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Two new species of *Batrisodes* Reitter (Coleoptera: Staphylinidae: Pselaphinae) from eastern North America

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Two new species of *Batrisodes* Reitter (Coleoptera: Staphylinidae: Pselaphinae) from eastern North America

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Abstract. Two **new species** of pselaphine staphylinids in the genus *Batrisodes* are described: *B.* (*Declivodes*) *dorothae* Ferro and Carlton from Feliciana Preserve, Louisiana; and *B.* (*Babnormodes*) *spretoides* Ferro and Carlton from Great Smoky Mountains National Park, Tennessee. They differ from all other described *Batrisodes* species in secondary male characters, especially details of the frontal region of the head. These two species bring the total diversity of the genus in North America to 88 species. Specimens were imaged using light microscopy, scanning electron microscopy, and X-ray microtomography (micro-CT) techniques. Utility of multiple imaging techniques, especially micro-CT, is discussed.

Keywords. Taxonomy; Overlooked Syndrome; Feliciana Preserve; Great Smoky Mountains National Park.

Introduction

Possibly no single genus of pselaphines (Coleoptera: Staphylinidae) in North America has received as much scientific study or is as important as a cultural element as *Batrisodes* Reitter. In North America, *Batrisodes* includes 80+ species, including several with apparently disjunct populations. Species are mostly associated with moist leaf litter and coarse woody debris in forests. The majority are epigean, but the genus includes facultative trogophiles, true troglobites (Chandler and Reddell 2001; Chandler et al. 2009), and myrmecophiles (synoeketes) (Park 1947). Males exhibit numerous external secondary sexual characteristics (Park 1947) that often serve as convenient species-level diagnostic characters. Two species are on the federal list of threatened and endangered species (Chandler and Reddell 2001; New 2010). Thus, *Batrisodes* offers the student of nature an opportunity to study: 1) speciation through natural selection, sexual selection, and drift; 2) adaptation to extreme environments; 3) coevolution with ants; and 4) natural history of two federally protected, and therefore economically and politically important, species.

Park (1947) provided the first comprehensive synthesis of North American *Batrisodes*. He reported 11 species from the west, and listed 41 species (plus one variety) from eastern North America, including three eastern species with disjunct populations in Colorado. He proposed nine tentative species groups within Nearctic *Batrisodes*, summarized the known biology of the genus, including association with ant hosts, and provided a key to the males of the eastern species. He also established a standardized terminology, with appropriate figures, regarding the external morphology of the genus.

The first world checklist of *Batrisodes* (Park 1948) listed 214 species distributed within the Nearctic, Palearctic, Afrotropical (Ethiopian), Oriental, and Australian regions. In North America 12 species were listed from the west and 41 from the east (plus one variety). The discrepancy between numbers of western species between Park (1947) and Park (1948) is unclear. Later, Jeannel (1949) proposed several new genera to contain species of *Batrisodes* within the Ethiopian, Oriental, and Australian regions,

which reduced *Batrisodes s.str.* to 94 species and restricted the genus to the Nearctic and Palearctic regions (Holarctic).

Park did extensive work on the eastern species of *Batrisodes* during the 1950s and 1960s. He described nine new species of *Batrisodes* from cave areas in eastern North America and formally erected six subgenera: *Babnormodes* Park; *Batriasymmodes* Park; *Declivodes* Park; *Elytrodes* Park; *Excavodes* Park; and *Pubimodes* Park (Park 1951). Later, Park (1953) erected two more subgenera, *Empinodes* Park and *Spifemodes* Park, and also provided a key for separation of all subgenera. Over the next few years an additional 18 species of *Batrisodes* were described by Park (1956, 8 spp.; 1958, 2 spp.; 1960, 8 spp.). Park (1960) then elevated his subgenus *Batriasymmodes* to full generic status, transferring 12 species from *Batrisodes* (Park 1947, 6 spp.; Park 1951, 4 spp.; 1956, 2 spp.).

The *Batrisodes* of western North America were revised by Grigarick and Schuster (1962), who described five new species and synonymized one. Park and Wagner (1962) provided a key to the species of *Batrisodes* in the Pacific Northwest. Later, Chandler (1983) described another species from California, resulting in a total of 17 western species.

Newton and Chandler (1989) summarized the generic and subgeneric status of *Batrisodes* and reported 154 species worldwide. In a study of Texas cave pselaphines, Chandler (1992) described four new species of *Batrisodes*, synonymized two species, and reported collection of three additional known species from Texas caves. Two species, *B. texanus* Chandler and *B. venyivi* Chandler, are on the federal list of threatened and endangered species (Chandler and Reddell 2001).

Chandler (1997) clarified some nomenclatural problems within the genus. Park (1947, 1948) had considered *B. spinifer* (Brendel) to be a junior synonym of *B. nigricans* and did not include the former species in his enumeration of North American taxa. Chandler (1994) designated the lectotype of *B. spinifer* and placed *B. triangulifer* (Brendel) in synonymy with it. Park (1947, 1948) treated *B. juvencus* Brendel as a junior synonym of *B. riparius* (Say) and did not include it in taxa counts; however, Chandler (1997) listed it as a valid species. Park included *B. luculentus* (Casey) as a valid species, but Chandler (1997) discovered it had been synonymized (Brendel and Wickham 1890). Chandler (1997) listed 76 valid species of *Batrisodes* plus one variety, but later synonymized four species (Chandler 1999).

Chandler and Reddell (2001) revisited the Texas cave fauna, described a further four new species of *Batrisodes,* and reported the collection of an undescribed species known only from a female specimen. Chandler (2003) described two new species of *Batrisodes* from Tehama Co., California and provided a key to species of pselaphines known from the county. Chandler and Lewis (2008) provided notes on the pselaphine fauna of Indiana caves and synonymized one species of *Batrisodes*. Chandler et al. (2009) described an additional five species from Texas caves, reported the discovery of three more undescribed species represented by distinctive female specimens, and provided a key to all pselaphine species known from Texas caves. Currently a total of 86 species of *Batrisodes* are known in North America: 19 western species; 13 species restricted to caves in Texas; and 54 cave entrance and epigean species throughout eastern North America extending west to Colorado, Oklahoma, and central Texas.

The two species of *Batrisodes* described in this work are of particular interest because the majority of specimens have been collected at preserves with ongoing biotic inventories and related research: Feliciana Preserve, Louisiana, USA; and Great Smoky Mountains National Park, Tennessee / North Carolina, USA.

Materials and Methods

The following institutions and curators loaned material on which this study is based with depositions of primary types as indicated: Field Museum of Natural History (**FMNH**, James Boone and Alfred F. Newton, Jr., Curators); Louisiana State Arthropod Museum (**LSAM**, Victoria Bayless, Curator).

Verbatim label data are given for all specimens examined, with specimens separated by an asterisk ("*"), label breaks indicated by a slash ("/"), and the lending institution and number of specimens and sex (M=male, F=female) are indicated, e.g. "(FMNH) (4M)". All specimens from Louisiana State Arthropod Museum have a database number as a separate label (i.e. "/LSAM 0000000"). Those specimens are deposited in the LSAM unless otherwise indicated. All holotypes of newly described species are deposited in FMNH.

Head, pronotum, elytra, and abdomen measurements were taken from the holotype. All measurements are in millimeters. All measurements were taken in dorsal view and represent the maximum value. The head was measured from the anterior margin of the clypeus to the back of the temples (area of greatest constriction of the occiput). Total length was measured from the holotype and was from the anterior margin of the clypeus to the end of the fourth visible abdominal tergite.

For continuity with prior work on the genus, the descriptions are based on the format and style of Park (1947, 1956) and use the terminology of Chandler (2001). Following Chandler (2001) tergites and ventrites are given Arabic numbers to denote sclerites that are visible (1–5) and Roman numerals to denote the morphological segments to which they belong (IV–VIII).

One specimen of *Batrisodes spretoides* was cleared in warm 10% KOH overnight, disarticulated, and mounted on a microscope slide in euparal. Compound microscopy and line illustrating were performed using an Olympus BX50 fitted with a drawing tube.

Point-mounted specimens were examined using a Wild Heerbrugg stereo microscope. Whole specimens were photographed using a Leica Application Suite Ver. 4.1.0, Leica Microscopy system and images were optimized using Adobe Photoshop®.

Specimens used for SEM and micro-CT imaging were removed from their original points using a hot water bath, washed in Ronsonol® lighter fuel (light petroleum distillate), allowed to dry, and remounted to points using Elmer's Glue-All®.

For SEM imaging the paper point with the specimen was affixed to a carbon adhesive tab placed on an aluminum mount stub (Electron Microscopy Science, Hatfield, PA). The beetle was examined in an FEI Quanta-200 ESEM (Environmental Scanning Electron Microscope) at low vacuum mode and an accelerating voltage of 20 kV. Resultant images were optimized using Adobe Photoshop®.

Micro-CT imaging was performed by The Inspection Services Group of North Star Imaging Inc., Rogers, MN (http://www.xrayinspectionservice.com/). Scans were performed using an X25 sub-micron digital radiography and computed tomography system with an X-ray energy of 160kV and a flat panel detector. Specific technique settings of the scan are proprietary and were retained by the company. Scan resolution was 2.3 microns. The 3D model was created using the software efX-ct Lite version 1.6.80.1 (http://www.4nsi.com/) which uses a back projection algorithm to create a 3D model of the subject. Within efX-ct Lite the histogram was optimized to remove background noise, the model was rotated, sliced, and the viewing density was adjusted to obtain desired graphics.

