possess the shortest scapes (SI 92–94), whereas the ones from Makirovana and Ambondrobe have the longest scapes (SI 99–102). However, the material from Binara and Montagne des Français shows intermediate values (SI 94–96). Furthermore, the metanotal groove is extremely weak in one specimen from Makirovana, almost absent. Also, as mentioned above, surface sculpturing is relatively variable in all three *Probolomyrmex* species. So, consequently, we prefer to keep all the material listed as *P. tani* as one somewhat variable species.

Probolomyrmex zahamena Hita Garcia & Fisher, sp. n.

http://zoobank.org/AD486A8E-1021-41F3-9AFE-AAAE7582E7E6
http://species-id.net/wiki/Probolomyrmex_zahamena
Figs 1C, 2A, B, 5, 6

Type material. Holotype, pinned worker, MADAGASCAR, Toamasina, Parc National de Zahamena, Onibe River, 17.75908°S, 48.85468°E, 780 m, rainforest, sifted litter (leaf mold, rotten wood), collection code BLF22214, 21.–23.II.2009 (*B.L. Fisher et al.*) (CASC: CASENT0914279). **Paratypes**, ten paratypes with same data as holotype (BMNH: CASENT0247390; CASC: CASENT0150894; CASENT0150896; CASENT0150897; CASENT0150898; CASENT0150899; CASENT0150900; CASENT0247389; MCZ: CASENT0247391).

Diagnosis. The following character combination distinguishes *P. zahamena* from the other two Malagasy species: in full-face view head around 1.4 to 1.5 times longer than broad (CI 67–70); SI 99–102; hind tibia around 1.1 to 1.2 times shorter than head width (HTLI 82–89); petiole relatively shorter, higher and stronger arched, in profile (without ventral process) between 1.0 to 1.2 times longer than high (LPNeI 103–116), in dorsal view petiole around 1.2 to 1.3 times longer than broad (DPeI 76–86).

Worker measurements (N=11). HL 0.64–0.68 (0.65); **HW** 43–45 (0.44); **SL** 43–45 (0.44); **WL** 0.79–0.87 (0.83); **PH** 0.28–0.33 (0.30); **PW** 0.33–0.37 (0.34); **HTL** 0.37–0.40 (0.38); **PeH** 0.30–0.34 (0.21); **PeNH** 0.23–0.25 (0.24); **PeNL** 0.24–0.29 (0.27); **PeW** 0.20–0.22 (0.21); **CI** 67–70 (0.68); **SI** 99–102 (0.100); **LMI** 34–38 (36); **HTLI** 82–89 (86); **DPeI** 76–87 (81); **LPeI** 79–86 (83); **LPeNI** 103–116 (109); **PeNI** 61–67 (62).

Worker description. In full-face view head between 1.4 to 1.5 times longer than broad (CI 67–70), posterior head margin weakly concave; lateral margins of head convex, broadest medially, posterolateral corners rounded; clypeus and anterior part of frons strongly protruding anteriorly as narrow frontoclypeal, subrectangular shelf or socket; antennal sockets exposed and closely approximated, separated by a thin, vertical lamella formed by fused frontal carinae; mandibles small, triangular to elongate-triangular, masticatory margin armed with one larger apical tooth and a series of six smaller denticles, in full-face view mandibles obscured by frontoclypeal shelf; palp formula 4,2; eyes absent; antennae 12-segmented, funicular antenommeres growing in size and width towards apex without forming well defined antennal club, apical antennomere much larger than remaining funicular antenommeres, antennal scape short (SI 99–102), far from reaching posterior head margin. Mesosoma slender, long, and relatively low (LMI 34–38), in profile mesosomal outline relatively flat; propleurae enlarged and projecting ventrally; promesonotal suture absent; metanotal groove present but weak; declivitous face of propodeum margined by low, obtuse, and concave lamella on each side, propodeal lamella posterodorsally with small, blunt tooth, posteroventrally with rounded lobe; posterior declivity of propodeum weakly concave in dorsal view. Legs long and slender; all tibiae

