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Obtusitermes monomorphus, a new termite species (Isoptera: Termitidae: Nasutitermitinae) from Panama

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Abstract

Obtusitermes monomorphus **sp. nov.** is described from the monomorphic soldier and worker castes. The two described congeners, *O. panamae* (Snyder, 1924) and *O. formosulus* Cuezzo and Cancello, 2009 both have dimorphic soldiers and workers. It is now demonstrated that the major worker hindgut of all three *Obtusitermes* species are unique among other termite taxa in due to the first proctodeal segment connected to the third proctodeal segment by a very long and tubular enteric valve (second proctodeal segment) with weak armature at both ends and a curvature of 180°. Additionally, *Obtusitermes monomorphus* is compared with other small monomorphic nasutitermitines of Panama.

Key words: monomorphic, second proctodeal segment, enteric valve armature, *Obtusitermes panamae*, *Obtusitermes formosulus*

Introduction

The first termites with their type localities ascribed to Panama were *Armitermes armiger* (Motschulsky, 1855) and *Nasutitermes corniger* (Motschulsky, 1855). Later, Banks (1918) described eleven additional species collected in Panama that he obtained from the American Museum of Natural History. As a result of termite damage in and around the Panama Canal Zone (Snyder and Zetek 1924), Snyder authored ten papers between 1922 and 1929, describing twenty-two additional species from in and around the canal zone including eight from Barro Colorado Island on which a trail he blazed is named in his and Ignacio Molino's honor (Andrew & Andrew 1953). Thorne (in Thorne and Levings 1989) described *Nasutitermes dasyopsis* from the Pacific coast of Panama, but this species is now a junior synonym of *N. nigriceps* (Haldeman, 1854) (Scheffrahn *et al.* 2024). Roisin (1995) recounts three small nasutitermitines with monomorphic soldiers that were known from Panama at the time, *Araujotermes zeteki* (Snyder, 1924), *Atlantitermes kirbyi* (Snyder, 1926), *Coatitermes clevelandi* (Snyder, 1926), and he described two new species, *Ereymatermes panamensis* Roisin,1995 and *Subulitermes denisae* Roisin,1995.

Two termite survey group expeditions to Panama were conducted in 2005 and 2010. These expeditions and a few samples donated from other sources yielded 1,566 colony samples from 115 localities (Fig. 1) and include about 85 described and undescribed species (complete data in Scheffrahn 2019). Herein *Obtusitermes monomorphus* **sp. nov.** is described as the third species of *Obtusitermes* Snyder, 1924 and the sixth member of the group of small monomorphic nasutes from Panama.

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Materials and methods

Morphological study

Specimens reported in this study were aspirated into vials containing 85% ethanol and curated in the University of Florida Termite Collection (UFTC) in Davie, Florida (Scheffrahn 2019). Laboratory microphotographs were taken with a Leica M205C stereomicroscope controlled by Leica Application Suite ver. 3.0 montage software. Specimens were submerged in hand sanitizer (70% ethanol) inside a plastic Petri dish. The worker enteric valve armatures (EVAs) were prepared for photography by removing the entire worker 2nd proctodeal segment (P2) section in ethanol. Food particles were expelled from the P2 by gentle pressure manipulation. The P2 sections were submerged in a droplet of PVA medium (BioQuip Products Inc.) which eased muscle detachment and removal. The remaining P2 cuticle was longitudinally cut, splayed open, and mounted on a microscope slide. The exposed EVAs were photographed with a Leica CTR 5500 compound microscope using the same montage software. The distribution map (Fig. 1) was produced using ArcGIS Pro Intelligence 3.0 software (Redlands, Calif.). The field photograph of live specimens (Fig. 6) was taken with a Nikon Coolpix S7c digital camera. Morphological characters follow the scheme of Noirot (2001).

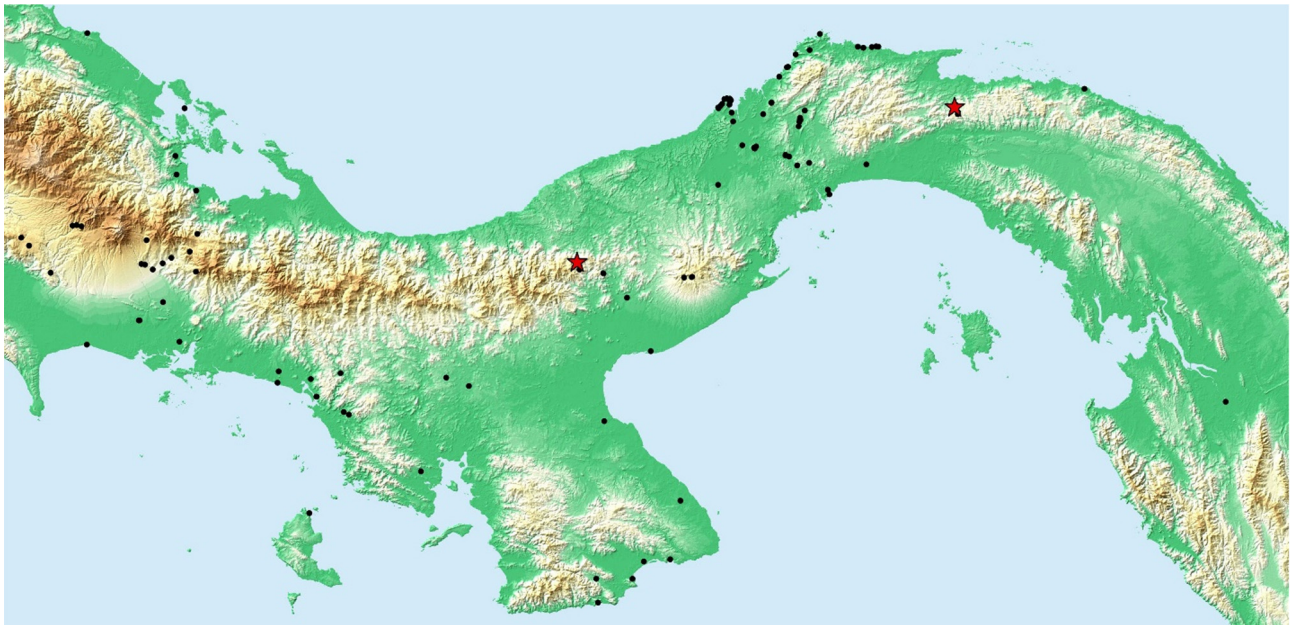

FIGURE 1. Localities of *Obtusitermes monomorphus* **sp. nov.** (red stars) and other University of Florida Termite Collection sites (black spots).