Stereo images are a standard technique to offer a three-dimensional viewing opportunity through a two-dimensional medium. Stereo pairs were created using the program StereoPhoto Maker Version 4.34 (http://stereo.jpn.org/eng/stphmkr/). Resultant images were optimized using Adobe Photoshop®. Images can be viewed by adjusting the focus of the eyes, or through the use of a stereo photo viewer. See the Wikipedia page on Stereoscopy for more information (http://en.wikipedia.org/wiki/Stereoscopy).

Maps were created using the mapping utility at GPS Visualizer (www.gpsvisualizer.com). Markers represent collection locations, not specimens.

Systematic Accounts

Order	Coleoptera Linnaeus, 1758
Family	Staphylinidae Latreille, 1802
Subfamily	Pselaphinae Latreille, 1802
Supertribe	Batrisitae Reitter, 1882
Tribe	Batrisini Reitter, 1882
Subtribe	Batrisina Reitter, 1882
Genus	*Batrisodes* Reitter, 1882

(For full synonymy and citations for family- and genus-group taxa, see Bouchard et al. (2011) and Newton et al. (2001).)

Diagnosis of genus *Batrisodes*

Members of the genus *Batrisodes* can be distinguished from those of all other genera of pselaphines in North America north of Mexico by the following combination of characters: eyes present, or if lacking,

ocular area flatly rounded or smoothly knobbed; antennae clubbed, with eleven antennomeres, scapes notched ventrally and dorsally at apex; pronotum with disk smooth or with pair of short lateral longitudinal carinae (some with median longitudinal sulcus), with pair of basolateral tubercles adjacent to median antebasal fovea; elytra with foveae only at base; mesotrochanter nearly triangular; metatibia with apical spur of coalesced setae, tarsal claws unequal in size; abdomen with five visible tergites, lateral margins of paratergites fused with ventrites (Newton et al. 2001).

Diagnosis of subgenus *Excavodes* Park 1951

Male members of the subgenus *Excavodes* can be distinguished from other subgenera within *Batrisodes* by the following combination of characters: face excavated between antennal cavities (with a continuous transverse depression from one antennal cavity to the other); tenth antennal segment usually foveate on ventral face; each elytron trifoveate; mesofemur lacking spines; mesotarsi straight, unmodified (Park 1951, 1953).

Species Accounts

1. *Batrisodes* (*Excavodes*) *dorothae* Ferro and Carlton
Figures 1–21; Map 1

Holotype, male: *Feliciana Preserve 6 mi. ESE of St. Francisville 30°47'N91°15'W 25 August 1995 D.Pashley / LSAM 0096001. Specimen deposited in FMNH.

Description: Holotype, male. Head 0.47 mm long (tip of clypeal horn to cervix); pronotum 0.40 mm long (dorsal, base to apex); elytra 0.66 mm long (base to apex, along suture); abdomen 0.72 mm long; total 2.25 mm. Holotype pale, teneral (Fig. 1); mature paratypes reddish-brown with paler palpi and legs. Pubescence elongate, semiappressed, flavous.

Head (Fig. 4–7, 11–14) elongate with prominent subreniform eyes of about 42 facets; supraocular carina absent (Fig. 7); lateral vertexal carina extending from temporal angles anteriorly, becoming obsolete just before reaching antennal incisures (Fig. 7); median vertexal carina short, extending from apical pronotal margin to level of vertexal foveae, obsolete apically (Fig. 7); vertexal foveae deep, nude (Fig. 7); circumambient sulcus well developed, same depth throughout, extending anteriorly to line drawn between anterior margins of eyes (Fig. 3–7); interfoveal integument shining and subimpunctate, clothed with a few long erect setae that converge apically to arch over interfoveal center (Fig. 6); vertex-front long, shallowly declivous, lighter than rest of head; overhanging frontal margin with anterior concavity, anterolateral sides produced, pair of apical setal tufts one third distance from lateral edges with setae curved medially, nearly touching clypeal horn (Fig. 4–6); face deeply excavate between antennal acetabulae (Fig. 11); clypeus medially elongate as conspicuous frontal horn projecting anteriorly beyond mandibles and vertically to level of the vertex between antennae (Fig. 4, 5, 11–13).

Antennae (Fig. 3, 4, 6, 7, 12–14) 11-segmented; segment I large, globose ventrally (Fig. 6, 7, 12, 13); segment II elongate (Fig. 14); segment III obconical (Fig. 14); segments IV–VIII similar, becoming transverse; segment IX abruptly wider than VIII (Fig. 14); segment X wider than eleventh, globular from above, with ventral face concave, concavity bearing in mesobasal area a small fovea (Fig. 14); segment XI with truncate base, pubescent, dorsal face slightly flattened, basal ridge of the segment without spines or teeth (Fig. 14). Antennal segment lengths 0.09, 0.06, 0.04, 0.04, 0.04, 0.04, 0.04, 0.04, 0.06, 0.09, 0.18 mm.

Pronotum (Fig. 3, 4, 8, 15) arcuate, greatest width at apical three fifths (Fig. 3); medial antebasal fovea and lateral antebasal foveae well developed, pubescent (Fig. 8); medial sulcus and lateral sulci becoming obsolete apically (Fig. 8); longitudinal carinae short, poorly developed with distinct acuminate basal spine (Fig. 8); median antebasal fovea connected to basal margin by longitudinal carina (Fig. 8).

Elytra (Figs 2, 3, 9) with humeral angle produced, ending with an acute tooth (Fig. 3, 9), evenly covered in widely separated semi-appressed pubescence (Fig. 2, 3); subhumeral fovea distinct, with subhumeral sulcus extending to elytral apex (Fig. 9); three basal elytral foveae present, deep, nude (Fig. 9); sutural stria entire (Fig. 9).

Thorax (Fig. 16). Metasternum medially flattened, the flattened area weakly longitudinally sulcate, the sulcus deepened apically into median preapical fovea. Metathoracic wings present. Thoracic foveation as for genus.

Abdomen (Fig. 1–3, 10, 16) as for supertribe (Chandler 2001), with five visible tergites (IV–VIII) and six ventrites (III–VIII), visible ventrites 1–2 (III–IV) fused; sixth ventrite (6, VIII) with posterolateral corners elevated into low tumuli, and with transverse arcuate subapical sulcus (Fig. 10).

Legs (Fig. 1, 2). Prothoracic legs simple, primary tarsal claw not bifid. Mesothoracic tibia with short apical spur of very approximate setae; mesotarsi simple. Metathoracic legs with the tibia bearing long apical setal spur.

Aedeagus (Fig. 21) flat, parallel sided, with acuminate tip; 0.30 mm long.

Paratypes (n=10). **UNITED STATES: LOUISIANA: East Feliciana Parish:** *USA: LA:E. Felicia. Par., Clinton III-24-2000, exotic bark beetles survey (LSAM, 2M). **West Feliciana Parish:** *LOUISIANA: W Feliciana Par., Feliciana Preserve 30°47’N 91°15’W. Flight intercept. 2-17 Mar 2002 A.Cline & A.Tishechkin / LSAM0029394 (1M). *LOUISIANA: W Feliciana Par., Feliciana Preserve 30°47’N 91°15’W. Flight intercept, sample A. 7 Mar- 23 May 2004. A. Tishechkin / LSAM 0096078 / Batrisodes n. sp. Det. C. E. Carlton 2011 (1M, specimen destroyed, single leg remains). *USA: LA: W.Feliciana Par. Feliciana Preserve 6 mi. ESE of St. Francisville 30°47’N91°15’W FIT 10-30March 1996 D.Pashley / LSAM 0096014 (1M). *LOUISIANA: W Feliciana Par., Feliciana Preserve 30°47’N 91°15’W. Flight intercept. 15 March – 14 April 2003. A.Tishechkin / LSAM 0235274 (1M). *USA: LA, W. Feliciana Par. Tunica Hills WMA Forest Litter. 6.IV.1995 D.Colby & D Landau leg. / LSAM 0096000 (1M). *USA: LA, W. Feliciana Par. Tunica Hills. WMA 1-10 May 1995. D. Pashley / LSAM0001528 (1F). *USA: LA: W.Feliciana Par. Feliciana Preserve 6 mi. ESE of St. Francisville 30°47’N91°15’W 25 August 1995 D.Pashley / LSAM 0096001 (1M). **SOUTH CAROLINA: Darlington / Florence Counties:** *USASCFLORENCE/DARLINGTON CoLineRidge Hope Pres 34°12’15”N 79°42’24”WE1320’ J&SCornell24X09 Berl Wash Soil Litter by rotten Pine Stump / LSAM 0235465 (1M).

Geographical Distribution. The majority of specimens of *Batrisodes dorothae* were collected in Feliciana Preserve, West Feliciana Parish, Louisiana (N 30.795°, W 91.254°; elevation 40 m [130 ft]) and from nearby Tunica Hills Wildlife Management Area (Map 1). Both localities encompass a portion of the Tunica Hills, an area with deep forested ravines, and a refugium for mixed mesophytic forest species during the Wisconsin glaciation (Delcourt and Delcourt 1975). The preserve has been the site of previous entomological studies (see list in Ferro et al. 2009) and consists of a secondary mixed mesophytic forest dominated by magnolia (*Magnolia grandiflora* L.), holly (*Ilex opaca* Aiton), beech (*Fagus grandifolia* Ehrhart), pine (*Pinus* spp.), and several species of oak (*Quercus* spp.). One specimen was collected from South Carolina (elevation 402 m [1320 ft]) indicating that the species is probably more widespread in southeastern United States than current data indicate.