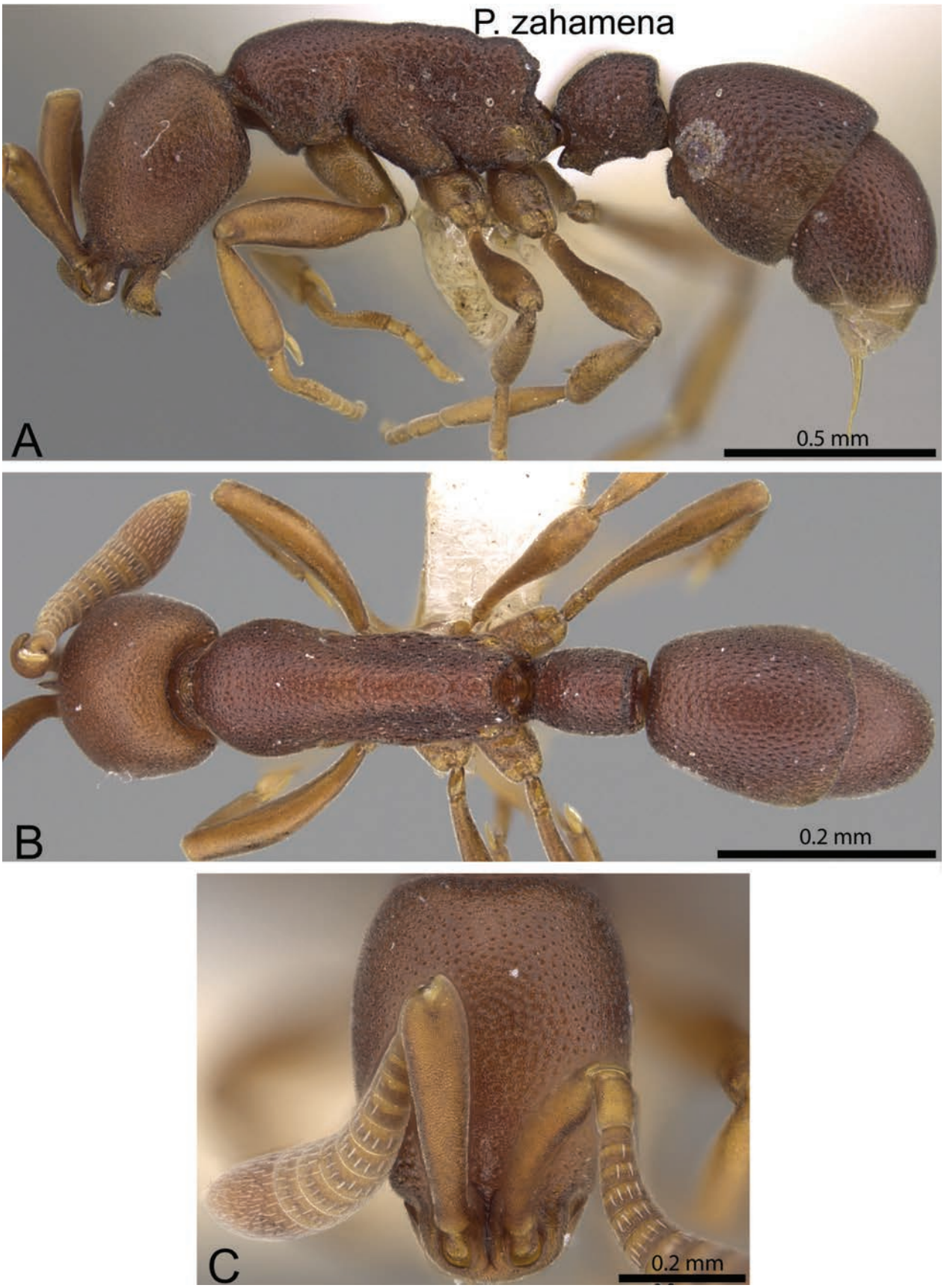

Figure 5. *Probolomyrmex zahamena* sp. n. holotype worker (CASENT0914279). **A** Body in profile **B** Body in dorsal view **C** Head in full-face view.

