



Two new species of whip spider (Amblypygi): an epigean and a cave dwelling *Charinus* Simon, 1892 from Belize

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Abstract

Central America is rich in whip spider species, mainly of the genera *Phrynus* and *Paraphrynus* (Phrynidae), but also includes few registers of *Charinus* (Charinidae) with no description of taxa. In this paper two new species of *Charinus* from Belize are described and illustrated (*Charinus belizensis* **sp. nov.** and *Charinus reddelli* **sp. nov.**) being the first species named from Central America. New records of *Charinus victori* Armas, 2010 from Puerto Rico, a comparative table listing the differential characters of the Caribbean and Central American species, and a distributional map of those species are also provided.

Key words: Central America, taxonomy, whip spider, troglobious

Introduction

The Caribbean region (*sensu* Morrone, 2006) is the most diverse area for the whip spiders. Most of the region species richness consists of the genera *Paraphrynus* Moreno, 1940 and *Phrynus* Lamarck, 1801 (family Phrynidae), which contain 43 species (14 and 29 each, respectively). The genus *Charinus* Simon, 1892 (family Charinidae) contains 12 species in the Great and Lesser Antilles, half of which are distributed in the Cuban archipelago (Armas, 2014). Despite of the low diversity compared to the Caribbean Phrynidae, the Antilles is one of the most diverse regions for *Charinus* in the world. Central America, on the other hand, is one of the least known areas. Until now, only two registers of the genus were published, both of undescribed species of *Charinus*, one from Belize (Reddell, 1982) and another from Panama (Viquez *et al.*, 2012). The absence of *Charinus* in Central America is probably due to the specimens' small size, which makes it hard for collectors to find them and frequently confuses researchers with juveniles of the large *Paraphrynus* and *Phrynus* (Viquez *et al.*, 2012).

Reddell (1982) reported a "troglobite of uncertain generic affinities" from the Footprint Cave, Caves Branch, Cayo district, Belize, but did not describe it because only small juveniles were collected. The third author (GW) visited that cave as well as other locations in Belize, collecting adults of the troglobite species from the Footprint cave and the Waterfall cave. After 33 years of its first record, the species from those caves is finally described. Moreover, *Charinus* specimens that were found outside the caves (living inside decomposing tree logs) proved to be members of a different species, and are described as well.

Material and methods

The specimens were collected with permits issued by the Forest Department, Ministry of Forestry, Fisheries and Sustainable Development in Belize (Permit Number 14/2000). They were found through visual searching along the

walls of the caves using a powerful LED headlamp, or by inspecting rotten tree logs in the forest. Specimens were captured by hand and placed in vials containing 70% ethanol, and were later deposited in the Israel National Arachnid Collection of The Hebrew University of Jerusalem and the National Museum of Rio de Janeiro. Some of the specimens were kept alive and taken to the laboratory for natural history and behavioral observations. Live specimens were kept in 10x5x5cm acrylic containers (AMAC plastics Ltd., California, USA) with moist peat substrate and a Styrofoam board placed diagonally as a resting spot. They were kept at 24°–26°C in a dark room, and were fed with live silverfish and ant pupae.

For nomenclature and measurements, we generally followed the proposals of Quintero (1981). The names of the gonopod structures of males followed Giupponi and Kury (2013). The article called tarsus by Quintero (1981) is divided here into the distitarsus and claw, as there is no fusion of these two segments in Charinidae. The spines of the pedipalpal tibia and teeth of the chelicerae are counted from the apex to the base. Measurements of the articles of the pedipalp were taken between the condyles of each segment in order to establish fixed points and adequate length measurements. We took measurements of the entire type series (quantity indicated as “n”), presenting first their mean values, followed by the range of variation in parentheses. Total body length is usually used as diagnostic of *Charinus* species, but was not included here due to the contractile nature of the abdomen; this information was added only for hatching juveniles in the Natural history section. Instead, the carapace width, pedipalp femur length, and femur I length are provided as diagnostic of each species described.