Comments: *Batrisodes dorothae* adults have been collected during March – October. Specimens were collected from a rotten pine stump, from forest litter using a Berlese funnel, and with a flight intercept trap.

Batrisodes dorothae superficially resembles *B. lineaticollis* Aubé. The two species can be separated with the following characters (*B. lineaticollis* in parentheses): head elongate (head subquadrate); median vertexal carina low (median vertexal carina pronounced, rising above level of rest of head); well-defined circumambient sulcus not extending beyond a line drawn between the front of the eyes (circumambient sulcus poorly defined, becoming obsolete apically); vertex-front long, truncate apically, subimpunctate (vertex-front short, rounded, roughly sculptured); antennal insertions exposed (antennal insertions concealed); aedeagus with acuminate tip (aedeagus with blunt tip).

Etymology. This species is named for Dorothy (Pashley) Prowell, collector of the holotype, principal developer of Feliciana Preserve, the type locality, and a tireless promoter of education and conservation.

Diagnosis of subgenus *Babnormodes* Park 1951 (males)

Male members of the subgenus *Babnormodes* can be distinguished from other subgenera within *Batrisodes* by the following characters: protibiae are often flattened and twisted in the apical half (Chandler et al. 2009); mesotarsi abnormal, tarsomere 2 excavate along ventral margin (Park 1951, 1953).

***Batrisodes* (*Babnormodes*) *spretoides* Ferro and Carlton**
Figures 22–31; Map 2

Holotype, male: *Gt.Smoky Mts.Nat.Pk. nr. Cades Cove Blount Co., Tenn. 8.VI.60 Alt. c1700' under rock / W. Suter & J. Wagner Collectors / male symbol / [blue triangle] / Field Mus. Nat. Hist. Orlando Park Pselaphidae Collection / TYPE [red paper]. Deposited in FMNH.

Description: Holotype, male. Head 0.34 mm long (apex of clypeus to cervix); pronotum 0.34 mm long (dorsal, base to apex); elytra 0.56 mm (base to apex, along suture); abdomen 0.60 mm long; total 1.84 mm. Holotype reddish-brown with paler palpi and legs. Pubescence elongate, semi-appressed, flavous (Fig. 22).

Head (Fig. 24–26) elongate with prominent subreniform eyes of about 40 facets; supraocular carina absent; lateral vertexal carina extending from temporal angles anteriorly, becoming obsolete at level of vertexal foveae; median vertexal carina faint, extending from apical pronotal margin to level of cervical sulcus, obsolete apically; vertexal foveae deep, nude; circumambient sulci indistinct, extending apically to margin of facial declivity; vertex with broad tumulus bordered laterally by circumambient sulci; interfoveal integument shining and subimpunctate, clothed with a few long erect setae; vertex-front short, shallowly declivous, lighter than rest of head, integument granular with dense short setae; frontal margin overhanging, covering antennal insertions, with pair of large blunt lateral projections mesad of the antennae, and two smaller medial projections separated by a medial cleft; face excavate between antennal acetabulae, excavation setose; clypeus with low, wide, medial projection; labrum transverse, apical margin concave.

Antennae (Fig. 22–26) 11-segmented; segment I large, globose ventrally; segment II elongate; segment III obconical; segments IV–VIII similar, becoming transverse; segment IX abruptly wider than VIII; segment X wider than eleventh, globular from above, with small fovea/large pore at apex; segment XI with truncate base, pubescent, dorsal face slightly flattened, basal ridge of the segment without spines or teeth. Antennal segment lengths 0.12, 0.07, 0.06, 0.05, 0.05, 0.04, 0.04, 0.04, 0.08, 0.10, 0.20 mm.

Pronotum (Fig. 23, 24) arcuate, greatest width at apical three fifths; medial antebasal fovea and lateral antebasal foveae well developed, pubescent; medial sulcus and lateral sulci obsolete; longitudinal carinae short, poorly developed with distinct basal spine.

Elytra (Fig. 23) with humeral angle produced, evenly covered in widely separated semiappressed pubescence; subhumeral fovea distinct, with humeral sulcus extending to elytral apex; three basal elytral foveae present, deep, nude; sutural stria entire.

Thorax. Metasternum medially flattened, the flattened area weakly longitudinally sulcate, the sulcus deepened apically into a fovea between the mesial angles of the metathoracic coxae. Metathoracic wings present.

Abdomen as for supertribe (Chandler 2001), with five visible tergites (IV–VIII) and six ventrites (III–VIII), visible ventrites 1–2 (III–IV) fused; sixth ventrite (6, VIII) with transverse median extension.

Legs (Fig. 22, 27, 28). Prothoracic legs slightly flattened, primary tarsal claw not bifid. Mesothoracic trochanter with posterior tooth (Fig. 28); mesotibia with short apical spur and dense setae on apical one third (Fig. 28); mesotarsi abnormal (Fig. 27, 28). Metathoracic legs with the tibia bearing a long apical tuft of setae.

Aedeagus (Fig. 29) parallel-sided, flat, with apical one-third smoothly bent 90 degrees ventrad, with acuminate tip; 0.24 mm long.

Female (Fig. 30, 31) similar to male, except eyes smaller, with ~25 facets; face entirely declivous, without transverse impressions or excavations; clypeus flat, covered in fine, dense setae, distinctly margined; antennae unmodified; mesothoracic tarsi normal.

Female specimens included as paratypes are based on association with males from the series collected by Suter and Wagner.

Paratypes (n=24). **UNITED STATES: TENNESSEE: Blount County:** *Gt.Smoky Mts.Nat.Pk. nr. Cades Cove Blount Co., Tenn. 8.VI.60 Alt. c1700' under rock / W. Suter & J. Wagner Collectors / male symbol [blue paper] / Field Mus. Nat. Hist. Orlando Park Pselaphidae Collection / PARATYPE [red paper] (FMNH) (7M, 1M slide). *Same data with additional metallic gold square below label bearing male symbol (FMNH) (1M). *Same data but with female symbol on blue paper rather than male (FMNH) (5F). *GRSM 26044 ACC 980 / Gt.Smoky Mts.Nat.Pk. nr. Cades Cove Blount Co., Tenn. 8.VI.60 Alt. c1700' under rock / W. Suter & J. Wagner Collectors / male symbol [blue paper] / PARATYPE [red paper] / Batrisodes (Babnormodes) spretoides Park / LSAM 0056952 (1M). *Same data but with female symbol on blue paper rather than male / LSAM 0056857 (1F). *TENNESSEE: Blount Co. *GSMNP*, Cades Cove ~1mi N Methodist Church 35°36'41"N 83°48'59"W 610 m. Forest litter 18 July 2003. A.Tishechkin / LSAM0014971 (1M). *USA TN BlountCo RichMtRd@IndianGraveTr 36°37.36'N [sic. 35°] 83°48.78'W J&TADCornell Wash ex. soil decid. woods 2754' [no date]/ Ex. J.F.Cornell Collection / LSAM 0235275 (1M). **Cocke County:** *TENNESSEE: Cocke Co., *GSMNP*, Foothills Pwy., 1st outlook E Cosby. Ravine leaf litter Berlese. 21 Jul 2003 P.E.Skelley / LSAM 0096203 (1F). *Same data, LSAM 0096204 (1M). *Same data, LSAM 0096205 (1F). **Sevier County:** *USA: TN: Sevier Co. GSMNP Sugarlands QW N35°39.826' 2 April 2007 W83°31.509' SN3 CWD5 3 of 3 –M Ferro / LSAM 0148221 (1M). *USA: TN: Sevier Co. GSMNP Greenbrier N35°430147' 1-8 July 2007 W83°23.349' FIT 1of3 – Original M Ferro / LSAM 0169452 (1M). *TENNESSEE: Sevier Co. *GSMNP*, W Old Settlers Trhd. 35°42.46'N 83°22.9'W Forest litter. 6 Oct 2005 D.Chouljenko, M.Gimmel & A.Heppermann / LSAM 0091908 (1M).

Geographical Distribution. *Batrisodes spretoides* is only known from Blount, Cocke, and Sevier counties in Tennessee. All known specimens have been collected within Great Smoky Mountains National Park. Specimens were collected between 520 and 840 m elevation.

Comments. *Batrisodes spretoides* most closely resembles *B. spretus* LeConte. The shape of the frontal margin, with two pairs of lateral and medial blunt projections as opposed to a single pair of medial conoidal tubercles, and the presence of a posterior tooth on the mesothoracic trochanter of *B. spretoides* will serve to distinguish it from *B. spretus*.

Park (1965) described the species *Batriasymmodes suteri* Park based on 34 specimens collected by Walter R. Suter and John A. Wagner on 8 June 1960 from Great Smoky Mountains National Park, Cades Cove, Blount County, Tennessee "in leaf mold, under bark of floor logs, and beneath rocks." The label information matches that of the type series of *B. spretoides* and presumably both species were collected during the same collection event. *Batrisodes spretoides* adults have been collected during April – October. Specimens have been collected from under rocks, sifted from decay class 5 coarse woody debris (see Ferro et al. 2012a), with a flight intercept trap (see Ferro et al. 2012b), and from forest litter using a Berlese funnel and soil washing. One teratological specimen, designated with a metallic gold square label, had antennomeres IX and X of the right antenna partially fused for approximately half their circumference.

