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A NEW SPECIES OF *NEBRIA* LATREILLE (COLEOPTERA: CARABIDAE: NEBRIINI)  
FROM THE GRAND CANYON, ARIZONA

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## ABSTRACT

*Nebria georgei*, new species (Coleoptera: Carabidae: Nebriini), is described from the riparian zone along the Colorado River in the Grand Canyon, Arizona (type locality = Arizona, Coconino County, Grand Canyon National Park, Colorado River). The first new *Nebria* described from North America in more than two decades, this species is most closely related to *Nebria desolata* Kavanaugh and *Nebria navajo* Kavanaugh, based on characters of external and male and female genitalic form and structure, and on preliminary DNA-sequence comparisons. This species is named in honor of George Eugene Ball, who first recognized specimens of this taxon, sent to him for identification, as likely representing an undescribed species.

KEY WORDS: Arizona, Carabidae, Colorado River, Grand Canyon, *Nebria*, Nebriini

## INTRODUCTION

One morning in early January 2005, I received a telephone call from Professor George Ball. Such calls are always a most welcome pleasure, but this one was especially memorable. Its purpose was to ask me if I would be interested in looking at two *Nebria* Latreille (Coleoptera: Carabidae; Nebriini) specimens, a male and a female, which George had received from Sandra Brantley at the Museum of Southwestern Biology of the University of New Mexico in Albuquerque. These specimens were part of carabid beetle material that he had agreed to identify for Sandra in support of a sampling project, which aimed to inventory and characterize the riparian arthropod fauna associated with different flow stage habitats along the Colorado River in the Grand Canyon, Arizona. It has been a career-long practice for George to agree to provide this service to any worthy project or individual, and also typical for him to recognize something unusual or unexpected and to pass it along to a willing colleague with a potential special interest in his discovery. George said that he had been unable to identify the specimens using my unpublished key to Nearctic *Nebria* species and, given the fact that no species of that genus was known to occur in the Grand Canyon, he suspected that it might represent an undescribed species. Without hesitation, I agreed to look at the specimens.

One week later, as I opened the package received from Alberta, I was able to confirm George's suspicion with just a glance at the specimens. They presented a new, unique, and obvious combination of external features which were subsequently supported by more detailed examination of external features, and dissection and study of internal reproductive structures. In fact, the specimens represented the first new species of *Nebria* discovered in the Nearctic Region since those that I described more than 20 years ago (Kavanaugh 1984). Pogue (2004) described a new species of noctuid moth, *Schinia immaculata* Pogue, from material collected by this same inventory project in the Grand

Canyon; so this was a second new species for that project and a new addition to the known riparian fauna of the Canyon.

Since 2005, I have been waiting for an opportunity to visit the Grand Canyon to try to obtain additional, fresh, and properly preserved material on which to base my description of this new species, ascertain possible morphological variation within the species, and perform DNA-sequence analysis to help develop an hypothesis of phylogenetic relationship for this species based on both morphological and molecular evidence. Sampling in the Canyon requires all appropriate permits and rather complicated logistics, and, to date, no such opportunity had come. However, Dr. Wendy Moore (current Schlinger Postdoctoral Fellow at the California Academy of Sciences) has obtained a DNA sequence for me from a single leg of one of the two specimens; and I can think of no more appropriate opportunity or venue for presenting this new species than in this volume in honor of George's 80th birthday. Hence, the purpose of this paper is to describe this new species of *Nebria*, which is named in George's honor.

## MATERIALS AND METHODS

This report is based on study of the two specimens from the Grand Canyon, described here as representing a new species, and tens of thousands of additional specimens representing all previously described Nearctic *Nebria* species. Codons used for collections in which specimens have been deposited and for other institutions cited in the text include:

CAS – California Academy of Sciences, 55 Concourse  
Drive, San Francisco, California 94118  
GCMRC – Grand Canyon Monitoring and Research  
Center, 2255 North Gemini Drive, MS-9394,



Fig. 1.—Digital image of holotype, *Nebria georgei*, new species; habitus, dorsal aspect. Scale line = 1.0 mm.