TABLE 1. Measurements (mm) of *Obtusitermes monomorphus* **sp. nov.** soldiers (n=5) from two colonies.

Measurement	mean	max	min
Head Length	1.25	1.30	1.20
Head Length to base of nasus	0.81	0.85	0.78
Nasus Length	0.43	0.45	0.40
Max. Head width	0.72	0.78	0.68
Head width Post margin of antennal sockets	0.55	0.58	0.53
Nasus width in middle	0.10	0.10	0.10
Max. Head Height at posterior occiput margin	0.49	0.50	0.45
Pronotum width	0.42	0.45	0.38
Hind Tibia length	0.87	0.90	0.83

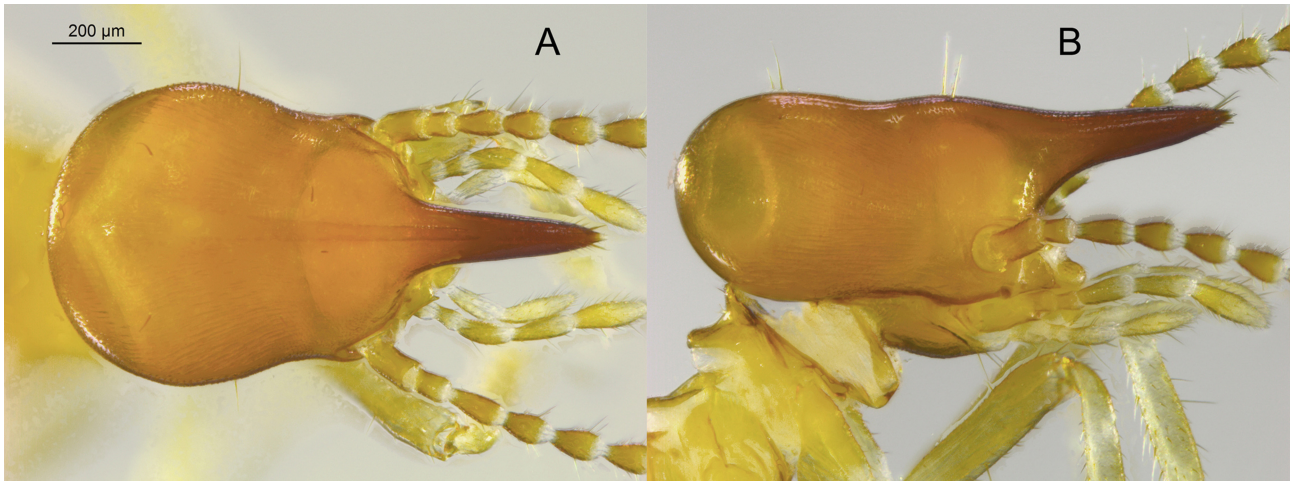

FIGURE 2. Holotype soldier of *Obtusitermes monomorphus* **sp. nov. A.** dorsal and **B.** lateral view of head capsule.