Etymology. *Batrisodes spretoides,* first collected in June 1960, was recognized by Orlando Park as an undescribed species, but he never described it. He segregated the type series, designated a holotype and paratypes, and added a manuscript name. Park's (1960) last work involving eastern *Batrisodes* was published in July 1960 (based on a presentation from December 1959) within the journal The American Midland Naturalist as part of a symposium series: Speciation and Raciation in Cavernicoles. The manuscript name has never appeared in print and is an available name used here following O. Park's original preference. The name is an allusion to the species *B. spretus*, which this new species closely resembles.

Discussion

Discovery of undescribed species of beetles—even from eastern North America, a region with a well-studied fauna—is not surprising. Many small, non-economically important organisms suffer from Overlooked Syndrome (Ferro and Carlton 2010) and remain in collections for decades or longer before they are "discovered" and described. While male members of the genus are generally easy to differentiate at the species level, the study of *Batrisodes* is handicapped by 1) the large number of species (88 in North America), 2) few active workers, and 3) lack of adequate comparative descriptions/illustrations and comprehensive keys. Partial keys do exist (see below).

Imaging. The elaborate and diverse secondary sexual characters of the faces of male *Batrisodes* are useful for identification and differentiation (if ever a group could be justifiably called "Gargoyle Beetles" this is it). However, the complex horns, shelves, declivities, etc. do not lend themselves to simple verbal description and offer a challenge to illustrators. Scanning electron microscopy (SEM) provides an opportunity to overcome some illustration challenges. It currently provides the highest resolution of any reasonable imaging technology, e.g. setae are clearly visible even in habitus micrographs. However, SEM has limitations: some systems require the specimen to be gold coated; only the external anatomy can be imaged; and the only views of the specimen, including 3D stereo, are the static images taken during the imaging session.

X-ray microtomography (micro-CT) provides an interesting new tool in the study of small organisms, especially *Batrisodes*. A fully rotatable 3D model of the external and internal anatomy of the specimen is created. The model can be repositioned and re-viewed at any time. Measurements of length, volume, and surface area can be taken in any view, and additional measurements can be taken at a later date. The model can be shared and copied indefinitely. Three-dimensional views can be rendered in any desired format. Micro-CT solves the problem of illustration of complex facial features in *Batrisodes* and offers an unambiguous, reproducible, and repositionable image of a given specimen.

Despite, or perhaps because of, budget cuts, natural history museums are increasingly at the forefront of emerging technology. Databases and the Internet have allowed institutions to share full label data for millions of specimens. Focus-stacking technology has allowed institutions to share high quality images of specimens, especially holotypes. GigaPan technology (www.gigapan.com/) provided institutions with the ability to share high resolution photos of entire drawers (Bertone et al. 2012). Micro-CT offers an opportunity for institutions and researchers to provide unparalleled models of external (Fig. 7–16) and internal morphology (Fig. 17–20) of select taxa and/or specimens. A central clearing house of micro-CT models, similar to what GenBank (https://www.ncbi.nlm.nih.gov/genbank/) does for DNA, would usher in a paradigm shift in morphological and morphometric studies. Morphbank (http://www.morphbank.net/) may develop into just such a resource, but currently only accepts 2D images.

Biology of *Batrisodes*. Adult and immature *Batrisodes* are generalist predators/ myrmecophiles that inhabit tree holes, forest litter, rotten wood, caves, and are occasionally found in the presence of ants (some species are obligate myrmecophiles). While poorly known at the level of species, *Batrisodes* is one of the most studied genera within Pselaphinae in terms of biology, largely due to the work of Luigi De Marzo and Orlando Park.

Works on immature *Batrisodes* include: Böving and Craighead 1930 (key of Coleoptera to subfamily, illustration of *B. monstrosus* LeConte); Carlton and Leschen 2008 (list of described immature stages of Pselaphinae); De Marzo and Vit 1982 (description and illustration of the first instar of *B. oculatus* Aubé and a brief description of the egg and pupa); De Marzo 1985 (description of larval anatomy of *B. oculatus* with special reference to exsertile head and abdominal organs and glands used for prey capture); De Marzo 1986a (description of eggs of 13 species of pselaphines, including the egg of *B. oculatus*); De Marzo 1986b (description of larval prey capture involving exsertile head organs, and pupal cocoon of *B. oculatus*); De Marzo 1987 (final instar larval morphology of *B. oculatus* and seven other genera); De Marzo 1988 (description of pupal chambers of pselaphines, including *B. oculatus*, larvae of which prepared a pupal chamber with soil and then created a cocoon using silk from the front legs); Jeannel 1950 (illustration of *B. monstrosus* based on Boving and Craighead 1930); Lawrence 1991 (key of Coleoptera to subfamily); Newton 1991 (overview of immature pselaphine biology and morphology);

Rosenburg 1925 (description and illustration of immature *B. venustus* Reichenbach); and Thayer 2005 (overview of Staphylinidae, including Pselaphinae, adult and immature biology and morphology).

Works containing information on the biology of *Batrisodes* include: Blatchley 1910 (key and natural history of eastern species); Chandler and Reddell 2001 (in Texas caves); De Marzo 1989 (description of internal genitalia of male and female pselaphines including *B. oculatus*); De Marzo and Vovlas 1989 (external secondary sexual characteristics of *B. oculatus*); De Marzo and Vit 1982 (notes on a large subterranean population of *B. oculatus*); Engelmann 1956 (feeding behavior of *B. lineaticollis* [as *B. globosus* LeConte]); Fall 1912 (association with ants); Holmquist 1928 (association with ants); Klimaszewski et al. 2007 (species in southeastern Quebec); Mann 1911 (association with ants); Park 1932 (feeding behavior of *B. lineaticollis* [as *B. globosus*]); Park 1935 (association with ants); Park 1947 (key to eastern U.S. species, general ecology of the genus); Park 1951 (species in eastern U.S. caves, key); Park 1956 (species in eastern U.S., behavior of *B. valentinei* Park); Park 1960 (species in eastern U.S. caves, checklist and key); Park et al. 1950 (species collected from tree holes); Reddell 1994 (in Texas caves); Schwarz 1894 (association with ants); Thayer 2005 (overview of Staphylinidae, including Pselaphinae, adult and immature biology and morphology); U.S. Fish and Wildlife Service 2014 (Texas endangered species); Webster et al. 2012 (species of New Brunswick, Canada); Whitaker 1986 (predation by salamander); Wickham 1894, 1896, 1898, 1900 (association with ants). See also works cited in Introduction.