Flagstaff, Arizona 86001  
MSBC – Museum of Southwestern Biology, MSC  
03 2020, University of New Mexico, Albuquerque,  
New Mexico 87131

Methods used in the present study, including dissection techniques and criteria for ranking taxa as distinct species, were as described in Kavanaugh (1979). The only measurement used is standardized body length (SBL), which equals the sum of the lengths of the head (measured from apex of clypeus to a point on midline at level of posterior margin of compound eye), pronotum (measured from apical margin to basal margin along midline), and elytra (measured along midline from apex of scutellum to apex of the longer elytron). Following dissection, preparations of female genitalic structures were stained with Chlorazol Black E<sup>®</sup> (Kodak Corporation) and digitally photographed using an Automontage imaging system by Syncrosopy with a Leica M420 dissecting microscope. Digital photographs of dorsal habitus, pronotum, and male genitalia were also taken with the Automontage system.

Several different calibration systems have been used for measuring locations along the Colorado River in Grand Canyon National Park. All river mileages used in this presentation conform to the river mileage system developed by the GCMRC.

#### DESCRIPTION

Order Coleoptera Linnaeus, 1758  
Family Carabidae Latreille, 1802  
Tribe Nebriini Laporte, 1834

#### *Nebria (Reductonebria) georgei* Kavanaugh, new species (Figs. 1-5)

**Types.**—HOLOTYPE, a male, deposited in MSBC, labeled: “USA AZ Coconino Co Grand Canyon Nat. Park, N36.102, W112.163 RM92.3L 06-07 May 2001 coll. Cobb, Brantley, Lightfoot”/ “shore zone pitfall trap”/ “COL CAR 001 006”/ “*Nebria* n. sp. ? det. G.E. Ball 2004”/ “UNM-29”/ “HOLOTYPE *Nebria georgei* Kavanaugh n. sp. des. by D.H. Kavanaugh 2007” [red label]. One paratype, a female, deposited in CAS, labeled: “USA AZ Coconino Co Grand Canyon Nat. Park, N36.187, W113.107 RM180.8R 01-02 Sept 2003 coll. Cobb, Brantley, Lightfoot”/ “shore zone pitfall trap”/ “COL CAR 001 006”/ “UNM-30”/ “PARATYPE *Nebria georgei* Kavanaugh n. sp. des. by D.H. Kavanaugh 2007” [yellow label].

**Type Locality.**—Colorado River, Grand Canyon National Park, Coconino County, Arizona.

**Etymology.**—It is my great pleasure to name this species in honor of George Eugene Ball, my mentor and friend, who was first to suspect that the specimens described here represented a new species. The species epithet is the Latinized form of his first given name in the genitive case.

**Diagnosis.**—Adults of this species can be distinguished from those of all other Nearctic *Nebria* species by the following combination of character states: body (Fig. 1)



Fig. 2.—Digital image of holotype, *Nebria georgei*, new species; pronotum, dorsal aspect. Scale line = 1.0 mm.

black to rufopiceous, vertex with pair of paramedial pale spots, legs black or rufopiceous; elytral microsculpture comprised of deeply impressed isodiametric meshes with slightly convex alveoli; pronotum (Fig. 2) with basal angles rectangular or very nearly so, basal sinuation of lateral margins distinct, moderately deep and short, lateral explanation narrow at middle, not or slightly broadened anteriorly, slightly broadened posteriorly, midlateral setae absent; elytral silhouette subovoid, distinctly narrowed basally, lateral margins straight sub-basally, humeral angles obtuse and markedly rounded, humeral carinae absent or only faintly suggested, not projected anteriorly; hind wings short and narrow; hind coxae bisetose or trisetose basally, middle tibiae dorsally sulcate in middle third and with distal brush of moderately dense dorsal setae present; abdominal sterna IV to VI (third to fifth visible sterna) each with two to four pairs of paramedial setae posteriorly; median lobe of male aedeagus with longitudinal groove lateroventrad to a slightly lobate ridge on right lateral face (Fig. 3b); bursa copulatrix of female genitalia (Fig. 4) with pair of digitiform dorsal accessory lobes.