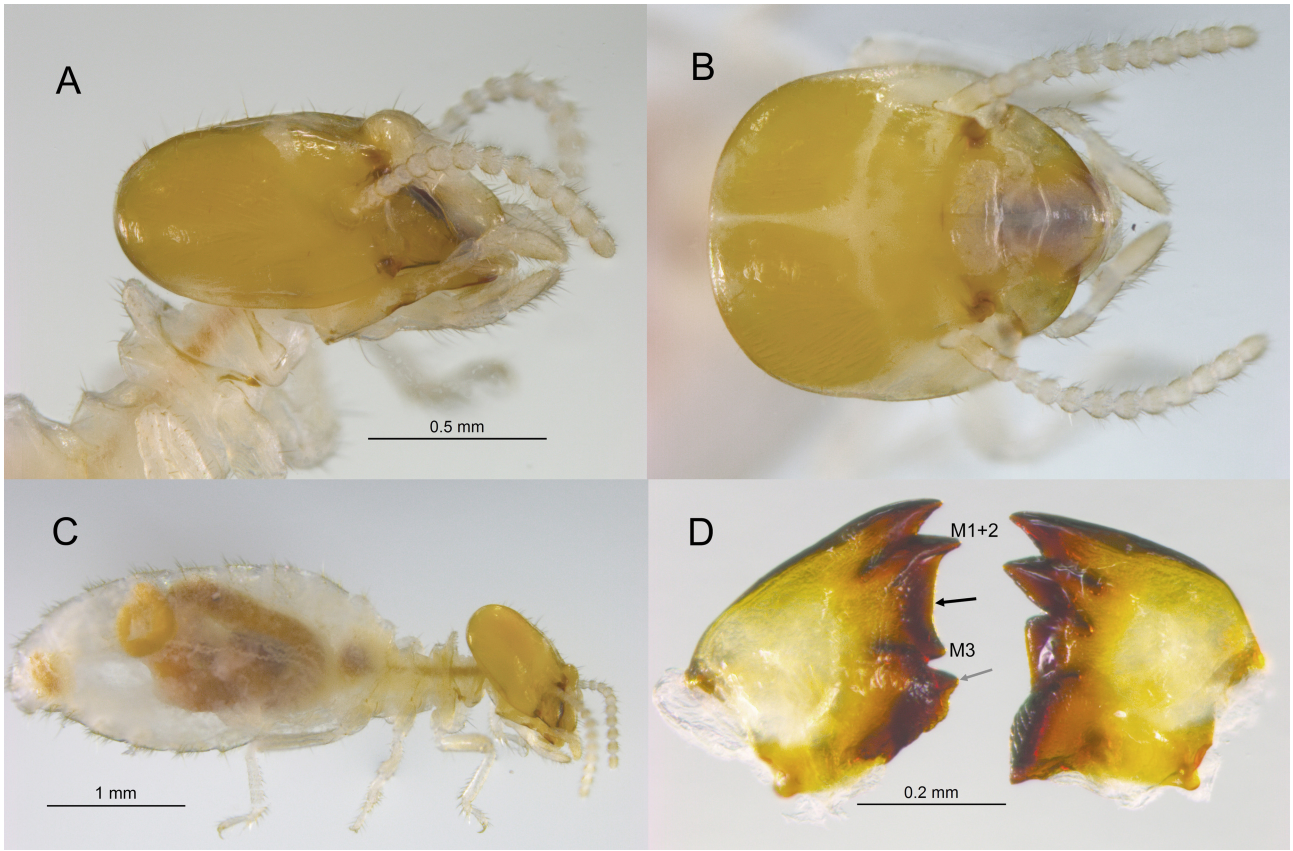

FIGURE 3. Worker of *Obtusitermes monomorphus* **sp. nov. A.** lateral and **B.** dorsal view of head capsule. **C**. habitus. **D**. dorsal view of mandibles (M1+2 = first and second marginal teeth, M3 = third marginal tooth. Black arrow = cutting edge, gray arrow = molar prominence).

TABLE 2. Measurements (mm) of *Obtusitermes monomorphus* **sp. nov.** workers (n=5) from two colonies.

Measurements	mean	max	min
Head Length to postclypeus	0.82	0.85	0.78
Head Width	0.89	0.95	0.85
Hind Tibia Length	0.73	0.75	0.70

Sequencing of samples

Here, we report the sequencing of 9 new samples. Whole genomic DNA was extracted using the DNeasy Blood & Tissue extraction kit (Qiagen), and libraries were prepared using the NEBNext® UltraTM II FS DNA Library Preparation Kit (New England Biolabs) and the Unique Dual Indexing Kit (New England Biolabs). The library preparation generally followed the manufacturer's guidelines, but: reagents were reduced to one-fifteenth of recommended volumes; and the enzymatic fragmentation step was set to a maximum of five minutes to avoid over-fragmentation. Libraries were pooled in equimolar concentration, and paired-end sequenced by Novogene on the NovaSeq 6000 Illumina platform at a read length of 150 bp.

Raw reads were quality-trimmed using fastp *v*0.20.1 (Chen *et al.*, 2018). Trimmed reads were assembled using metaSPAdes *v*3.13 (Nurk *et al.*, 2017), and mitogenome scaffolds were identified and annotated with MitoFinder *v*1.4 (Allio *et al.*, 2020). Mitogenomes of *Obtusitermes* spp. were deposited in GenBank under accessions OR607549 (PN1415), OR607575 (PN153), PQ558610 (TT1220), and PQ558611 (VZ919). Mitogenomes of five additional nasutes were similarly deposited under PQ213041 (EC1259, *Atlantitermes* sp. nr. *kirbyi*), PQ213044 (TT2110, *Araujotermes* sp.), PQ213042 (PN1494, *Ereymatermes panamensis*), PQ213045 (VZ646, *Subulitermes* sp.), and OR601026 (PU342, *Coatitermes clevelandi*).

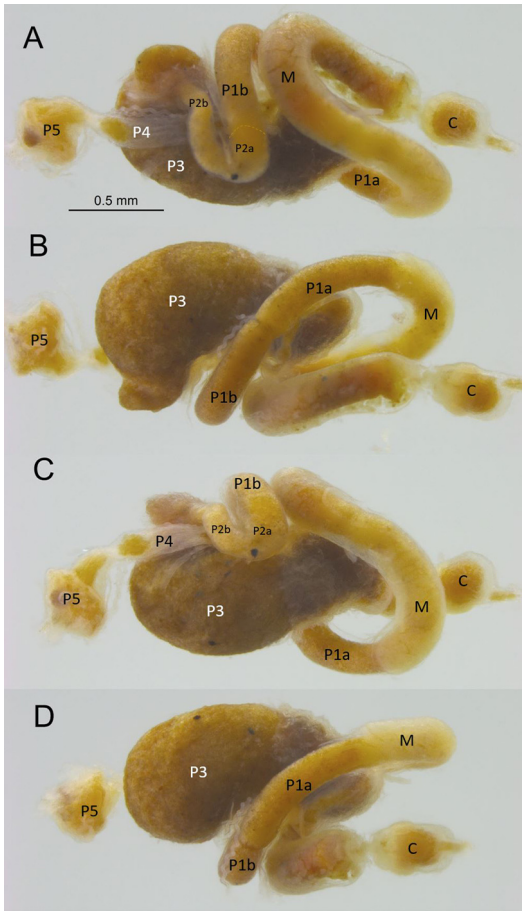

FIGURE 4. Worker gut of *Obtusitermes monomorphus* **sp. nov. A–D:** dorsal, right, ventral, and left views, respectively. Abbreviations: C=crop, M=mesenteron, P1a=proximal 1st proctodeal segment, P1b=distal 1st proctodeal segment, P2a= proximal enteric valve, P2b distal enteric valve, P3=3rd proctodeal segment, P4=4th proctodeal segment, and P5=rectum.

Phylogenetic reconstructions

We positioned *Obtusitermes* within a phylogeny reconstructed from the mitogenomes of 64 samples representative of Isoptera and of Nasutitermitinae (Fig. 11). The 55 samples used to anchor our reconstructions were published elsewhere (Cameron *et al.*, 2012; Bourguignon *et al.*, 2015, 2016, 2017; Wang *et al.*, 2019, 2022, 2023; Hellemans

et al., 2022a; b; Arora *et al.*, 2023). The two rRNA and 22 tRNA mitochondrial genes were aligned using MAFFT *v*7.305 (Katoh & Standley, 2013). The 13 protein-coding genes were translated into the corresponding amino acid sequences using the transeq function from EMBOSS *v*6.6.0 (Rice *et al.*, 2000). Protein sequences were aligned with MAFFT, then back-translated into codon alignments using PAL2NAL *v*14 (Suyama *et al.*, 2006). Finally, all 37 mitochondrial gene alignments were concatenated using FASconCAT-G_v1.04.pl (Kück & Longo, 2014).