Photographs were made using a BK plus Imaging System from Visionary Digital (Palmyra, PA, USA; <http://www.visionarydigital.com/>) equipped with a Canon 7D digital camera at the Zoological Museum, Copenhagen (ZMUC). Stacks of images from multiple focal planes were combined using Zerene Stacker (Zerene Systems LLC, <http://zerenesystems.com/cms/stacker>) and processed in Photoshop CS6 (Adobe, San Jose, CA, USA) to adjust color, brightness, and contrast. The plates were mounted in Corel Draw X5 (Corel, Mountain View, CA). One female specimen of each population was examined using scanning electron microscopy (SEM). SEM images were collected with FEI Inspect at the Geological Museum, Copenhagen, Denmark. Images of both species and, for *C. reddelli* **sp. nov.**, both known populations (Footprint and Watterfall caves) are provided to show variation and characterize the species.

The summarized characters shown in Table 1 were gathered through examination of the specimens here described as well as the specimens listed in the additional material and data in the literature (listed in the legend of Table 1, and González-Sponga, 1998).

The distribution map was produced and edited using ArcGis 10.2 (ESRI, CA). The coordinates were obtained from the labels of the specimens analyzed, from the descriptions of the known species, and with Google Earth when a precise location was available in the literature. The following references provided distributional information on the Caribbean *Charinus*: Armas (2004, 2006, 2010, 2014), Armas and Ávila Calvo (2000), Armas and Pérez González (1997), Armas and Teruel (1997), Pérez and Teruel (2004), Quintero (1983, 1986), Teruel (2011), Teruel and Questel (2011), Teruel *et al.* (2009), and Viquez *et al.* (2012).

Additional material examined. *Charinus acosta* (Quintero, 1983): G.S.Miranda 2015 det., Cuba, Alejandro de Humboldt National Park, area around the station Bahía de Taco, 20°31'4,14"N 74°39'32,14"W, CarBio team *leg.*, iii–v.2012 (1 female, USNM ENT 00783165); G.S.Miranda 2015 det., Cuba, Alejandro de Humboldt National Park, area around the station Bahía de Taco, 20°31'4,14"N 74°39'32,14"W, CarBio team *leg.*, iii–iv.2012 (1 juvenile, USNM ENT 00783162); G.S.Miranda 2015 det., Cuba, Camagüey, Sierra de Cubitas, Limones,-Tuabaquey Ecological Reserve, Boca de Miel, 21°34'56,69"N 77°45'0,47"W, CarBio team *leg.*,iii–iv.2012 (1 female, USNM ENT 00784407); G.S.Miranda 2015 det., Cuba, Guantánamo, Alejandro de Humboldt National Park, near Yunque de Baracoa, 20°21'8,11"N 74°34'28,76"W, CarBio team *leg.*, iii–iv.2012 (1 juvenile, USNM ENT 00784829).

Charinus victori Armas 2010: G.S.Miranda 2014 det., Puerto Rico, Peñuelas, Cueva Mapancho (1 female); G.S.Miranda 2014 det., Puerto Rico, Bosque Nacional El Verde, El Yunque Natinal Forest, 10.ii.2012 (1 male, USNM ENT 00782819); G.S.Miranda 2014 det., Puerto Rico (1 juvenile, CarBio 0002541A); G.S.Miranda 2014 det., Puerto Rico (1 juvenile, CarBio 00002540A); G.S.Miranda 2014 det., Puerto Rico (1 juvenile, CarBio 00002401A); G.S.Miranda 2014 det., Puerto Rico, 10.ii.2012, PRC057 (1 female, B10AB); G.S.Miranda 2014 det., Puerto Rico, Aguas Buenas, 10.ii.2012, PRC060 (1 female, 013CAB); G.S.Miranda 2014 det., Puerto Rico, Aguas Buenas, 10.ii.2012, PRC059 (1 female, 012CAB); G.S.Miranda 2014 det., Puerto Rico, Rio Grande, El Yunque, El Verde, N18.321688, W65.819908, Alt. 110m, Agnarsson *et al.*, Team1, 16–18.ii.2011, CR-LIT/BUR (1 female,

USNM ENT 00392752); G.S.Miranda 2014 det., Puerto Rico, Guajonales Matuyas, Alto Maunabo, 23.vii.2012 (1 female, USNM ENT 00785110); G.S.Miranda 2014 det., Puerto Rico, Guajonales Matuyas, Alto Maunabo, 23.vii.2012 (1 male, USNM ENT 00782527).