Members of this species are most similar externally to those of *Nebria mannerheimii* Fischer von Waldheim and *Nebria darlingtoni* Kavanaugh, with which they share dark body and appendage color and similar pronotal form. They differ from *N. mannerheimii* adults in having elytral microsculpture with slightly convex, regularly isodiametric meshes (flat, irregularly isodiametric to slightly convex

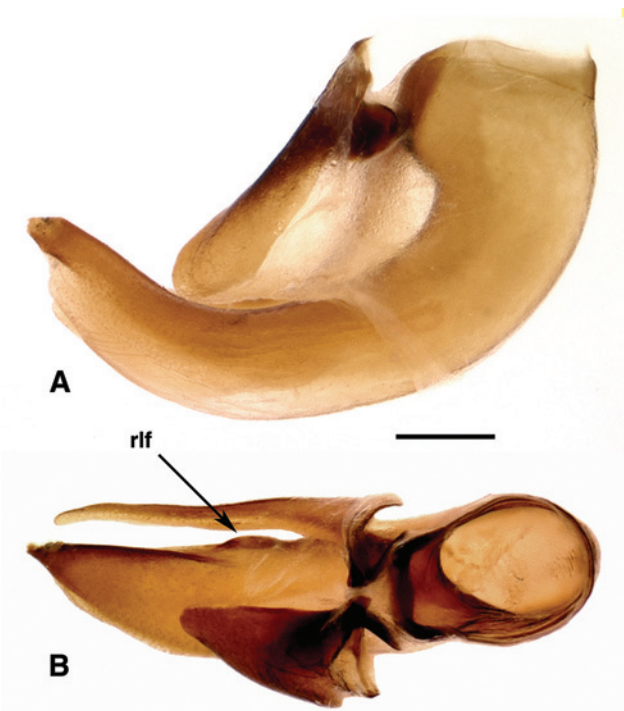


Fig. 3.—Digital image of holotype male, *Nebria georgei*, new species; median lobe and parameres of genitalia. **A**, left lateral aspect; **B**, ventral aspect. Abbreviation: **rif**, right lateral flange. Scale line = 1.0 mm.

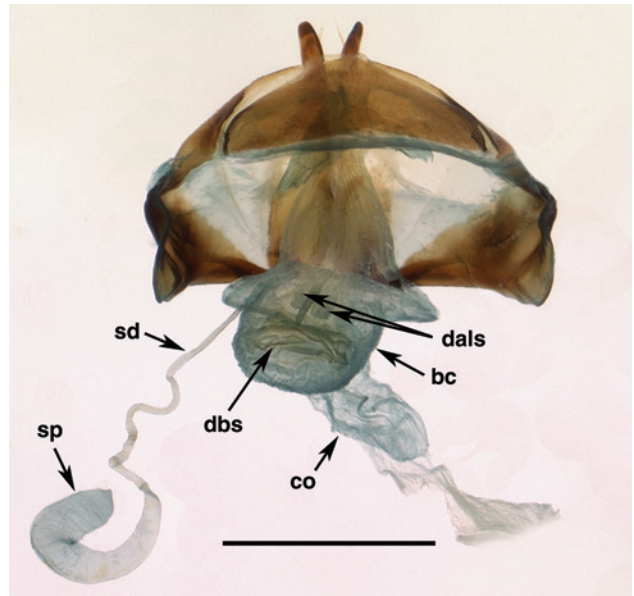


Fig. 4.—Digital image of paratype female, *Nebria georgei*, new species; reproductive system, dorsal aspect. Abbreviations: **bc**, bursa copulatrix; **co**, common oviduct; **dals**, dorsal accessory lobes; **dbs**, dorsal bursa sclerite; **sd**, spermathecal duct; **sp**, spermathecal reservoir. Scale line = 1.0 mm.

meshes in the latter) and from both *N. mannerheimii* and *N. darlingtoni* in having their elytral silhouette subovoid and distinctly narrowed basally (also subovoid, but not more narrowed basally than apically in the other two species). Internally, males differ from those of both of these species in having the longitudinal groove and associated flange present on the right ventrolateral surface of the median lobe (absent from males of the other two species). Females have paired dorsal accessory lobes on the bursa copulatrix (absent from females of the other two species). In addition, *N. mannerheimii* is a species of the northwest coastal region, from southern Alaska to central Oregon, and *N. darlingtoni* is restricted to the western slope of the central Sierra Nevada in California.

**Description.**—Body size medium for *Nebria*, SBL male = 9.7 mm, SBL female = 11.3 mm; head black to rufopiceous, with pair of paramedial pale spots present on vertex; pronotum, elytra, venter, femora and tibiae black to rufopiceous; tarsi brown or reddish-brown; dorsum and venter without metallic reflection; frons and vertex smooth, impunctate; microsculpture regularly isodiametric, faintly impressed on frons, moderately impressed on pronotum, deeply impressed on elytra, alveoli flat on head and pronotum, slightly convex on elytra.