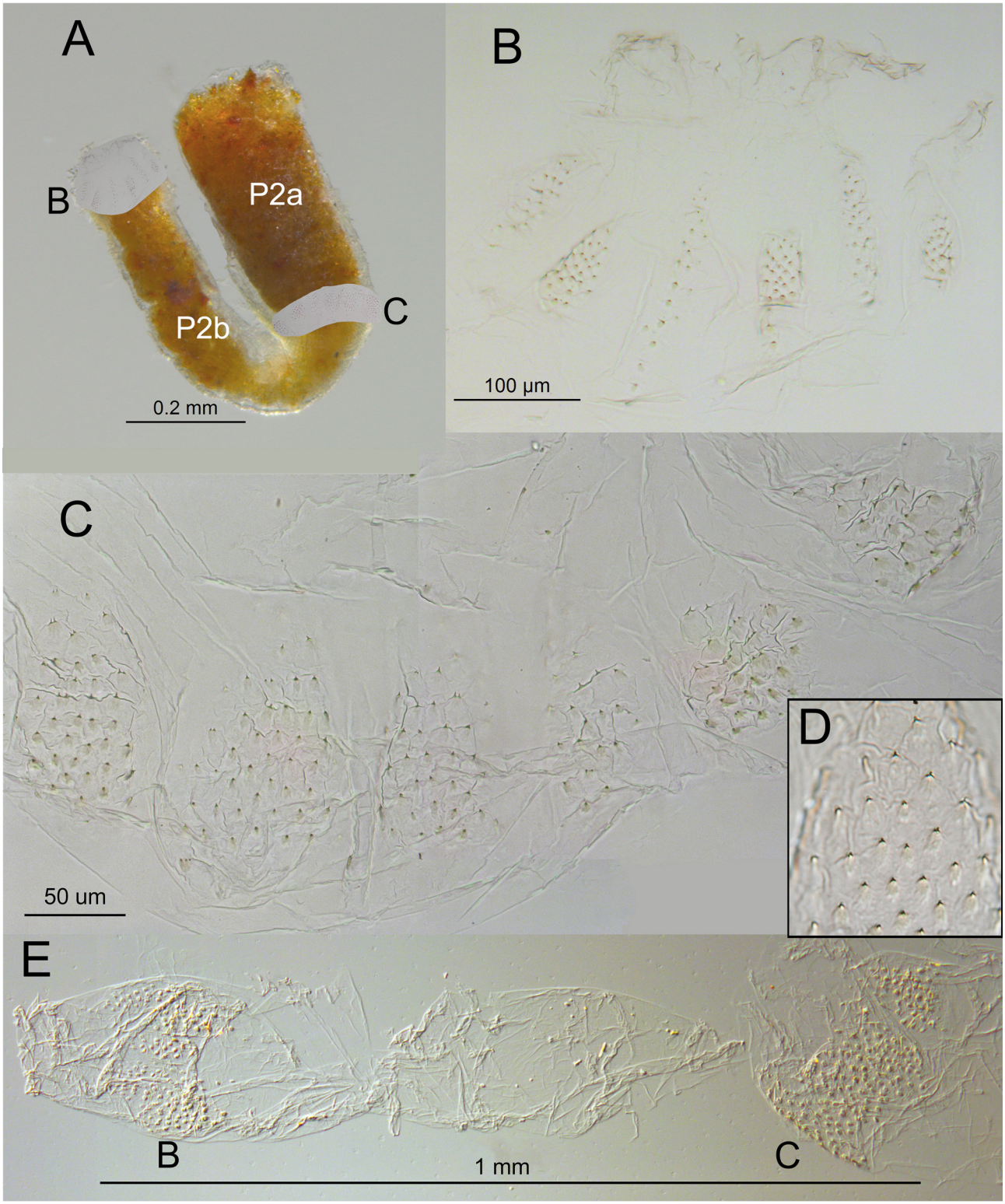

FIGURE 5. Enteric valve of *Obtusitermes monomorphus* **sp. nov. A.** Proximal enteric valve tube (P2a) and distal enteric valve tube (P2b) with respective spiny cushions superimposed. **B.** Distal spiny cushions and **C**. proximal spiny cushions. **D.** Phase contrast of a single proximal cushion. **E.** Entire P2 with food particles removed.

FIGURE 6. Live habitus of *Obtusitermes monomorphus* **sp. nov.** (PN1415).

The concatenated sequence alignment was partitioned into 41 partitions: one partition with the combined rRNAs; one with the tRNAs; and each of the 13 protein-coding genes were separated in three partitions (*i.e.*, one for each of the three codon positions). The phylogenetic tree was reconstructed with IQ-TREE *v*2.2.2.5 (Minh *et al.*, 2020). The partitions were first merged and the top 10% were investigated using the options "-m MFP+MERGE -rcluster-max 2000 -rcluster 10" (Chernomor *et al.*, 2016). The best-fit nucleotide substitution models were selected with the Bayesian Information Criterion using ModelFinder implemented in IQ-TREE (Kalyaanamoorthy *et al.*, 2017). Branch supports were assessed with 1,000 bootstrap replicates, both with the ultrafast algorithm (UFB) (Hoang *et al.*, 2018), and the Shimodaira–Hasegawa approximate likelihood-ratio (SH-aLRT) test (Guindon *et al.*, 2010).

Description

Obtusitermes monomorphus sp. nov. Scheffrahn

Holotype. Soldier from University of Florida Termite Collection (UFTC) no. PN153.

Type locality. PANAMA: Coclé, El Cope Natl. Park; 8.6790, -80.5972; 841 m asl;
30-May-2005; J Chase coll.; UFTC PN153; many soldiers and workers taken from under horse dung.

Paratypes. PANAMA: Guna Yala (formerly San Blas), Kuna Rd. Stop 4; 9.3261, 78.9992; 360 m asl; 5-Jun-2010; R Scheffrahn coll.; UFTC PN1415; many soldiers and workers taken from under a decaying branch.

Etymology. Named for the monomorphic soldier caste which is exclusive to *Obtusitermes*.

