

A NEW SPECIES OF CAVE ADAPTED NICOLETIID (ZYGENTOMA: INSECTA) FROM SISTEMA HUAUTLA, OAXACA, MEXICO: THE TENTH DEEPEST CAVE IN THE WORLD

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Abstract: *Anelpistina specusprofundi*, n. sp., is described and separated from other species of the subfamily Cubacubaninae (Nicoletiidae: Zygentoma: Insecta). The specimens were collected in Sótano de San Agustín and in Nita Ka (Huautla system) in Oaxaca, México. This cave system is currently the tenth deepest in the world. It is likely that *A. specusprofundi* is the sister species of *A. asymmetrica* from nearby caves in Sierra Negra, Puebla. The new species of nicoletiid described here may be the key link that allows for a deep underground food chain with specialized, troglobitic, and comparatively large predators such as the tarantula spider *Schizopelma grieta* and the 70 mm long scorpion *Alacran tartarus* that inhabit the bottom of Huautla system.

INTRODUCTION

Among international cavers and speleologists, caves that surpass a depth of minus 1,000 m are considered as imposing as mountaineers deem mountains that surpass a height of 8,000 m in the Himalayas. Among deep caves, those in the Huautla Plateau, Oaxaca, México, are among the most profound in the world. Exploration of their vast underground passages has taken more than 40 years. To explore their depths, a revolution in cave techniques such as the use of multiple underground camps and the use of computer controlled rebreathers was required. It also took its human toll. In 1980 a Polish team suffered two serious accidents below 600 m and an international effort was successful in rescuing them, but Josef Cuber was paralyzed with a fractured spinal column. Then in 1994, Ian Rolland died while diving a sump at minus 1,325 m (Stone et al., 2002).

Cavers are relentless in their pursuit to break depth records in caves. Year after year they discover new and deeper caves, thus the list of the deepest caves is always changing. Throughout the history of cave exploration, the Huautla caves have always been in the forefront. Starting in 1967, cavers exploring the Sótano de San Agustín ran out of rope at a depth of 449 meters, establishing it as the second deepest cave in North America. Then in 1969 cavers reached a sump in San Agustín at a depth of 612 m, making San Agustín the deepest cave in the Americas. By 1977, exploration had reached a depth of 800 m. In 1980, Bill Stone made the celebrated sump dive that connected Li Nita cave to Sótano de San Agustín, giving the combined system a depth of 1,220 m and making it the world's third deepest cave. Ten years later, another sump dive joined Nita Nanta cave to the system, bringing its depth to 1,353 m and briefly making the Huautla system the world's second deepest cave. In 1989 Nita Ka was explored to

760 m, but no human sized passage was found that joined it into the system. The last relevant exploration was in 1994, when an international team of 44 cavers and divers pushed its depth to 1,475 m. For a full description of the caves of the Huautla Plateau, see the bulletins from these periods of exploration in the National Speleological Society (NSS), the Association for Mexican Cave Studies (AMCS), and the book by Stone et al. (2002). With its current 1,475 m depth and as of June, 2007, the NSS compilation of the world's deepest caves, the Huautla system is the second deepest cave in México (just 9 m below Sistema Cheve/Cuicateco), and the tenth deepest cave in the world (www.caverbob.com/wdeep.htm as of 2007).

From a biological perspective, deep caves are a particularly harsh environment where few organisms can survive. The few species adapted to this extreme environment have to endure continuous darkness, but more significantly, a lack of food (Hüppop, 2005). Since most energy sources ultimately come from the sun and photosynthesis, the further away from the surface, the more diluted the energy supplies become. A large proportion of cave adapted species (troglobites) actually live comparatively close to cave entrances where they depend for their sustenance on bat droppings as guanobites (Gnaspini, 2005) or on surface debris that is washed in or percolates from a nearby surface source (Trajano and Bichuette, 2006).

In a pyramid of productivity, each higher level of producers, primary consumers, secondary consumers, tertiary consumers, etc., has a multiplicative loss of energy in the food chain that severely limits the overall biomass of top level carnivores that any ecosystem can support (Campbell and Reece, 2002). In extreme environments where the net primary productivity of autotrophs is low, or in places where primary consumers have restricted access to nutrients, such as in caves, food chains tend to be simple,

productivity pyramids typically have few tiers, and specialized large predators are typically absent.