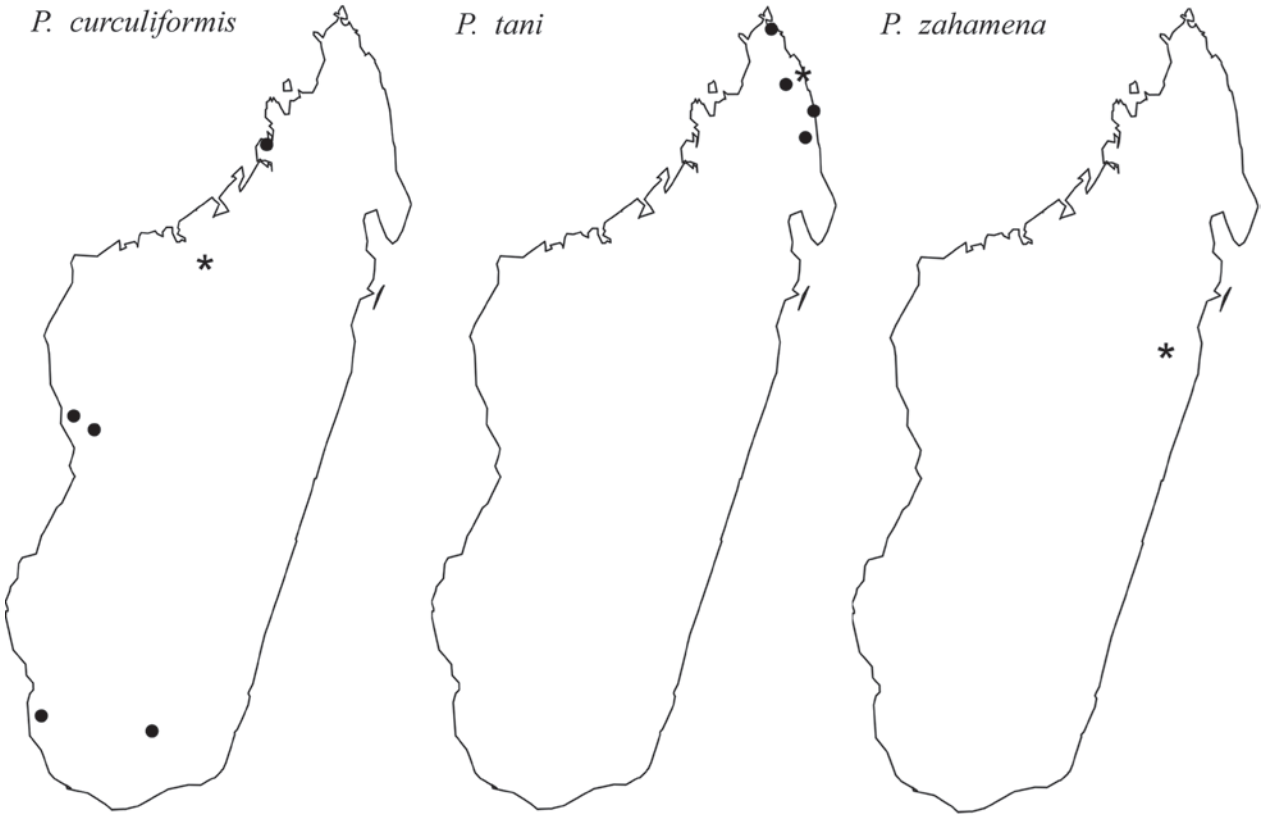

Figure 6. Geographic distribution maps of Madagascar for *P. curculiformis*, *P. tani*, and *P. zahamena*. Star symbols represent type localities while circles represent non-type localities.

with single, pectinate spur; pretarsal claws simple without median tooth; hind tibia around 1.1 to 1.2 times shorter than head width (HTLI 82–89). In profile petiole with subpetiolar process around 1.2 times longer than high (LPeI 79–86), petiole without subpetiolar process between 1.0 to 1.2 times longer than high (LPNeI 103 - 116), petiolar dorsum strongly arched, much higher posteriorly, anterior face curving smoothly onto dorsum without well developed anterodorsal margin, posterior face vertical and concave, enclosed laterally and dorsally by low, thick carina; in dorsal view petiole around 1.2 to 1.3 times longer than broad (DPeI 76–87); pronotum between 1.5 to 1.7 times longer than petiolar width (PeNI 60–67); subpetiolar process well developed and lamelliform, ventral face weakly concave, anteroventral and posteroventral corners well angled, posteroventral portion slightly sharper but not projecting backwards or dentate. Abdominal segment III in profile narrowed anteriorly, broadest posteriorly. Sting well developed and very long. Surface sculpture very conspicuous, throughout whole body densely foveolate overlaying conspicuous very fine, dense, coriaceous microsculpture. Pilosity strongly reduced throughout and virtually absent, except for few short hairs below frontoclypeal shelf, some longer hairs on mandibles, and some short, fine hairs around metapleural gland orifice. Pubescence whitish, extremely fine, very short, and appressed, present over most of body, funicular antenommeres with such pubescence overlaid by much scattered, much longer, appressed hairs. Colour dark reddish brown, appendages light brown.

Etymology. The new species is named after the type locality, the Zahamena National Park in eastern Madagascar. Zahamena is part of the UNESCO World Heritage Site "Rainforests of the Atsinanana", and considered as one of the WWF's Global 200 priority eco-regions for conservation priority. By naming the new species after this locality we want to draw attention to this very important locality with its high conservation value. The species epithet is treated as a noun in apposition, and thus invariant.

Distribution and biology. At present, *P. zahamena* is only known from the type locality, which is a tropical rainforest situated at an elevation of 780 m. All the available material is from a single leaf litter collection. It is surprising that *P. zahamena* is the only known species found in eastern Madagascar, especially considering the very high leaf litter sampling effort performed by the Malagasy ant project from 1992 to the present. This suggests that the species is either comparatively rare or predominantly hypogaeic. As for the other two species, the use of soil sampling methods might yield additional material.

Discussion. *Probolomyrmex zahamena* is fairly distinct and its identification straightforward. The shape of the petiole, which is relatively short, high and stout, distinguishes it clearly from *P. tani*, while the presence of a metanotal groove separates it from *P. curculiformis*. In addition, *P. zahamena* has a slightly broader head (CI 67–70) than the other two (CI 62–66).

Variation. Since *P. zahamena* is only known from one collection event, the observable variation is insignificant.

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