Imago. Unknown.

Soldier (Fig. 2, 6; Table 1). Monomorphic, small size. Head capsule reddish brown, nasus darker. Antennal articles and palps reddish brown. Head capsule pyriform from above, constricted at anterior one-third. Lateral view of head capsule convex behind antennal sockets. Vertex with two long setae at summit of convexity and four long setae at posterior half of vertex. Nasus broadly conical, upturned about 10°. Antennae with 11 articles; antennal article formula $2<3>4\leq5$. Mandibles with small points.

Comparisons. The soldier of *O. monomorphus* **sp. nov.** differs from the major soldiers of *O. panamae* (Fig. 8A, B) and *O. formosulus* (Fig. 9A, B) in that *O. monomorphus* **sp. nov.** soldier has six long setae on the vertex while the other two species have numerous scattered long and short setae. The head capsule of *O. monomorphus* **sp. nov.** is more pyriform in dorsal view than the other two species of the genus. The soldier of *O. monomorphus* **sp. nov.** differs from the other monomorphic small nasutes of Panama in having the head capsule, antennal articles, and palps reddish brown instead of yellowish (Fig. 7). The nasus of the *O. monomorphus* **sp. nov.** soldier is more broadly conical with the exception of *Coatitermes clevelandi* (Figs. 7G, H). Among this group, only *Obtusitermes* and *Atlantitermes kirbyi* (Figs. 7D, E) have six long setae on the head capsule versus dozens or more on the other species.

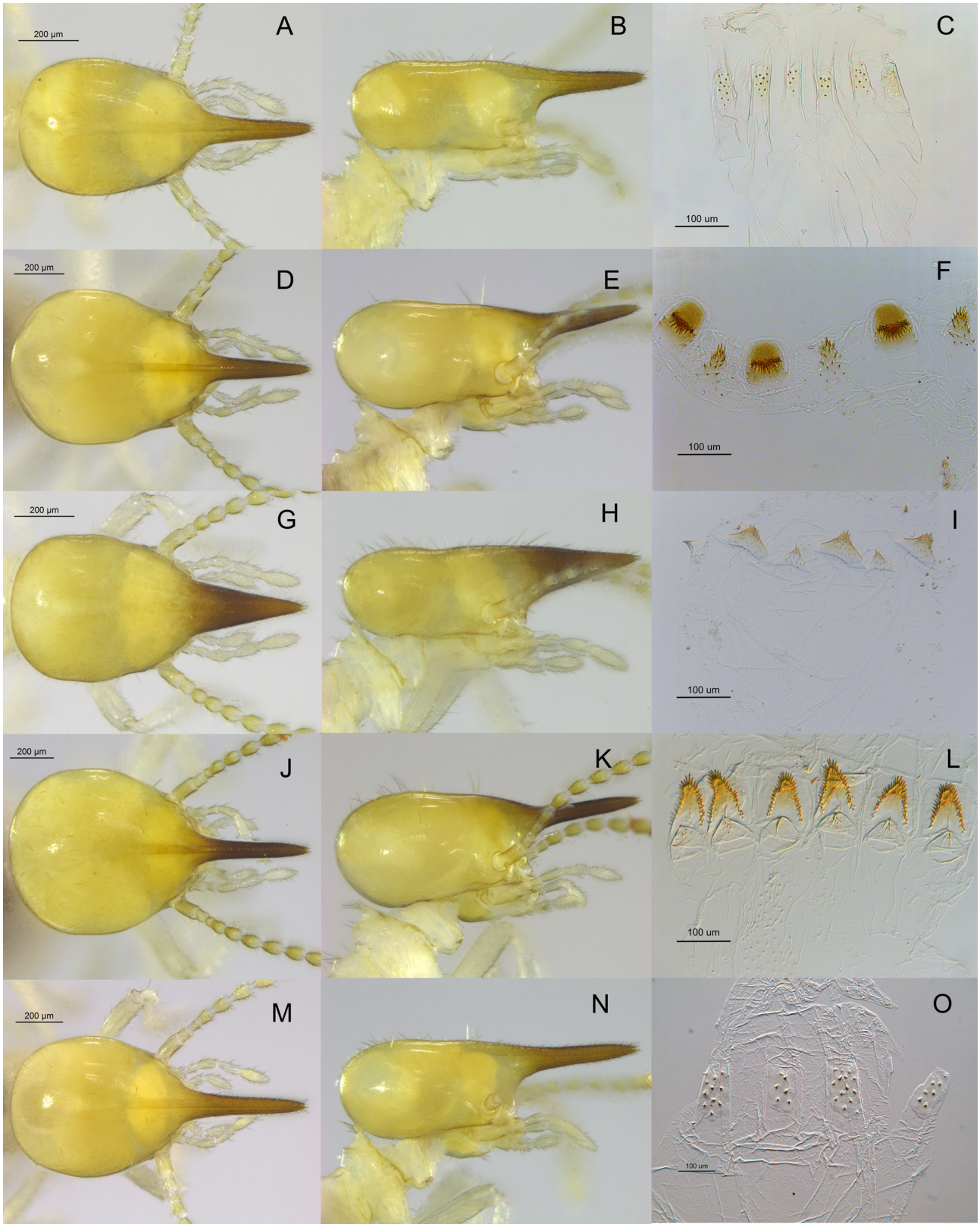

FIGURE 7. Other small monomorphic nasute species from Panama: dorsal and lateral views of soldier head capsule and worker enteric valve armature. **A–C.** *Araujotermes zeteki* (Snyder, 1924). **D–F.** *Atlantitermes kirbyi* (Snyder, 1926). **G–I.** *Coatitermes clevelandi* (Snyder, 1926). **J–L.** *Ereymatermes panamensis* Roisin, 1995. **M–O.** *Subulitermes denisae* Roisin, 1995.