Acronyms used: **CarBio**: Caribbean Biogeography Project (Vermont, USA); **HUJINVAMB**: The Hebrew University of Jerusalem Zoological Museum (Jerusalem, Israel); **MNRJ**: Museu Nacional (Rio de Janeiro, Brasil); **USNM ENT**: US National Museum of Natural History (Washington, USA).

Taxonomy

Family Charinidae Quintero, 1986

Genus *Charinus* Simon, 1892

Charinus belizensis sp. nov.

Figs. 1A, D; 2A, B; 3A, C; 4A, C; 5A, B, G; 6A, D, G; 7A; 8.

Diagnosis. median eyes and tubercle absent, small size (carapace mean width: 2.62; pedipalp femur mean length: 1.99; femur I mean length: 4.14), tibia I with 23 articles, tarsus I with 41 articles, proximal article of tarsus I three to four times longer than the second, cheliceral claw with four teeth, and cusps of the bifid tooth of the basal segment of the chelicerae with the relation $p=d$, gonopods cushion-like.

Etymology. the epithet is a noun in apposition referring to the name of the country where the species was collected.

Type material. Holotype: BELIZE, ARMENIA, CAYO DISTRICT: Caves Branch forest, nature trail, Ian Anderson's Caves Branch Jungle Lodge, 07.ix.2014, Wizen G. *leg.*, under and inside rotting logs, 17,165804'N, 88,682192'W (1 male, HUJINVAMB117). **Paratypes:** Caves Branch forest, Nature trail, Ian Anderson's Caves Branch Jungle Lodge, under and inside rotting logs, 02.ix.2014, Wizen G. *leg.*, 17,165804'N, -88,682192'W (1 females, 1 juvenile, HUJINVAMB118; 1 female MNRJ 9306).

Description of the male holotype (variations found in the paratypes are indicated in brackets; description of the chelicerae and gonopod are based on paratypes):

Carapace (Fig. 1A). Carapace flattened, wider than long (1.6 times), slightly bent downwards below lateral eyes; a thin median furrow reaches the fovea starting from the depression that replaces the median eye and tubercle. Anterior margin straight, with six frontal setae. Frontal process large, triangular, not visible from above, with a rounded tip. Three pairs of shallow furrows in the lateral of the carapace, and an oval and deep fovea. First pair of furrows placed just behind the lateral boss behind the lateral eyes; any of the furrows reaches the middle line. Median eyes and tubercle completely absent, a deep depression instead; no setae present in the depression. Lateral eyes well developed, pale, one large seta behind each triad; lenses directed upwards and slightly anteriorly.

Sternum (Fig. 1D): tetra-segmented, all pieces well sclerotized. Tritosternum with a round basis and projected anteriorly in a small blunt tubercle, reaching the base of the pedipalp coxae, with two apical, two median and two basal setae, with smaller ones on the base. Middle piece (tetrasternum) in one convex piece, with a pair of large setae in its apex, and a pair of small setae in its base. Third piece (pentasternum) formed by one convex piece, smaller than the middle piece, with two long setae at its top and with no small setae on its base. Sternites separated from each other by length of the third piece. Metasternum not paired (i.e., one single piece), with one pair of setae on an elevation at the posterior region of the plaque.

Abdomen (Fig. 1A): oblong, with almost indistinguishable punctuations. Ventral sacs not developed.

Chelicera (Fig. 5G): Cheliceral furrow with four internal teeth; first tooth (upper) bifid, proximal cusp of the same size as distal cusp. Third tooth slightly thinner and shorter than second tooth. Fourth tooth one third larger than the third. No tooth in the external row of the basal segment. Mesal face with a longitudinal row of seven setae. Claw with four denticles.