The Huautla system is inhabited by ten troglobites (Stelle and Smith, 2005) but two of them are particularly remarkable; the scorpion *Alacran tartarus* Francke and the tarantula spider *Spelopelma grieta* Gertsch. In his description of the new scorpion, Francke (1982) comments, "The surprising fact is the depth at which these scorpions exist: about 750 to 820 m below the cave entrance! This is one order of magnitude deeper than the previous depth record for troglobitic scorpions, *Typhlochactas ellioti* Mitchell from Sótano de Yerbaniz (minus 75 m) ... Equally remarkable, and unexpected, is the rather large size these deep dwelling scorpions attain: 60–70 mm in total length. *Typhlochactas* spp. are less than 20 mm long." The troglobitic tarantula is also found deep in the caves (Stelle and Smith, 2005). That such specialized and relatively large predators can survive at such depth is startling. To explain their presence, there must also be a suitable source of large prey. The new species of nicoletiid described here may be the key that permits the rather complex food chain to exist at such depth in the Huautla system. It is hoped that this study will contribute to a better understanding of trophic levels and food webs of extremophiles in harsh environments, such as troglobites in deep caves.

MATERIAL AND METHODS

Samples examined are from the Texas Memorial Museum of Invertebrate Zoology collection. They were left in vials with ethanol. All illustrations were made with the aid of a camera lucida attached to a compound microscope.

RESULTS AND DISCUSSION

MATERIAL

Sótano de San Agustín, Huautla Cave System, San Agustín (5 km SE Huautla de Jiménez), Oaxaca, México. 96.773206 longitude, 18.079458 latitude.

Holotype male, body 17 mm long, antennae 42 mm, caudal appendages 30 mm, hind tarsus 3.1 mm. 01/28/88 Tex. Mem. Mus. Invertebrate Zool. Coll # 23,595. Allan Cobb col.

Paratypes: 2 females; 10 and 19 mm long. May 1985. Tex. Mem. Mus. Invertebrate Zool. Coll # 23,597. A. G. Grubbs, L. Wilk, J. H. Smith, F. Holladay, and J. Blaksley cols. 3♂ and 2♀; 7, 9.2, 16 mm long and 15, 18 mm long. 1988. Tex. Mem. Mus. Invertebrate Zool. Coll # 23,596. A. G. Grubbs col.

Other localities: Nita Ka cave, Huautla. 1 male; 12 mm long. 1988. Tex. Mem. Mus. Invertebrate Zool. Coll # 23,600. A. G. Grubbs col.

DESCRIPTION

Overall morphology long, slender, and with long appendages (Fig. 1A). Maximum body length 19 mm.