**Head.**—Size and width relative to pronotum average for genus, slightly larger and wider in female than male; genae and occiput not inflated in male, slightly inflated in female. Eyes medium-sized, moderately convex. Antennae moderately elongate; scape medium-length, straight, oval or convex anteromedially and nearly flat posteromedially, with one anterodorsal seta subapically; pedicel with one ventral seta subapically; flagellar antennomeres moderately elongate, slender. Labrum with apical margin moderately bisinuate. Clypeus with apical margin truncate or slightly concave. Mentum with pair of M2 (setal nomenclature as in Kavanaugh 1979) setae long and slightly removed from basal margin. Submentum with three or four pairs of lateral setae, medial setae absent.

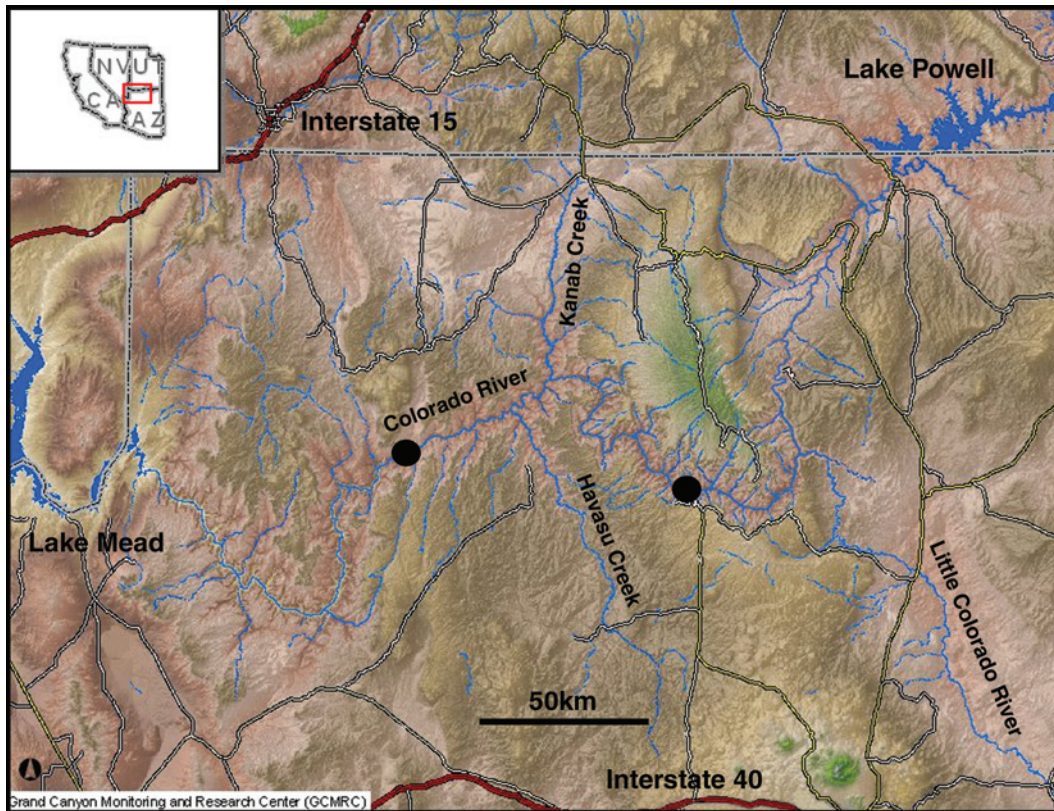


Fig. 5.—Map of known geographical distribution of *Nebria georgei*, new species (black dots = known localities). Base map used with permission of the Grand Canyon Monitoring and Research Center, U.S. Geological Survey.

*Pronotum*.—Size and width relative to elytra average for genus; shape (Fig. 2) moderately cordate and convex, basal margin slightly narrower than apical margin; lateral margins moderately arcuate, with basal sinuation moderately deep; lateral explanation present throughout pronotal length, narrow medially, not or slightly broadened apically and slightly broadened basally; basal margin slightly sinuate laterally; apical angles moderate in length, width slightly narrowed, apices moderately rounded; basal angles rectangular or very slightly obtuse, without or with very small tooth laterally; lateral margination present, narrow and shallowly impressed, vaguely impressed basally; anterior margination present in lateral thirds only, moderately impressed and moderately wide; anterior transverse impression narrow and moderately deep; basal foveae deep, slightly broad, slightly divergent basally; midlateral setae absent; basolateral setae present.