Pedipalp: Trochanter (Fig. 1A, 2A, B): large ventral apophysis, located in the posterior border of the trochanter, spiniform, bearing 11 large setae, and with a blunt tip pointed forward; two subequal spines, one in about the center of the anterior row of setiferous tubercles (three setae on each side), the other at the external border, below the apophysis, a bit curved inwards. **Femur** (Fig. 1A, 2A, B, 3A): three dorsal spines (I>II>III) with

two prominent setiferous tubercle before the first spine; three ventral spines (I>II>III) with one small setiferous tubercle before the first spine [one female paratype have two spines]. **Tibia** (Fig. 1A, 2A, B, 3A): three dorsal spines (I>II>III); one spine distal to I (about one third the size of I); one small setiferous tubercle proximal to spine III; spine II two thirds spine I and spine III one third spine I; spine I and II with two setiferous tubercle on its basal third; spine III with one setiferous tubercle in its half. Two ventral spines; second spine half size of the first (I>II). **Basitarsus** (Fig. 1A, 2A, B): two dorsal spines, the basal 2/3 the size of the distal. One ventral spine at the distal half, 2/3 the basal spine dorsal. **Distitarsus** (Fig. 3C): two large curved spines, the distal half the size of the article and pointed forward; the proximal half the size of the distal and pointed upward. Cleaning organ about half of the article length. **Claw** (Fig. 1A, 2A, B, 3C): long, with an acute, curved tip.



FIGURE 1. Habitus (A–C) and sternum (D–F) of *Charinus belizensis* sp. nov. (holotype: A, D) and *C. reddelli* sp. nov. (holotype: B and E; paratype from Footprint cave: C and F). The distinctly short tristosternum of the holotype (E) is an abnormality and is not found in any other specimen of the species. Scale bars: 1mm.

Legs: All setose. Ventral corner of the prolateral face of femora II–IV projecting in a distinct spiniform process. **Femur length:** I>III>II>IV. Tibia I with 23 articles; distal segments (Fig. 4A) with two small trichobothria, one on the dorsal and one in the lateral (ectal) side of the segment; one trichobothria in the second and fourth (from distal to proximal) segments, close to the distal border, one more lateral and the other more dorsal, respectively; no trichobothria on the other segments. Tarsus (basitarsus+distitarsus) I with 41 articles; proximal segment 3.3 times longer than the next (Fig. 4A).

Leg IV: Basitibia: divided into three pseudo-articles, with one trichobothrium on the first third of the last pseudo-segments (trichobothrium *bt*). **Distitibia** (Fig. 5A, B): three proximal and 13 distal trichobothria (total of

16); trichobothrium *bc* midway to *bf* and *sbf* [in the paratypes, *bc* is closer to *sbf* than to *bf*]; *sf* and *sc* with five trichobothria. **Basitibia-distitibia length** DT>BT1>BT4>BT3>BT2. **Tarsus:** with very weak mark of the white ring in the distal part of the second segment of distitarsus IV (Fig. 4C).