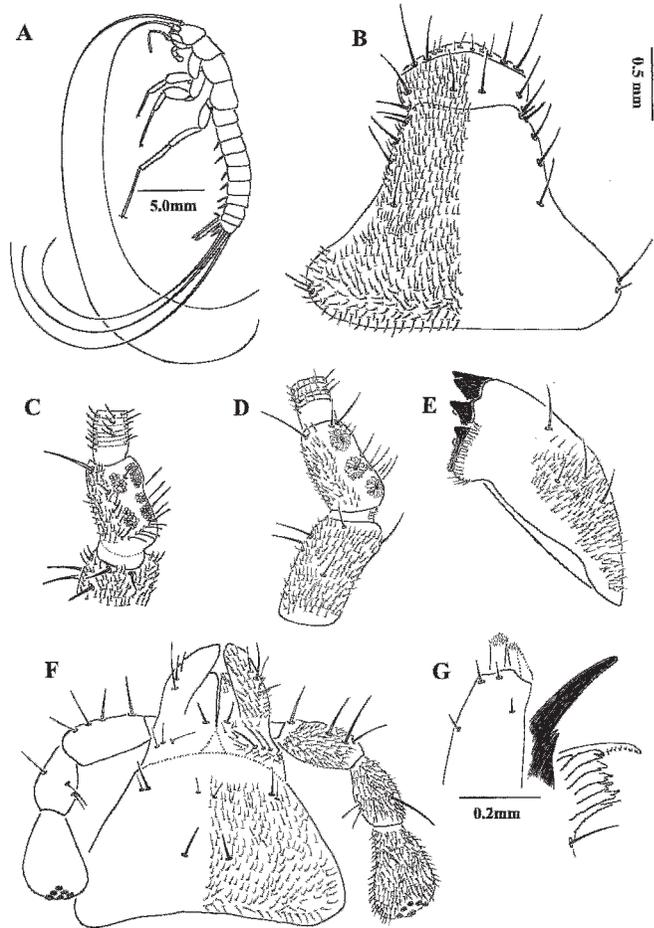


Figure 1. *Anelpistina specusprofundi* n. sp., Microchaetae partially shown. A, Adult female. B, Dorsal side of head. Antennal insertion sockets, although not illustrated, are positioned before the clypeus, under the edges of both sides of the head with five macrochaetae. C, Ventral face of antennae in adult males. D, Outside lateral face of antennae in adult males. E, Mandible. F, Labial palp and labium. G, Galea (with two different conules) and lacinia. Scale on upper right corner for all illustrations, except where indicated.

Maximum conserved length of antennae 42 mm. Maximum conserved length of caudal appendages 36 mm. General color light yellow to white. Body very abundantly covered with small microchaetae (Figs. 1B, 2E and 3A–C). Head with approximately 5 + 5 macrochaetae on border of insertion of antenna (Fig. 1B). Pedicellus in adult males slightly smaller than scapus and with unicellular glands on ventral surface, clustered approximately in five groups and with a row of microchaetae bordering them in form of a "U" (Fig. 1C). On outside lateral border an extra three clusters (Fig. 1D). Female basal articles of antenna simple and pedicellus about half the length of scapus.

Mandible chaetotaxy as in Figure 1E, with four distinct macrochaetae. Mouthparts long and slender (Figs. 1F and 2A). Labial palp as in Figure 1F. Apical article subtrian-

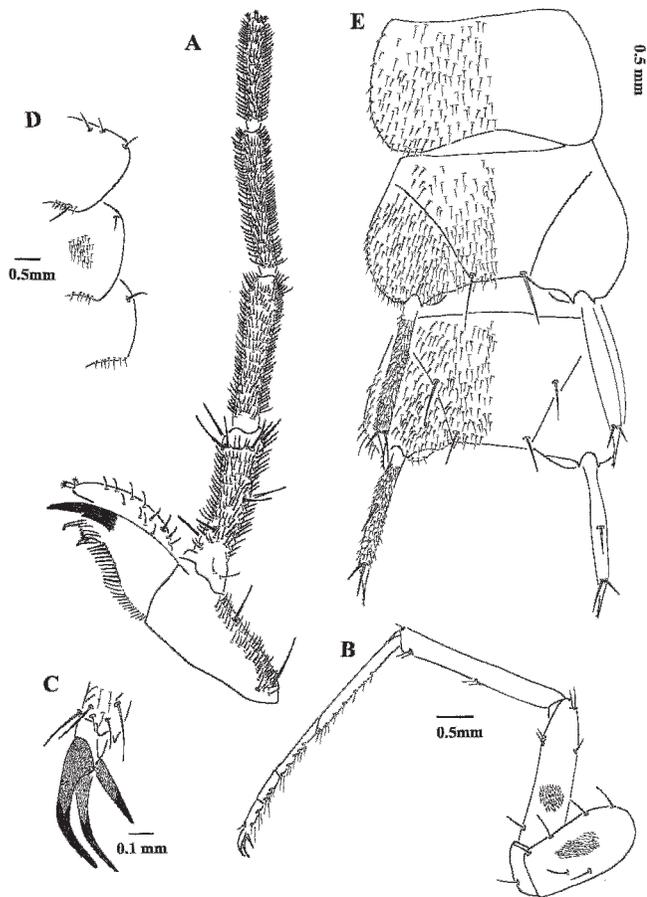


Figure 2. *Anelpistina specusprofundi* n. sp., Microchaetae partially shown. A, Maxilla. B, Hind leg. C, Endopodium and lateral claws. D, Thoracic terga. E, Urosterna I–III. Scale on upper right corner for all illustrations, except where indicated.

gular and distinctly longer than at its largest width at its tip. The article is also distinctly longer than penultimate article. Penultimate article with a barely conspicuous bulge containing two macrochaetae. Labium and first article of labial palp with macrochaetae. Maxilla as in Figures 1G and 2A. Apex of galea with two conules, one longer than wide and the other wider than long (Fig. 1G). Caution should be used when assessing this character, because at most angles of observation, both conules appear longer than wide (Fig. 2A). Ultimate article of maxillary palp approximately 3/4 length of penultimate article and approximately six times longer than wide (Fig. 2A).