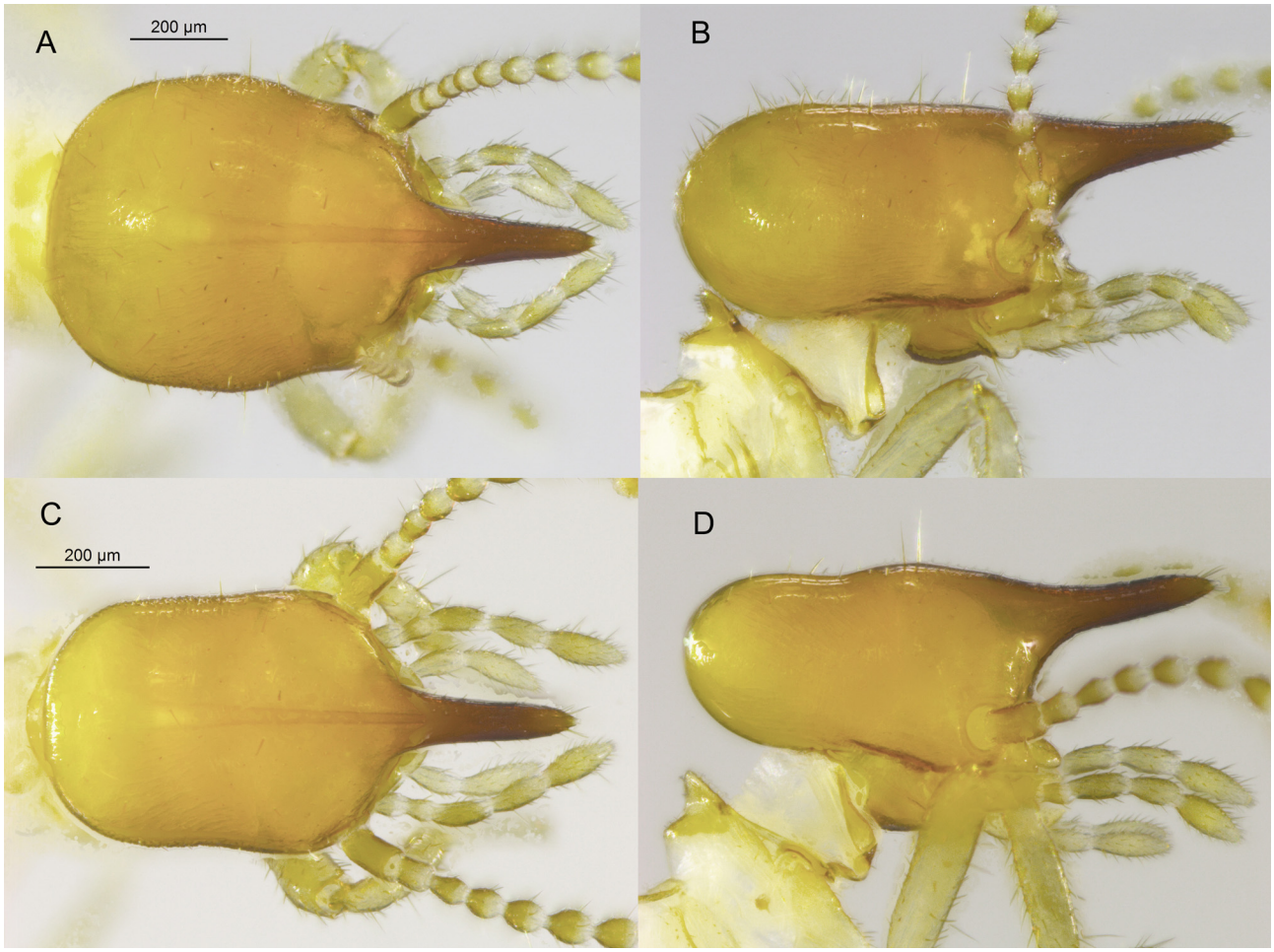

FIGURE 8. Soldiers of *Obtusitermes panamae* (Snyder, 1925) (UFTC PN1076). **A.** dorsal and **B.** lateral view of major soldier head capsule. **C.** dorsal and **D.** lateral view of minor soldier head capsule.

Worker (Figs. 3–6, 10; Table 2). Monomorphic. Head capsule yellowish brown; vertex with concavity behind postclypeus; postclypeus slightly inflated. Antennae with 12 articles; antennal article formula 2>3≥4=5. Mesenteron and P1 tubular, mixed segment lacking; P1 divided near middle by slight darkened constriction. Enteric valve armature very long, tubular, curved 180°; armature at both ends; EVA seating simple. Enteric valve armature composed of two rings separated by nearly 1 mm of smooth cuticle. Proximal EVA ring at the terminus of P1 consists of six triangular cushions with their apex directed distally with food stream. Each cushion contains about 20 to 30 scales terminating in short spines. Distal ring at insertion of P3 consists of six cushions alternating in pairs of triangular and elongate scaled cushions; scale texture as in the proximal ring. Left mandible with apical and first marginal teeth equal; molar prominence small; distal margin of the M1+2 forms a long, slightly concave cutting edge longer than apical tooth distance to molar prominence. Right mandible with apical tooth narrower than first marginal. Molar plates with ridges.

Comparisons. The worker head capsule width of *O. monomorphus* **sp. nov.** is somewhat larger (0.95–0.85 mm) than the major worker of *O. panamae* (0.64–0.78 mm, UFTC PN1076; 0.60–0.62, Snyder 1924) or the major worker of *O. formosulus* (0.70–0.85 mm, Cuezzo & Cancello 2009). Mandibular dentition of all three are identical. The worker hindgut of *Obtusitermes* spp. is unique among termites in having the P1 joined to the P3 by a very long and tubular P2 with a curvature of 180° and weak armature at both ends (Figs. 5, 10).