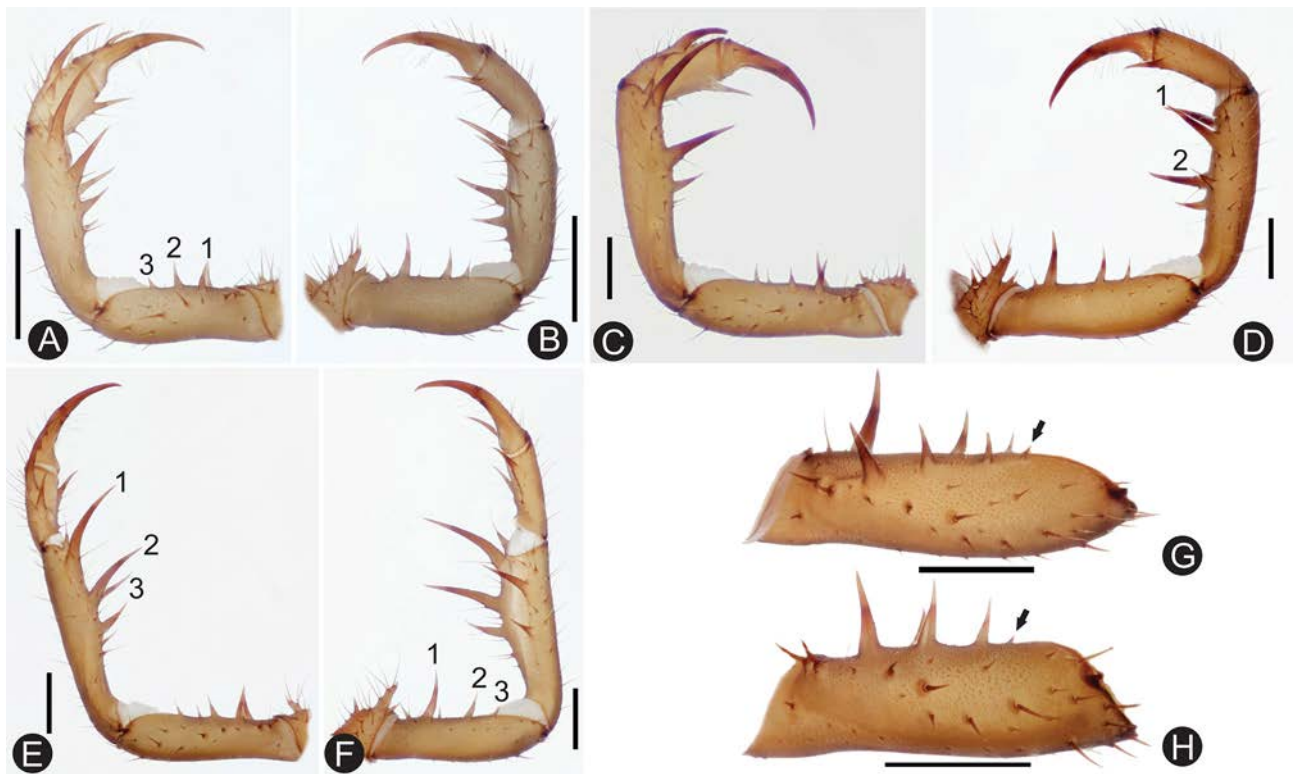


FIGURE 2. Dorsal (A, C, E) and ventral (B, D, F) view of the pedipalp of *Charinus belizensis* sp. nov. (holotype: A, B) and *C. reddelli* sp. nov. (holotype: C, D; paratype from Footprint Cave: E, F). G: right femur of the holotype showing the extra dorsal spine. H: right femur of a paratype from Waterfall cave with an arrow on dorsal spine 4. Scale bars: 1mm.

Measurements (in mm): **Female** (n=2): **Carapace:** Length: 1.97, Width: 2.94. **Pedipalp:** Femur 1.5, Tibia 1.55, Basitarsus 0.88, Distitarsus 0.63, Tarsal claw 0.45. **Leg I:** Femur 4.35, Tibia 6.80, Tarsus 6.80. **Leg II:** Femur 3.20, Basitibia 1.63, Distitibia 1.38, Basitarsus 0.75, other tarsal articles 0.50. **Leg III:** Femur 3.60, Basitibia 2.0, Distitibia 1.6, Basitarsus 0.88, Other tarsal articles 0.76. **Leg IV:** Femur 3.20, Basitibia I 1.56, Basitibia II 0.41, Basitibia III 0.72, Distitibia 1.97, Basitarsus 1.96, Other tarsal articles 0.51.

Measurements (in mm): **Male holotype:** **Carapace:** Length: 1.72, Width: 2.78. **Pedipalp:** Femur 1.58, Tibia 1.56, Basitarsus 0.91, Distitarsus 0.66, Tarsal claw 0.51. **Leg I:** Femur 4.63, Tibia 8.00, Tarsus 8.50. **Leg II:** Femur 3.50, Basitibia 2.25, Distitibia 1.95, Basitarsus 1.00, Other tarsal articles 0.60. **Leg III:** Femur 3.80, Basitibia 2.68, Distitibia 1.72, Basitarsus 1.08, Other tarsal articles 1.00. **Leg IV:** Femur 3.20, Basitibia I 1.52, Basitibia II 0.40, Basitibia III 0.76, Distitibia 1.80, Basitarsus 1.04, Other tarsal articles 0.60.