Legs long and slender (Figs. 1A and 2B). Hind tibia approximately eight times longer than wide and approximately 2/3 length of tarsus. Claws with a hairy appearance (similar to other *Anelpistina* (Espinasa et al., 2007)) and very long (Fig. 2C). Mesonotum with a single distinct macrochaetae on lateral borders and on posterolateral borders several setae of varied sizes, although none distinctly more robust than the other (Fig. 2D). Abdom-

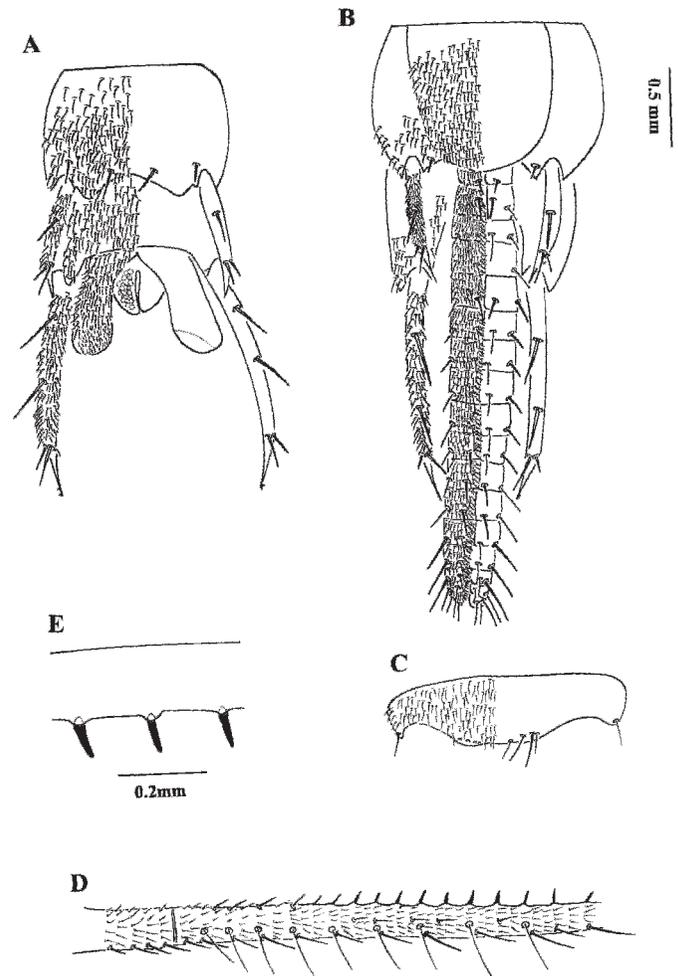


Figure 3. *Anelpistina specusprofundi* n. sp., Microchaetae partially shown. A, Urosterna VIII–IX, parameres and penis in adult male. B, Urosterna VIII–IX, subgenital plate and ovipositor in adult female. C, Urotergum X. D, Male cercus. E, Spines in cercus. Scale on upper right corner for all illustrations, except where indicated.

inal urosterna II–VII subdivided into coxites and sternites (Fig. 2E) and sterna VIII and IX of male entire (Fig. 3A), as in other members of subfamily. No apparent modifications in urosternum III and IV of adult male. Urosternum VIII of adult male emarginated and its projections are rounded to slightly acute (Fig. 3A). Stylets IX slightly larger than others, with two macrochaetae and an extra subapical pair. Other stylets with one macrochaeta plus the subapical pair (Fig. 3A–B). Terminal spine with small teeth. Stylets IX without modifications in males and females.