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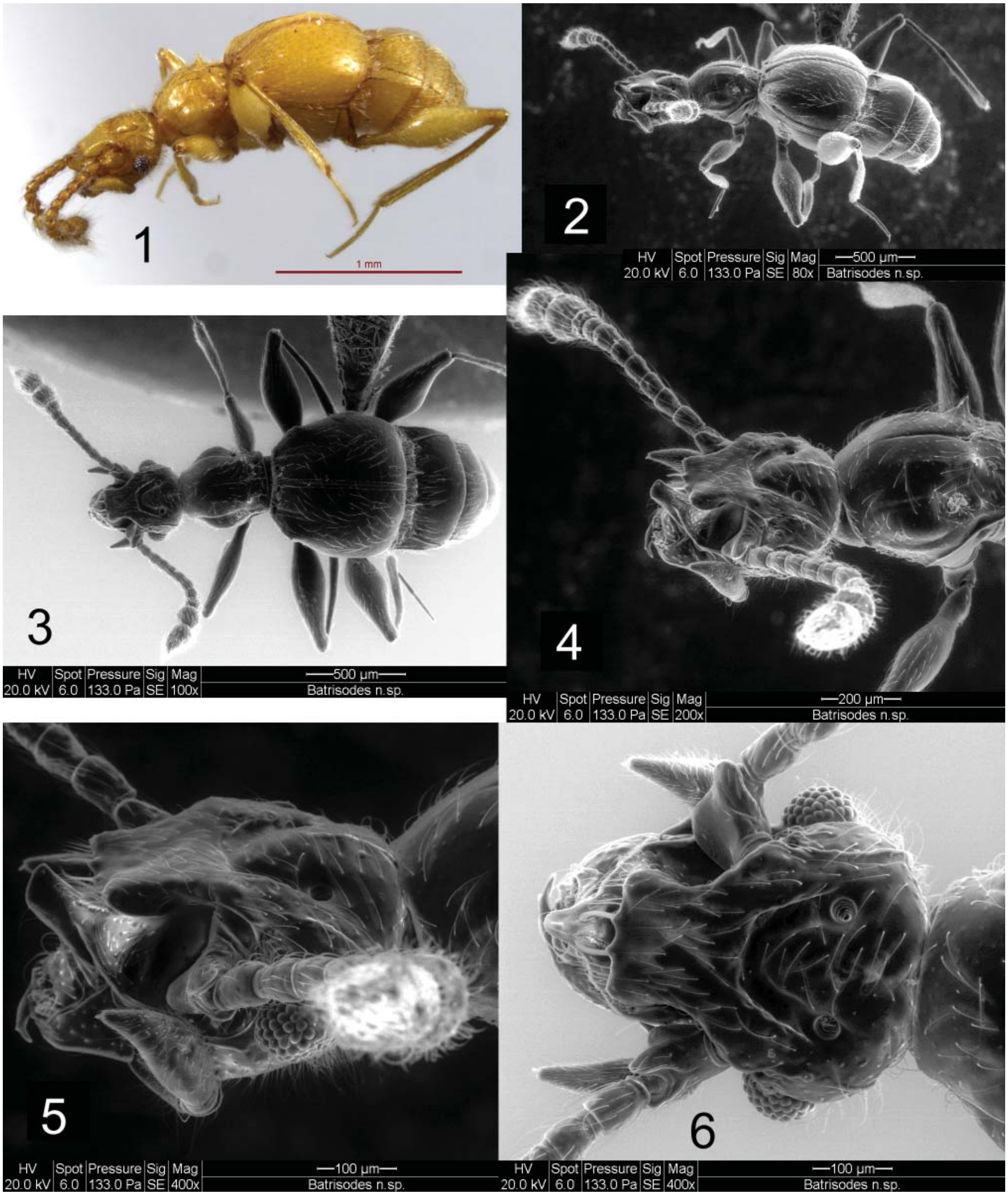
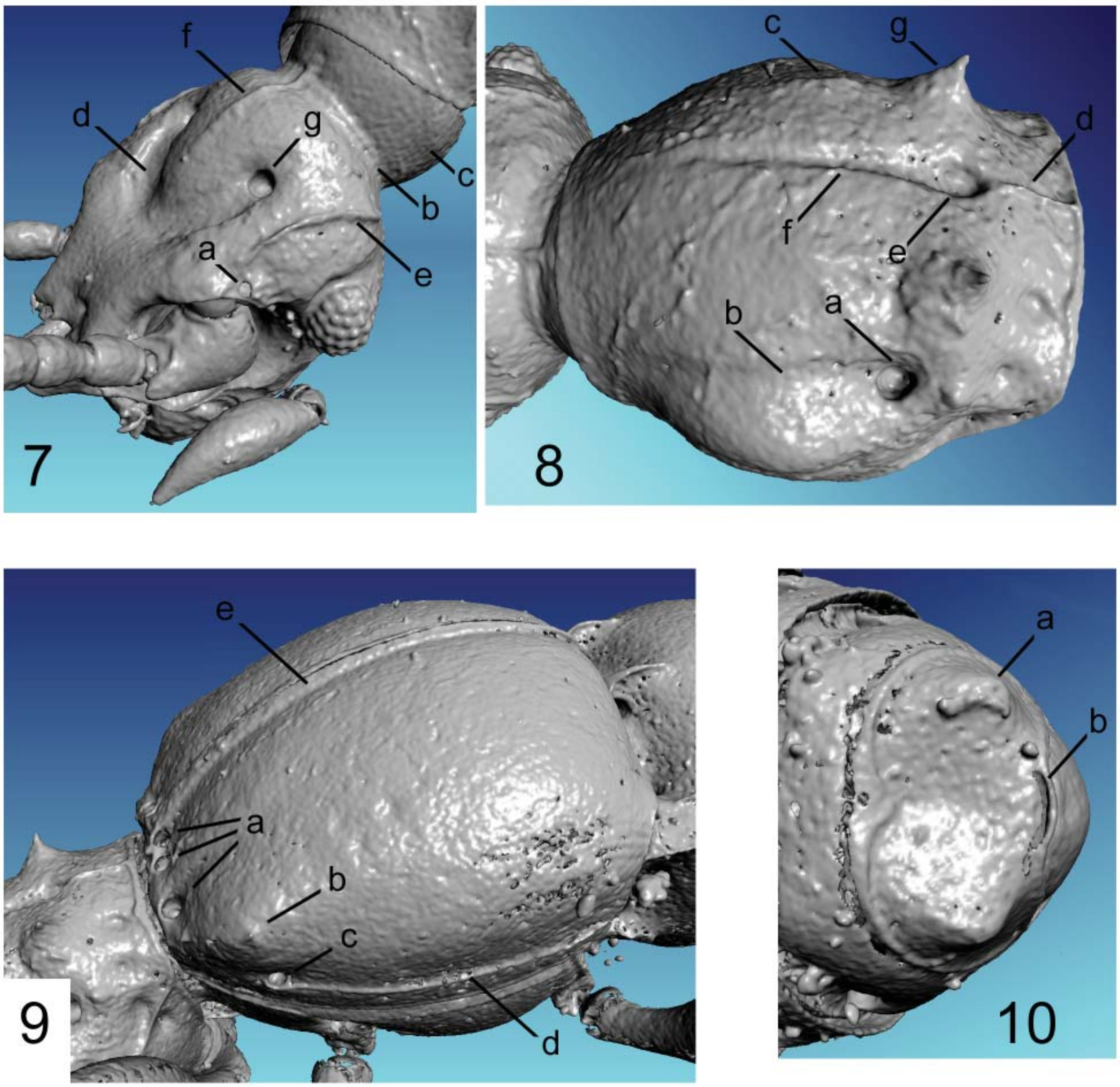


Figures 1–6. *Batrisodes dorothae*. **1)** Holotype, male habitus. **2)** Paratype, male, SEM micrograph, habitus, lateral. **3)** Paratype, male, SEM micrograph, habitus, dorsal. **4)** Paratype, male, SEM micrograph, head and antennae, three quarter view. **5)** Paratype, male, SEM micrograph, head, three quarter view. **6)** Paratype, male, SEM micrograph, head, dorsal.



Figures 7–10. Batrisodes dorothae, micro-CT capture. **7)** Male head: a = antennal incisures; b = cervical sulcus; c = cervicum; d = circumambient sulcus; e = lateral vertexal carina; f = median vertexal carina; g = vertexal fovea. **8)** Pronotum: a = lateral antebasal fovea; b = lateral sulcus; c = longitudinal carina (weak); d = median basal carina; e = medial antebasal fovea; f = median sulcus; g = spine. **9)** Elytra: a = basal elytral foveae; b = humeral spine; c = subhumeral fovea; d = subhumeral sulcus; e = sutural stria. **10)** Sixth ventrite: a = posterolateral tumulus; b = subapical sulcus.

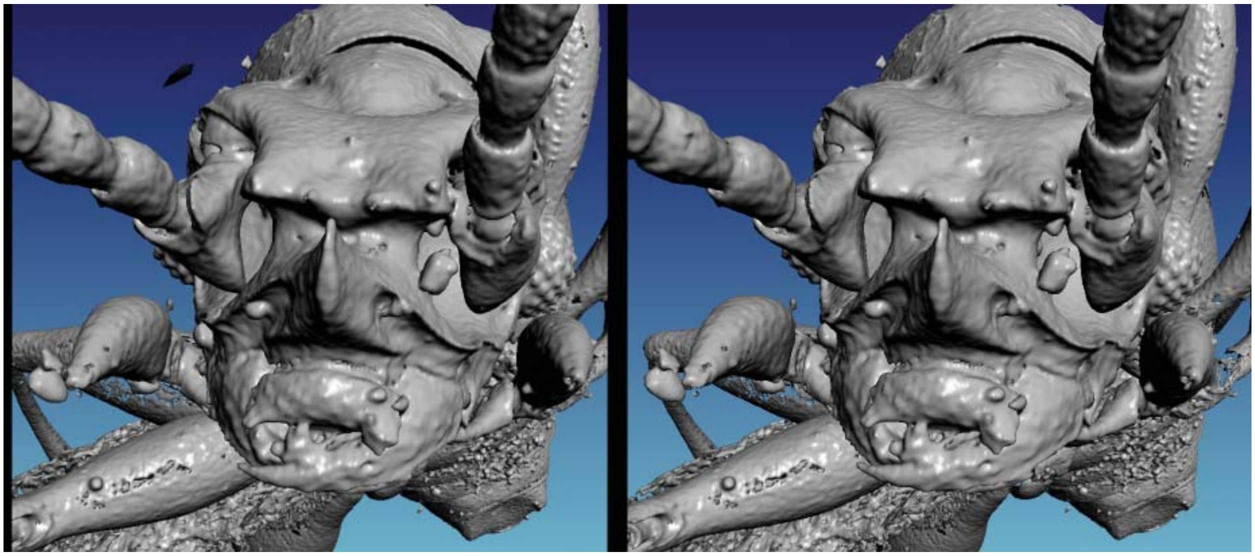


Figure 11. *Batrisodes dorothae* male, stereo pair, frontal view. Micro-CT capture.

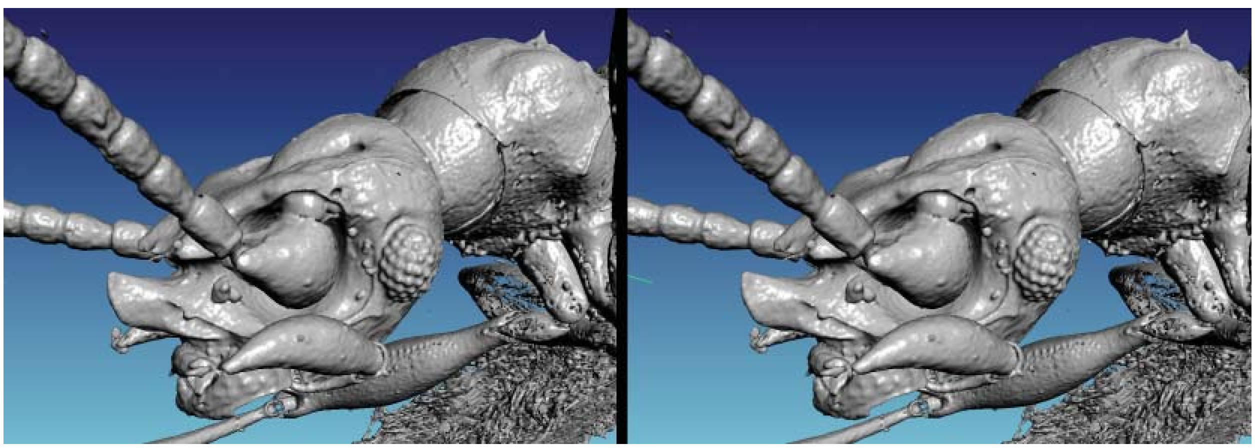


Figure 12. *Batrisodes dorothae* male, stereo pair, head in three-quarter view. Micro-CT capture.