*Thoracic Venter*.—Prosternal intercoxal process moderately lanceolate, smooth, with margination complete except at apex. Mesosternum smooth, impunctate. Mesepisternum sparsely, faintly punctate. Metasternum faintly punctulate laterally and smooth medially, slightly shortened, margination of anterior intercoxal process complete, broad and moderately impressed medially. Metepisternum smooth.

*Elytra*.—Slightly longer in relation to length of forebody than average for genus, distinctly longer in female than male, relative width and convexity moderate; elytral silhouette subovoid, moderately narrowed basally, sides nearly straight sub-basally; basal marginations slightly shortened, moderately concave; humeri markedly rounded, humeral carinae absent or only faintly suggested, humeral teeth absent; subhumeral sinuations shallow; elytral apices moderately divergent from midline, apices narrowly oblique medially, angulate posteriorly; elytral striae moderately deep, faintly punctate; intervals slightly convex, smooth, without catenations; basal (parascutellar) setae present; interval 3 with five to seven slightly foveate setiferous pores, intervals 5 and 7 without

setiferous pores; umbilicate series comprised of 12 to 14 setiferous pores with anterior-most seta at humeral angle.

*Hind Wings*.—Short and narrow, stigma reduced.

*Legs*.—Hind coxae with two or three setae basally. Hind trochanters kidney-shaped, medium length, broadly rounded apically. Middle tibiae with dorsal sulcus present in middle third, with moderately dense setal brush dorsosubapically. Tarsi without pubescence dorsally; protarsi of males with basal three tarsomeres broadened and with pads of adhesive setae ventrally; hind tarsi with ventroapical margin of tarsomere 4 moderately lobed laterally.

*Abdomen*.—Sternum II (first visible sternum) faintly punctulate; sternum III without setae medially; sterna III-VI with two to four pairs of posterior paramedial setae, paralateral setae absent; sternum VII of male with one pair of posterior paramedial setae, female with two pairs.

*Male Genitalia*.—Median lobe of aedeagus (Fig. 3a) with mid-shaft slightly thickened, markedly narrowed apically, and with its axis bent about 90 degrees (in lateral aspect), moderately compressed (in cross-section); right face with a longitudinal groove ventral to a thin, slightly lobate flange (Fig. 3b); preapical shaft moderately broad and tapered apically, ventral margin slightly recurved dorsally (in lateral aspect), symmetrical, broad, moderately tapered apically (in dorsal aspect); apical orifice moderately deflected right; apical lamella connected slightly right of center on preapical shaft and slightly deflected right (in ventral aspect), plane of lamellar face (in apical aspect) slightly twisted left, apical shape unknown (apex slightly damaged in holotype). Left paramere broad, short, narrowed basally, right paramere slender, moderately long, right medial parametric sclerite absent.

*Female Genitalia*.—Hemisternites of sternum VIII with a few short to medium-length setae medially on apical margin; basal apodemes wide, deeply emarginate, with lateral lobes slightly shorter than median lobes. Ovipositor with gonocoxite I and gonocoxite II fused medially,

moderately broadly separate laterally; gonocoxite I not or only faintly sclerotized ventrally apicomediaally to basolaterally, fully sclerotized medially, with a diagonal (basolateral to apicomediaal) row of three or four setiform setae ventrally; gonocoxite II of medium length and width, bluntly rounded apically and moderately bent ventrolaterally (in lateral aspect), with two slightly long, setiform mediodorsal setae in a longitudinal row; both gonocoxites with moderately dense vestiture of setae on medial surface. Bursa copulatrix (Fig. 4) with longitudinal axis moderately sigmoid (in lateral aspect); spermathecal chamber medium length, slightly and broadly ovoid and symmetrical (in dorsal aspect), with paired, digitiform dorsal accessory lobes lateral to spermathecal duct insertion point and with a broad, wrinkled, lightly sclerotized plate on anterodorsal surface; spermathecal reservoir arcuate, simple, medium-length; spermathecal duct slightly elongate, narrow, loosely and irregularly convoluted, inserted at posterior end of spermathecal chamber at base of vertical (posterior) face of chamber in midline.