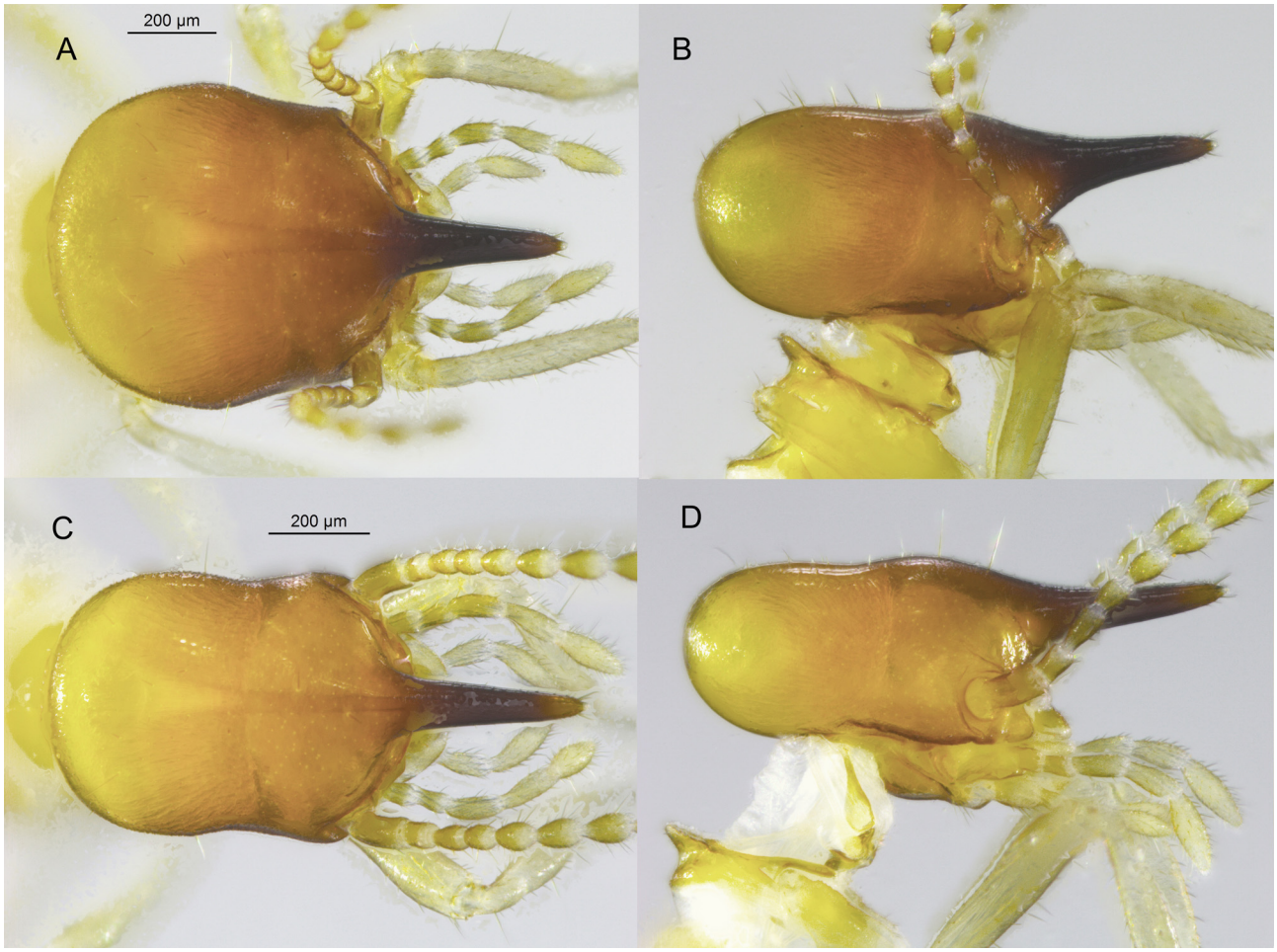

FIGURE 9. Soldiers of *Obtusitermes formosulus* Cuezzo and Cancello, 2009 (UFTC VZ1171). **A.** dorsal and **B.** lateral view of major soldier head capsule. **C.** dorsal and **D.** lateral view of minor soldier head capsule.

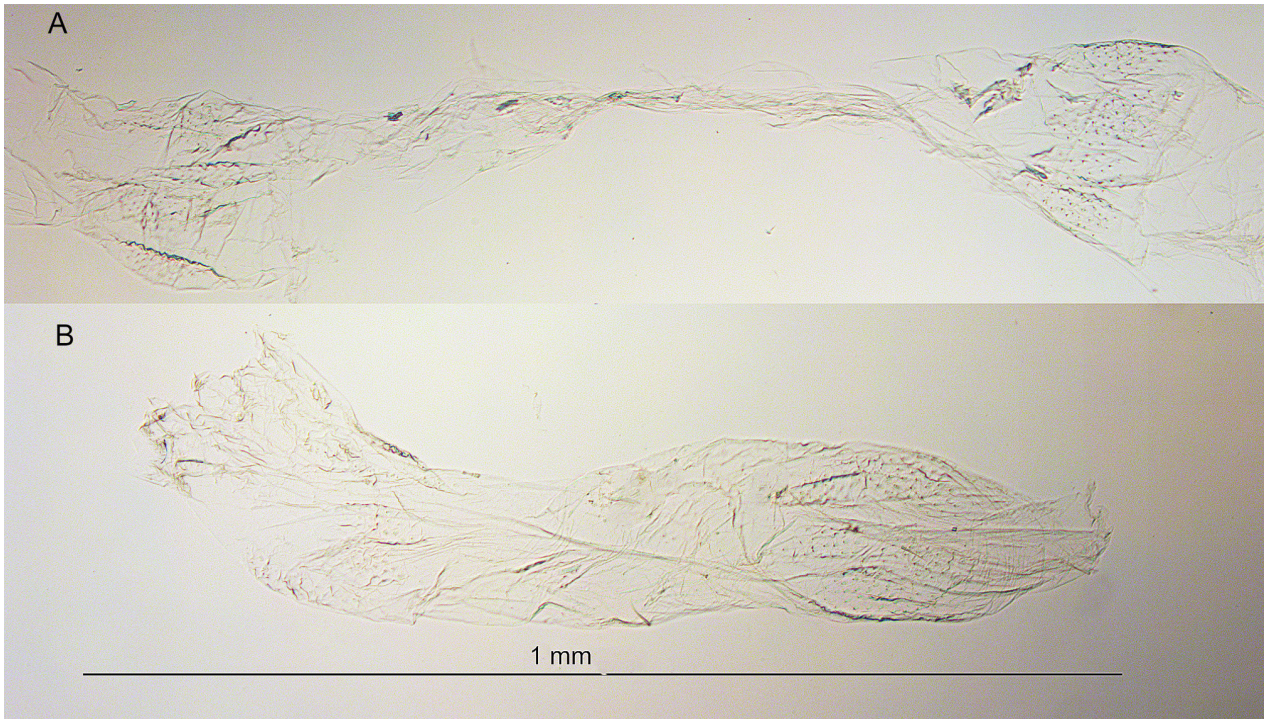

FIGURE 10. Worker enteric valve (P2) of *Obtusitermes panamae* (Snyder, 1925) (UFTC PN1076, **A**.) and *O. formosulus* Cuezzo and Cancello, 2009 (UFTC VZ1171, **B**.). Cellulose particles removed.