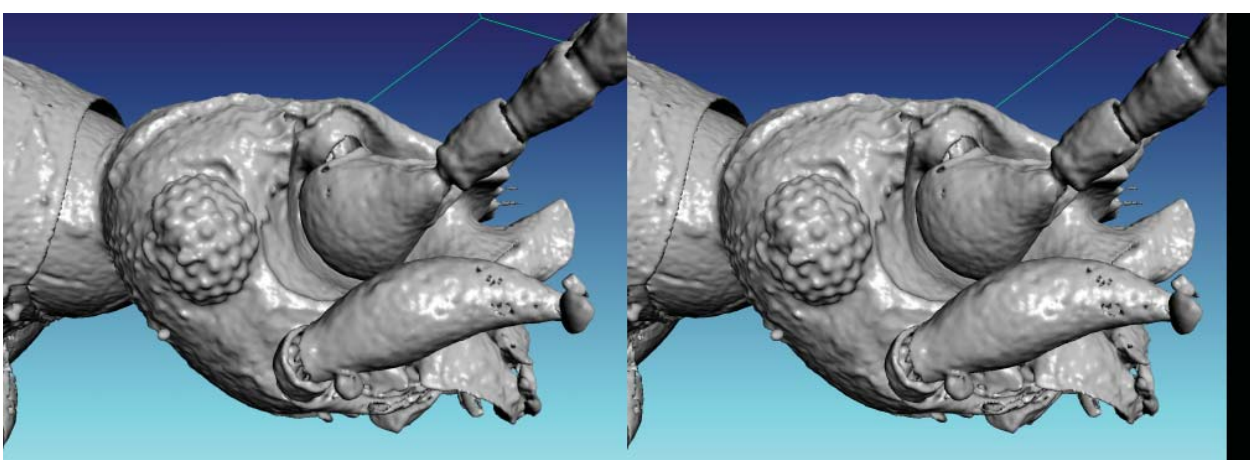


Figure 13. *Batrisodes dorothae* male, stereo pair, lateral head. Micro-CT capture.

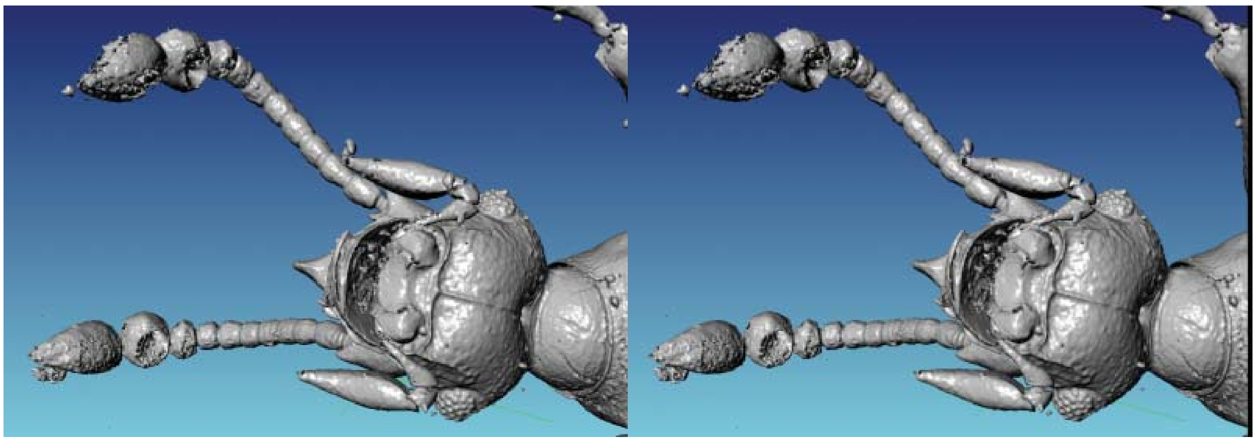


Figure 14. *Batrisodes dorothae* male, stereo pair, underside of head. Micro-CT capture.

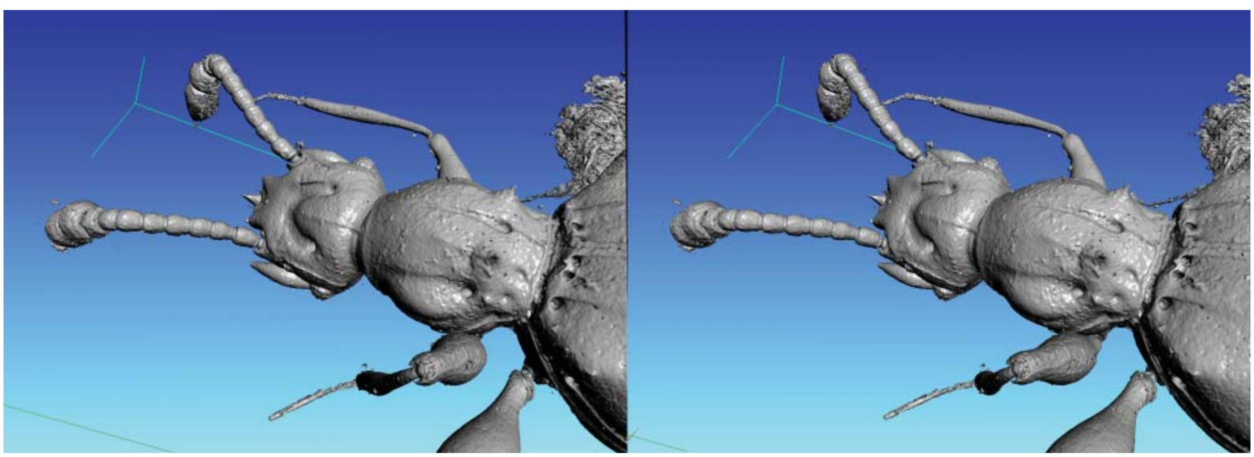


Figure 15. *Batrisodes dorothae* male, stereo pair, head and pronotum. Micro-CT capture.

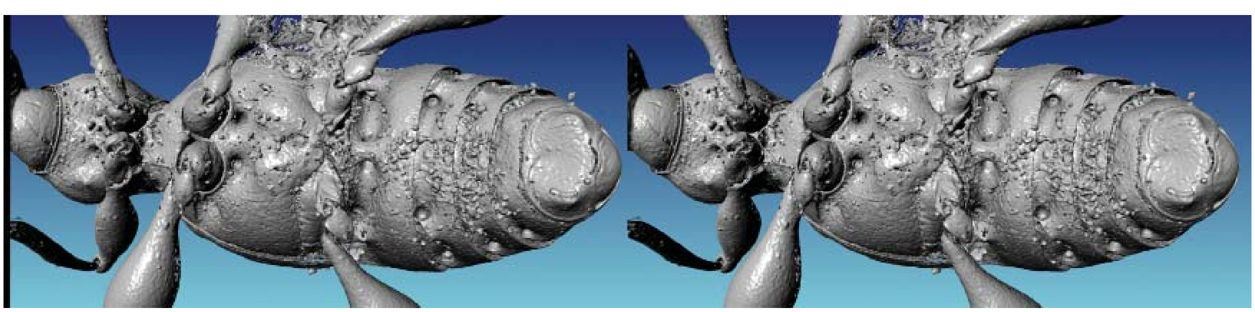


Figure 16. *Batrisodes dorothae* male, stereo pair, ventral view. Micro-CT capture.

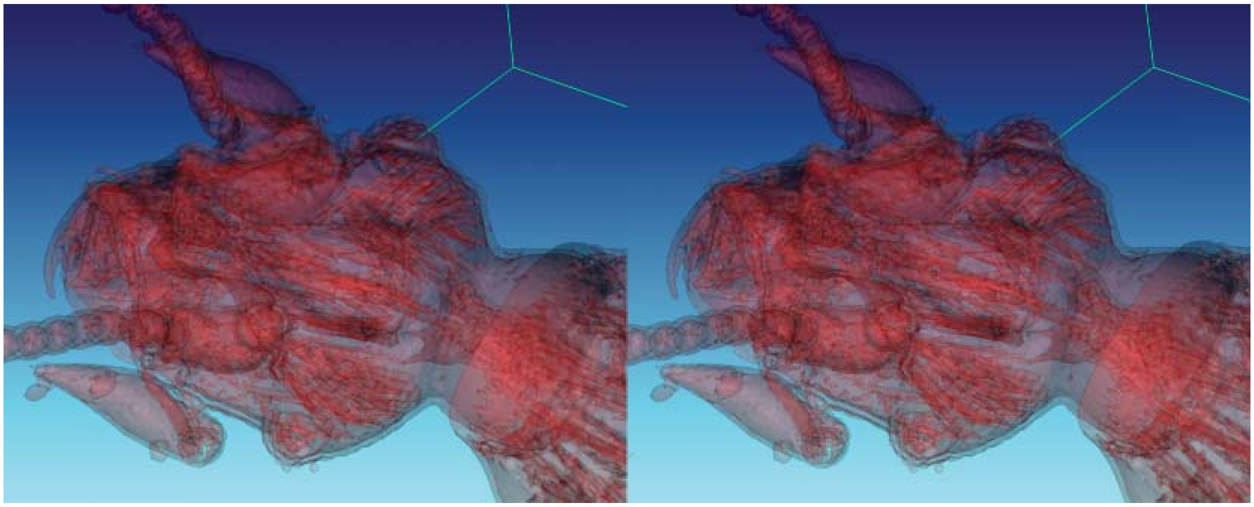


Figure 17. *Batrisodes dorothae* male, stereo pair, head, internal view. Micro-CT capture.