Penis and parameres of adult males as in Figure 3A. Parameres attaining about 1/3 the length of stylets IX. Point of insertion of parameres in urosternum IX shallow, slightly below level of styli in this segment. Coxal processes and middle posterior portion of urosternum IX without any distinct setae (Fig. 3A). Adult female genital area as in

Figure 3B. Subgenital plate square-like in appearance, flat-rounded distally (Fig. 3B). Ovipositor in adult female surpassing stylets IX by 1/2 of stylets length and gonapophyses with about 18 annuli.

Urotergite X shallowly emarginate in both sexes, posterior angles with several macrochaetae and a few relatively strong setae. Length of inner macrochaetae almost 1/2 distance between them (Fig. 3C). Cercus of adult male typically with a longer than wide basal annulus followed by a very long annulus with spines (Fig. 3D). The spines' composition is homogeneous, with no spine being distinctly longer or inserted in distinctly larger tubercles (Fig. 3E). Female cercus simple.

Postembryonic development of males: specimens of 12, 16, and 17 mm body length share similar morphology, with the exception of a Nita Ka specimen (12 mm), in which the penis is proportionally bigger, reaching almost the apex of the parameres. It is unknown if this difference reflects individual or population differences or if all medium sized males have this size ratio. Smaller male specimens (7 and 9.2 mm) with smaller pedicellus, about half the length of scapus, but still with gland clusters, and cerci without spines.

Postembryonic development of females: specimens of 15 and 18 mm body length have ovipositors surpassing stylets IX by about 1/2 of the stylets length and gonapophyses with about 18 annuli. In a female 10 mm body length, ovipositor just beginning to develop and barely reaching base of stylets IX. Gonapophyses without distinct annuli.

DISTRIBUTION

Specimens of this species have been collected from Sótano de San Agustín, Nita Ka, and Li Nita, which are part of the Sistema Huautla cave system. Only the specimens from Sótano de San Agustín and Nita Ka were available for examination during this study. It is likely that *A. specusprofundi* is endemic to caves within the karstic area of Huautla, Oaxaca, México.

ETYMOLOGY

From specus=cave and profundi=deep, in genitive singular. It makes reference to its habitat within one of the deepest caves in the world.

REMARKS

The new species described here is a member of the subfamily Cubacubanae, which has a neotropic distribution. It has stylets on urosternite II, but lacks scales, sensory pegs in the appendix dorsalis, and conspicuous lateral lobes bearing numerous glandular pores. As such, its generic allocation is within *Anelpistina* Silvestri, 1905 as defined by Espinasa et al. (2007).

The genus *Anelpistina* has 23 species described. Within these members of the genus, *A. specusprofundi* n. sp. shares only with *A. asymmetrica* (= *Cubacubana asymmetrica* (Espinasa, 2000)), *A. parkerae* (= *Cubacubana parkerae*

(Espinasa and Rishmawi, 2005)), and *A. yatbalami* Espinasa et al. 2007 a unique combination of characters that separates them from all other described *Anelpistina* species: a) Head with about five macrochaetae by insertion of antennae (Fig. 1B); b) Mandible with four macrochaetae (Fig. 1E), and c) Galea with conules of different size (Fig. 1G). All other species of *Anelpistina* lack this unique set of characters.

Anelpistina yatbalami was collected from under rocks in the Maya ruins of Yaxchilan, Chiapas. Since it is a surface species, it can easily be differentiated from *A. specusprofundi* because it lacks the adaptive modifications of a troglobite, such as a long, slender body and appendages. Furthermore, the point of insertion of parameres in urosternum IX is deep in the epigeal species and the body is covered by few microchaetae, while in the new hypogean species insertion of parameres is shallow and the microchaetae covering their body are much more abundant. Although only immature females were available when *A. yatbalami* was described, it also appears that its gonapophysis may be subdivided into more annuli (about 20–25) in *A. yatbalami* than in the new species (about 18).