**Sexual Dimorphism.**—The male specimen is slightly smaller than the female, with relatively narrower head, shorter elytra, and slightly longer antennae and legs. The basal three tarsomeres of the male protarsi are broad and have dense pads of adhesive setae ventrally. These tarsomeres are slender and without such setal pads in the female. Sternum VII in the male has a single pair of posterior paramedial setae, whereas there are two such pairs of setae in the female.

**Geographical Distribution.**—At present, this species is known only from the Grand Canyon of the Colorado River in Coconino County, Arizona. (Fig. 4). The two specimens studied to date are from localities in the canyon located about 88 river miles (141 kilometers) apart (GCRMS river miles 92.6 and 181.3), so the species is likely distributed along the river between these two points, and perhaps also some unknown distances upstream and downstream from this section of the river.

**Habitat Distribution.**—Both of the specimens examined were collected in pitfall traps placed along the main river. The upstream locality (GCRMS mile 92.6) was a thin rocky strip of shore with many 0.5 to 2.0 meter diameter boulders and some sandy areas between them, with the pitfall traps placed about 1 meter above the high water line. Placement of traps at the downstream locality (GCRMS mile 181.3) was in an area mainly with fine sediments (M. Kearsley, personal communication).

**Phylogenetic Relationships.**—Based on characters of external morphology and form and structure of both male and female genitalia, *N. georgei* is most closely related to *Nebria desolata* Kavanaugh and *Nebria navajo* Kavanaugh. Males of this species share uniquely with those of the latter two species an aedeagal median lobe with a longitudinal groove ventral to a thin flange on the right face of the shaft; and females of these three species uniquely share paired dorsal accessory lobes on the spermathecal chamber of the bursa copulatrix. Preliminary results from analysis of DNA sequence data for two independent genes, COI (cytochrome oxidase I, a mitochondrial protein-coding gene) and 28S (a nuclear, ribosomal gene), also support a close relationship among these three species.

**Geographical Relations with Most Closely Related Species.**—The known geographical range of *N. georgei* is allopatric with respect to those of *N. desolata* and *N. navajo*. The known range of *N. desolata* is confined to southern Utah, on the Escalante River system, at elevations from 1710 to 2130 meters, and on the East Fork of the Virgin River, at elevations from 1660 to 1730 meters. The closest known localities for *N. desolata* and *N. georgei* are separated by 127 kilometers linear distance and about 1100 meters of elevation. The known range of *N. navajo* is confined to the tributary canyons of Tsegi Canyon in north-eastern Arizona, at elevations from 1930 to 2150 meters. These canyons constitute the main watershed for Laguna Creek, which drains into Chinle Creek and, downstream, into the San Juan River. The closest known localities for *N. navajo* and *N. georgei* are separated by 162 kilometers linear distance and about 1200 meters of elevation.

Although all the known localities for both *N. desolata* and *N. navajo* are along river systems which drain ultimately into the Colorado River, none of these rivers joins the Colorado between Lake Powell and Lake Mead. These ranges are probably just an artifact of collecting; and streams such as Kanab Creek to the north and the Little Colorado River to the south should be sampled for these or other related species.

#### ACKNOWLEDGMENTS

First and foremost, I thank George Ball for recognizing the specimens described here as likely representing an undescribed species and for forwarding these specimens to me for study. I thank Sandra Brantley (MSBC) and Mike Kearsley (Northern Arizona University, Flagstaff (NAU)) for permitting me to describe this new species and for providing information about the collecting sites. Sandra, Neil Cobb (NAU), and Carl Olson (University of Arizona, Tucson) searched through other material in their care from the Grand Canyon survey project for possible additional *Nebria* specimens without success, but I much appreciate their efforts in this regard. I am also indebted to Larry Stevens (Museum of Northern Arizona, Flagstaff) for helpful discussions of regional biogeography and endemism. I thank Wendy Moore (CAS) for obtaining and providing preliminary DNA-sequence data for this new species. The map of the Grand Canyon region on which localities for *N. georgei* were plotted (Fig. 5) was used with permission of the Grand Canyon Monitoring and Research Center of the U.S. Geological Survey, courtesy of Thomas Gushue, Geographer.

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