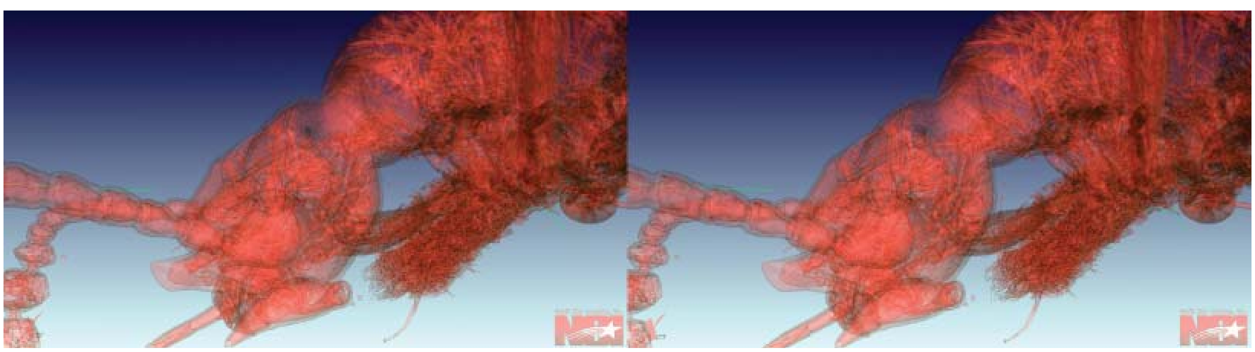


Figure 18. *Batrisodes dorothae* male, stereo pair, head and pronotum, internal view. Micro-CT capture.

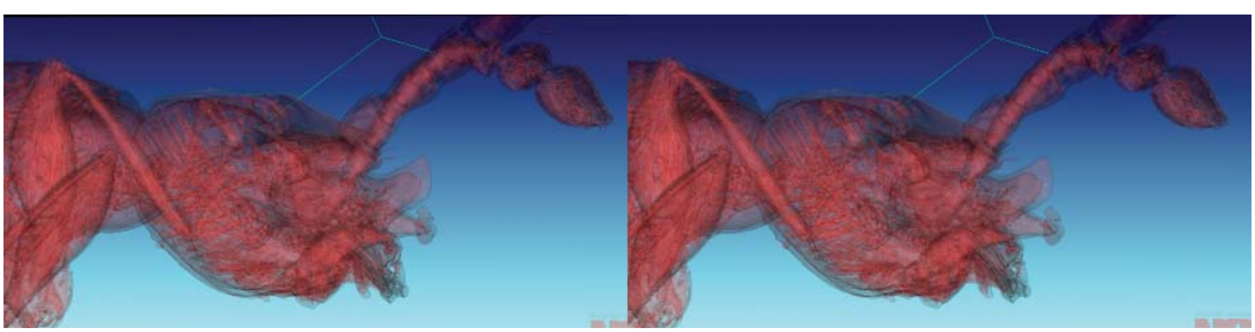
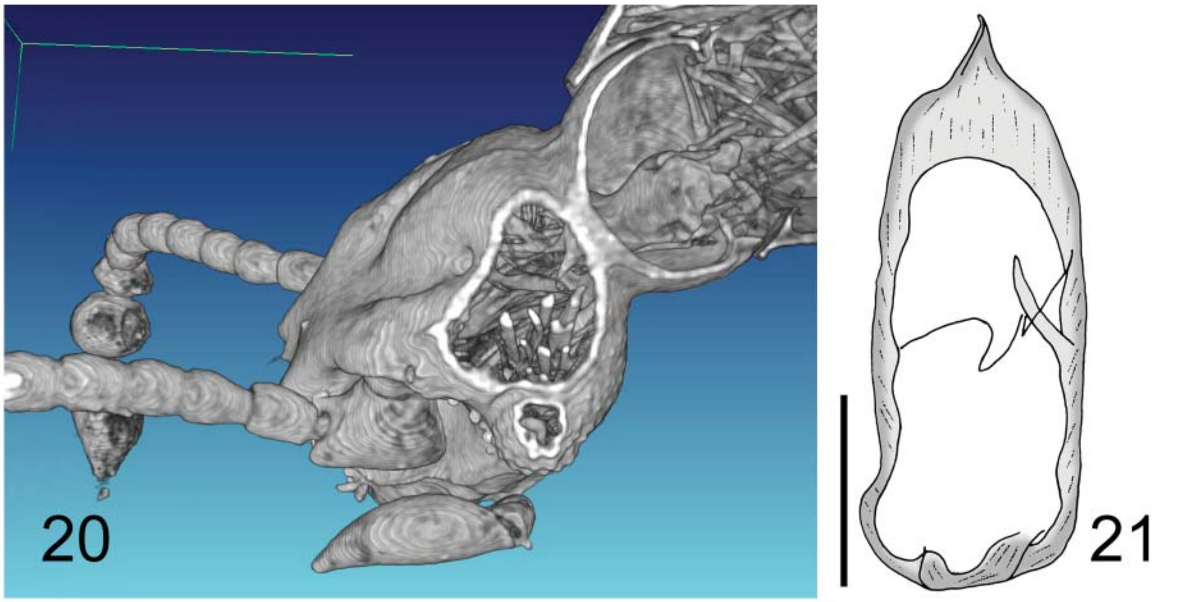
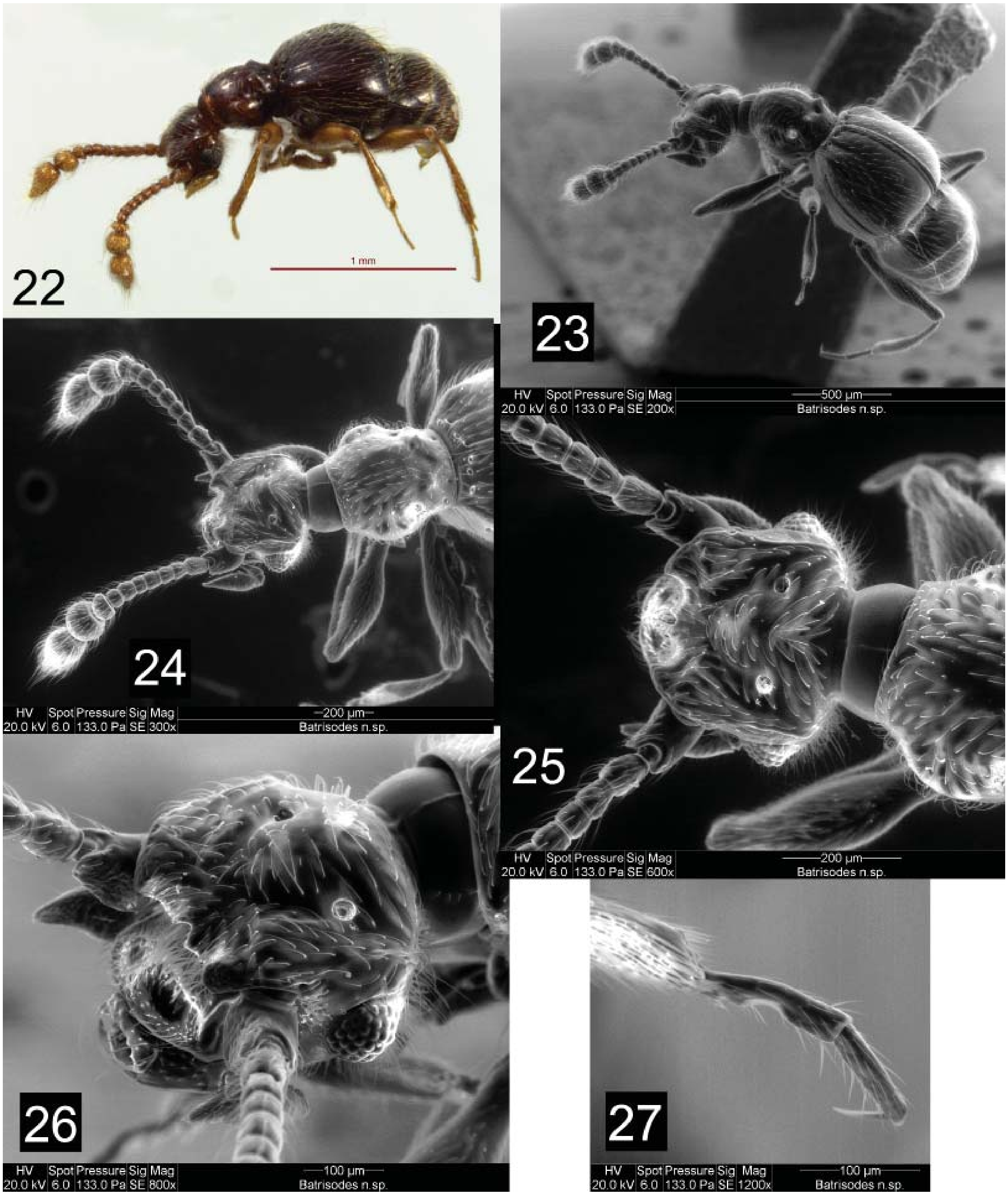


Figure 19. *Batrisodes dorothae* male, stereo pair, head, internal view, lateral. Micro-CT capture.