Anelpistina parkerae was described from El Sótano Hondo del Pinalito, in Hidalgo. Also being a troglobite, it shares with *A. specusprofundi* the long and slender proportions of its body and appendages. Males can be differentiated because in the former species the pedicellus is distally much enlarged, creating a lobe, and its cerci have heterogeneous spines inserted in tubercles of different length. In the new species the pedicellus, although modified, is not enlarged to the extent of creating a lobe (their maximum width is less than double of the following articles of the antennae) and the cerci spines are homogeneous. Females from Pinalito appear to have a gonapophysis subdivided into less annuli (about 10–11) than in the new species. Finally, the body in specimens of the new species is also covered by more microchaetae.

Anelpistina specusprofundi is more difficult to differentiate from *A. asymmetrica*. *A. asymmetrica* has been described from three caves: TP4 13, Xaltégoxtl, in Puebla, and Cueva de Gabriel, in Oaxaca (Espinasa et al., 2007). They both share a labial palp with a subtriangular apical article, homogeneous spines in the cerci, and an ovipositor of similar length and subdivision (17–18 annuli). Females of both species are mostly undistinguishable based on sexual secondary characters as the increase in length of the ovipositor with respect to stylets IX follows a similar rate. Males are more easily differentiated based on sexual secondary characters because similarly sized adult males of the new species lack the curved cerci and the asymmetric pedicellus of adult *A. asymmetrica* males. Furthermore, in *A. asymmetrica* the penis is much enlarged and almost reaches the apex of the parameres, while in the new species (except in the Nita Ka specimen) the penis is of normal dimensions when compared with other *Anelpistina* and reaches only about 1/2 the length of the parameres.

The clearest character that allows the differentiation between both species, independent of the postembryonic development of sexual secondary characters, is that although both have long and slender bodies and appendages, as expected from troglobitic species, *A. asymmetrica* appears to be proportionally longer and more slender than *A. specusprofundi*. For example, in *A. asymmetrica* the ultimate article of the maxillary palp is approximately 14 times longer than wide, while in *A. specusprofundi* the ultimate article of maxillary palp is approximately six times longer than wide.

It is likely that *A. specusprofundi* belongs within the South Mexico and Antilles phyletic species group presented in the cladogram obtained from a phylogeny study of the Cubacubaninae using five molecular loci (Espinasa et al., 2007). Both *A. yatbalami* and *A. asymmetrica* belong to this phyletic group. Furthermore, it is even likely that *A. specusprofundi* and *A. asymmetrica* are sister species because of their morphological similarity and because they inhabit caves that are only about 30 km away in the mountain range that divides the states of Puebla and Oaxaca.

DISCUSSION

The rather long (≈ 90 mm including antennae and caudal appendages) new species of nicoletioid described here is a good candidate to explain the presence of a specialized and relatively large (≈ 70 mm) deep dwelling predator such as the troglobitic scorpion found at depths of 750 to 820 m below the cave entrance in the Huautla system. For such a large predator to survive, there must also be a suitable source of large prey. This prey should have a very efficient secondary productivity (rate at which consumers convert the chemical energy of the food they eat into their own new biomass within an ecosystem). As mentioned before, because most energy sources ultimately come from the sun and photosynthesis, the further from the surface, the more diluted the energy supplies become, and only an organism with very efficient secondary productivity could provide the overall biomass to support top level carnivores.

Andy Grubbs, one of the collectors of both the scorpions and the nicoletioids from Li Nita and San Agustín caves, has corroborated that both species are “definitely down in the same areas” near where both caves have an underground connection (A. Grubbs, pers. comm.). He also mentioned that the nicoletioids were found in the wet areas with mud banks. Mud banks are a common habitat of nicoletioids (Reddell, 1981) where specimens eat the soil and extract from its minimal supplies of organic compounds enough energy to survive, grow and reproduce.

Furthermore, Nicoletioids as a group are common inhabitants of the cave environment. They are broad generalists in their feeding habits and a recent bioinventory of entranceless voids on a highway project in Williamson

County, Texas, found that the most common troglobitic fauna in caves with no natural entrances are nicoletioids, suggesting that they can subsist in low energy habitats (P. Sprouse, pers. comm.). It is likely that nicoletioids are one of the few taxa of troglobites that can efficiently convert enough chemical energy from the minimal supplies found in deep caves to produce enough secondary productivity to sustain a food chain that includes a specialized and relatively large predator. The new species of nicoletioid described here is most likely the key link that allows for the rather complex food chain present at such depth in the Huautla system.

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