Color Pattern (in alcohol): Chelicerae, pedipalps, carapace and abdomen yellowish-brown. Legs tibia and tarsus lighter colored. Color in live animals is similar, except for the chelicerae that are burgundy.

Genitalia: Female gonopod (Fig. 6A, D, G): posterior margin of genital operculum straight, with few setae along its margin and on its surface. Gonopods oval, cushion-like, placed close to the border of the genital operculum, with a soft projection in the shape of a claw-like flap that covers the genital operculum. Internal border of the flap serrated, with few and spaced cusps. Male gonopod with distal border of fistula sclerotized; PI straight; Lol1 short and fimbriated.

Natural history: *C. belizensis* sp. nov. inhabits decomposing parts of fallen tree logs and deserted termite galleries in the broadleaf forest. It shares this habitat with several other arthropods, and occasionally it is found together with *Diplocentrus maya* Francke, 1977 (Scorpiones: Scorpionidae) and millipedes of the order Platydesmida. More than one individual of *C. belizensis* can be found using the same log cavity, which suggests a degree of tolerance towards conspecifics. It is unknown whether *C. belizensis* leaves the log to forage. It was often recorded feeding on small spiders and insects inside the log.



FIGURE 3. Frontal view of pedipalp tibia and distitibia of *C. belizensis* sp. nov. (A, C), and *C. reddelli* sp. nov. (B, D). Scale bars: A and B: 1mm; C and D: 0.5mm.

***Charinus reddelli* sp. nov.**

Figs. 1B, C, E, F; 2C–H; 3B, D; 4B, D; 5C–F, H; 6B, C, E, F, H; 7B, C; 8.

Diagnosis: median eyes and tubercle absent, large size (carapace mean width: 3.77; pedipalp femur mean length: 2.61; femur I mean length: 8.63), tibia I with 23 articles, tarsus I with 41 articles, proximal article of tarsus I 1.4 to 1.9 times longer than the second, cheliceral claw with four teeth, and cusps of the bifid tooth of the basal segment of the chelicerae as $p=d$.

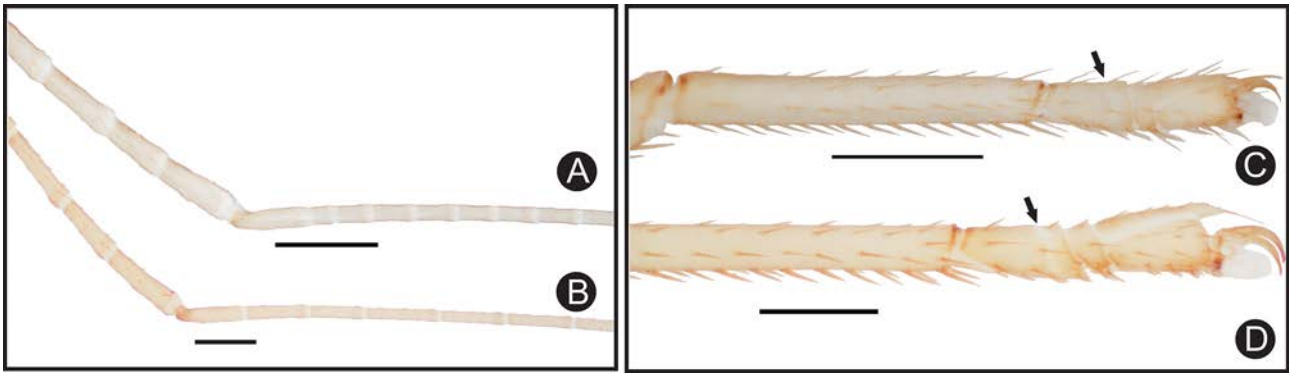


FIGURE 4. Part of tibia and tarsus I and last segments of tarsus IV, all lateral view. Tibia and tarsus I of *C. belizensis* sp. nov. (A) and *C. reddelli* sp. nov. (B). Tarsus IV of *C. belizensis* sp. nov. (C) and *C. reddelli* sp. nov. (D). Arrows points to the membranose ring in the second segment of the tarsus. Scale bars: 0.5mm.