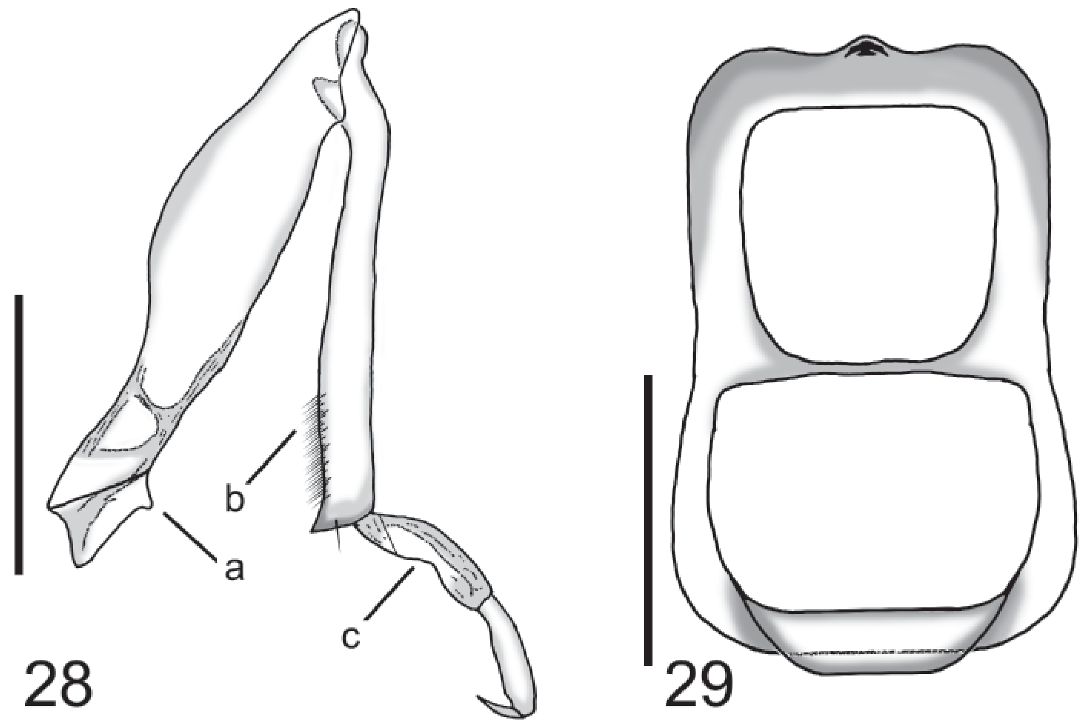


Figures 20–21. *Batrisodes dorothae*. **20)** Male head, internal view, lateral, micro-CT capture. **21)** Aedeagus. Bar = 0.1 mm.

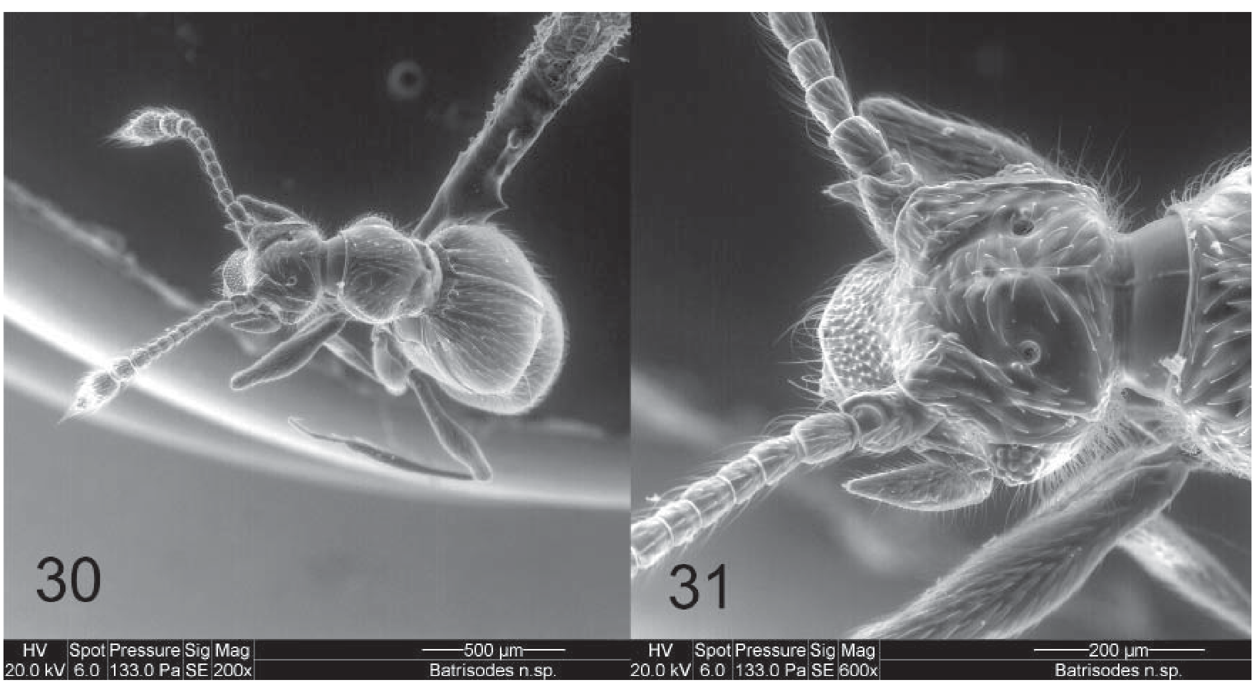
Map 1. *Batrisodes dorothae* collection localities.



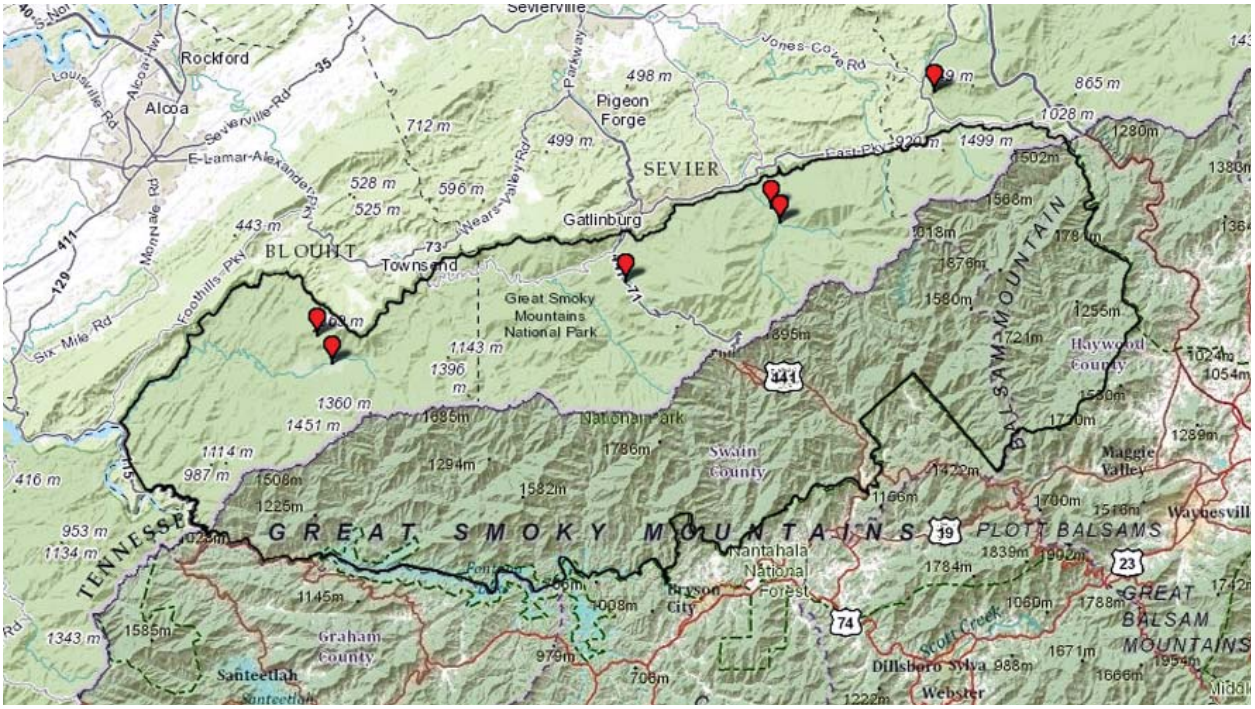
Figures 22–27. *Batrisodes spretoides*. **22)** Holotype male, habitus. **23)** Paratype, male, SEM micrograph, habitus, lateral. **24)** Paratype, male, SEM micrograph, head and antennae, three quarter view. **25)** Paratype, male, SEM micrograph, head, dorsal. **26)** Paratype, male, SEM micrograph, head, three quarter view. **27)** Paratype, male, SEM micrograph, mesotarsus.



Figures 28–29. *Batrisodes spretoides*. **28)** Male mesothoracic leg: a = mesothoracic trochanter with posterior tooth; b = dense setal patch on mesotibia (other setae not shown); c = “abnormal” mesotarsus. Bar = 0.4 mm. **29)** Aedeagus. Bar = 0.1 mm.



Figures 30–31. *Batrisodes spretoides* female, SEM micrograph. **30)** Habitus. **31)** Head three quarter view.



Map 2. *Batrisodes spretoides* collection localities. The northeastern-most locality is on Foothills Parkway, a portion of Great Smoky Mountains National Park.