Discussion

Obtusitermes monomorphus **sp. nov.** is newest one of six species of small monomorphic nasute genera known from Panama (Figs. 2, 7). Two species of small dimorphic nasutes are also known from Panama including *Obtusitermes panamae* (Snyder, 1925) and *Velocitermes barrocoloradensis* (Snyder, 1925). All the other nasutitermitine species in Panama are in the *Nasutitermes* sen. str. clade of Noirot (2001). Both *O. monomorphus* **sp. nov.** localities (Fig. 1) are at higher elevations covered with mature forests. *Obtusitermes formosulus* and *O. panamae* are also forest species occurring at elevations of 16–1220 m and 12–381 m, respectively, based of UFTC data (Scheffrahn 2019). Based on their ridged molar plates, the three *Obtusitermes* species are wood feeders.

Within the nasutitermitines, *Obtusitermes monomorphus* **sp. nov.** and its dimorphic congener, *O. formosulus* occupy a phylogenetic branch sister to the *Constrictotermes* and *Angularitermes* branch (Fig. 11). The other monomorphic small nasute genera found in Panama (*Araujotermes*, *Atlantitermes*, *Coatitermes*, *Ereymatermes*, and *Subulitermes*, Fig. 7) cluster in a clade sister to the non-Panamanian Neotropical genera *Caetetermes* Fontes, 1981 and *Anhangatermes* Constantino, 1990.

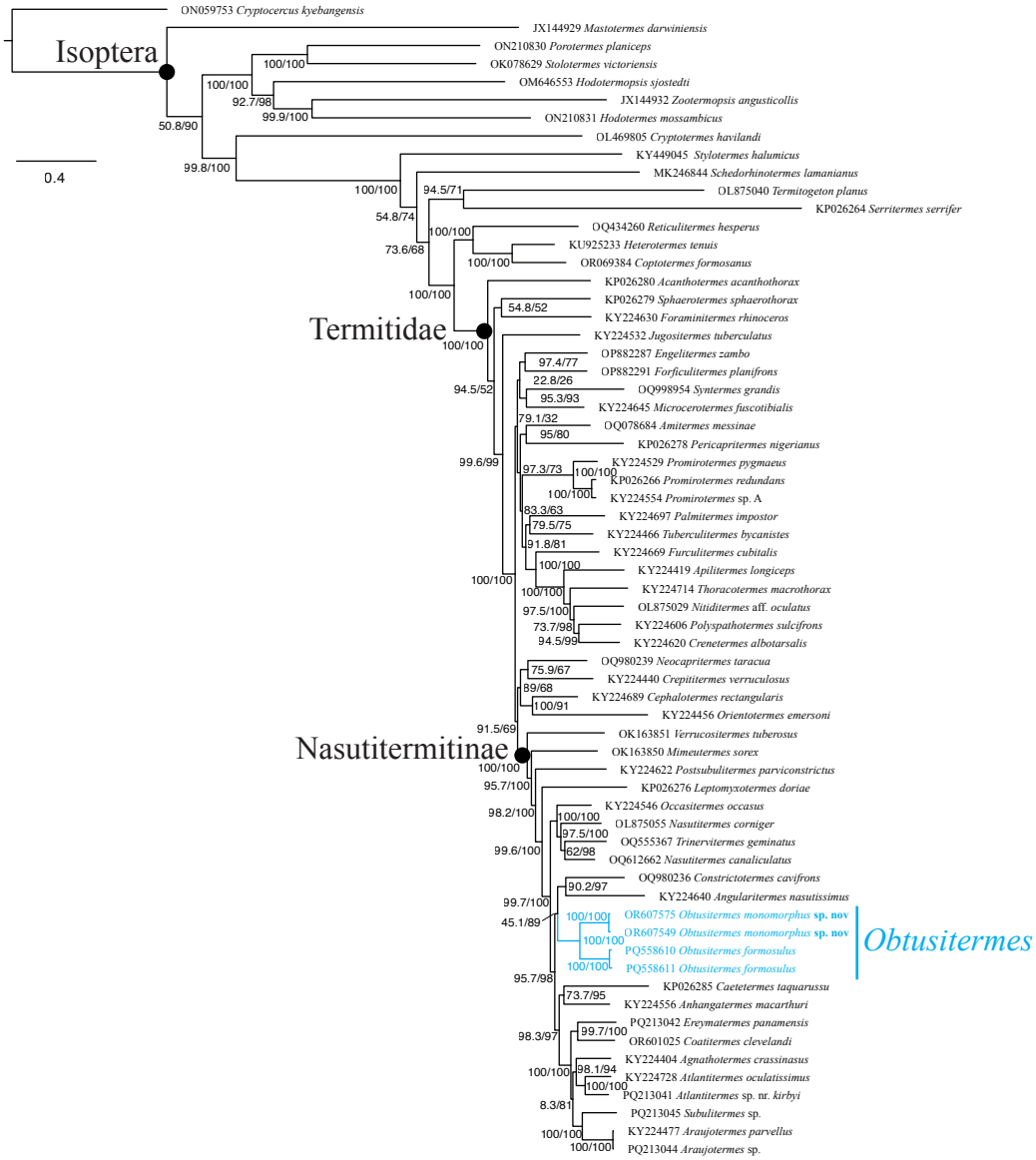

FIGURE 11. A phylogenetic tree of *Obtusitermes* spp. and other related taxa inferred from the mitogenomes.

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