Etymology. the epithet is a patronym to Dr. James R. Reddel for the first finding of *Charinus* in the Footprint cave and in Central America, and for his enormous contribution to the study of the arachnids.

Type material: Holotype. BELIZE, ARMENIA, CAYO DISTRICT: Waterfall Cave (Actun Lubul Ha), Karst cave, in cave, 500m from entrance, on walls and ceiling, 30.viii.2014, Wizen G. leg., 17,108611'N, -88,730833'W (1 female, HUJINVAMB115). **Paratypes:** Waterfall Cave (Actun Lubul Ha), Karst cave, in cave, 500m from entrance, on walls and ceiling, 30.viii.2014, Wizen G. leg., 17,108611'N, -88,730833'W (1 male, 2 females, HUJINVAMB116); Waterfall Cave, 3.ix.2014, Wizen G. leg. (2 females, MNRJ 9305); Footprint Cave, Karst cave, in cave, 200m from entrance, on sand next to cave walls, 07.ix.2014, Naskrecki P. and Wizen G. leg., 17,127500'N, -88,732222'W, (1 female, HUJINVAMB112); Footprint Cave, Karst cave, in cave, 200m from entrance, on sand next to cave walls, 02.ix.2014, Wizen G. leg., 17,127500'N, -88,732222'W (2 females, HUJINVAMB113); Footprint Cave, Karst cave, in cave, 200m from entrance, on sand next to cave walls, 02.ix.2014, Wizen G. leg., 17,127500'N, -88,732222'W (2 juvenile females, HUJINVAMB114).

Description of the female holotype (variations found in the paratypes are indicated in brackets; description of the chelicerae and gonopods based on paratypes):

Carapace (Fig. 1B, C). Carapace flattened, wider than long (1.4 times), slightly bent downwards below lateral eyes; a thin median furrow reaches the fovea starting from the depression that replace the median eye and tubercle. Anterior margin straight, with six frontal setae. Frontal process large, triangular, not visible from above, with a rounded tip. Three pairs of shallow furrows in the lateral of the carapace, and a triangular and deep fovea. First pair of furrows placed just behind the lateral boss behind the lateral eyes; any of the furrows reaches the middle line. Median eyes and tubercle completely absent, a deep depression instead; no setae present in the depression. Lateral eyes well developed, pale, one large setae behind each triad; lenses directed upwards and slightly anteriorly.

Sternum (Fig. 1E, F): tetra-segmented, all pieces well sclerotized. Tritosternum with a round basis and projected anteriorly in a small blunt tubercle, reaching the base of the pedipalp coxae, with two apical, two median and several smaller ones on the base (the paratypes have a longer tritosternum and longer basal pair of setae). Middle piece (tetrasternum) in one convex piece, with a pair of large setae in its apex, and four small setae in its base. Third piece (pentasternum) formed by one convex piece, smaller than the middle piece, with two long setae at its top and with one small setae on its base. Sternites separated from each other by length of the third piece. Metasternum not paired (i.e., one single piece), with one pair of setae on an elevation at the posterior region of the plaque.

Abdomen (Fig. 1B, C): oblong, with almost indistinguishable punctuations. Ventral sacs not developed.

Chelicera (Fig. 5H): Cheliceral furrow with four internal teeth; first tooth (upper) bifid, proximal cusp of the same size as distal cusp. Third tooth slightly thinner and shorter than second tooth. Fourth tooth one third larger than the third. No tooth in the external row of the basal segment. Mesal face with a longitudinal row of seven (five in paratypes) setae. Claw with four denticles.

Pedipalp: Trochanter (Fig. 2C–F): large ventral apophysis, located in the posterior border of the trochanter, spiniform, bearing 13–14 large setae, and with a blunt tip pointed forward; two subequal spines, one in about the center of the anterior row of setiferous tubercles (three setae on each side), the other at the external border, below

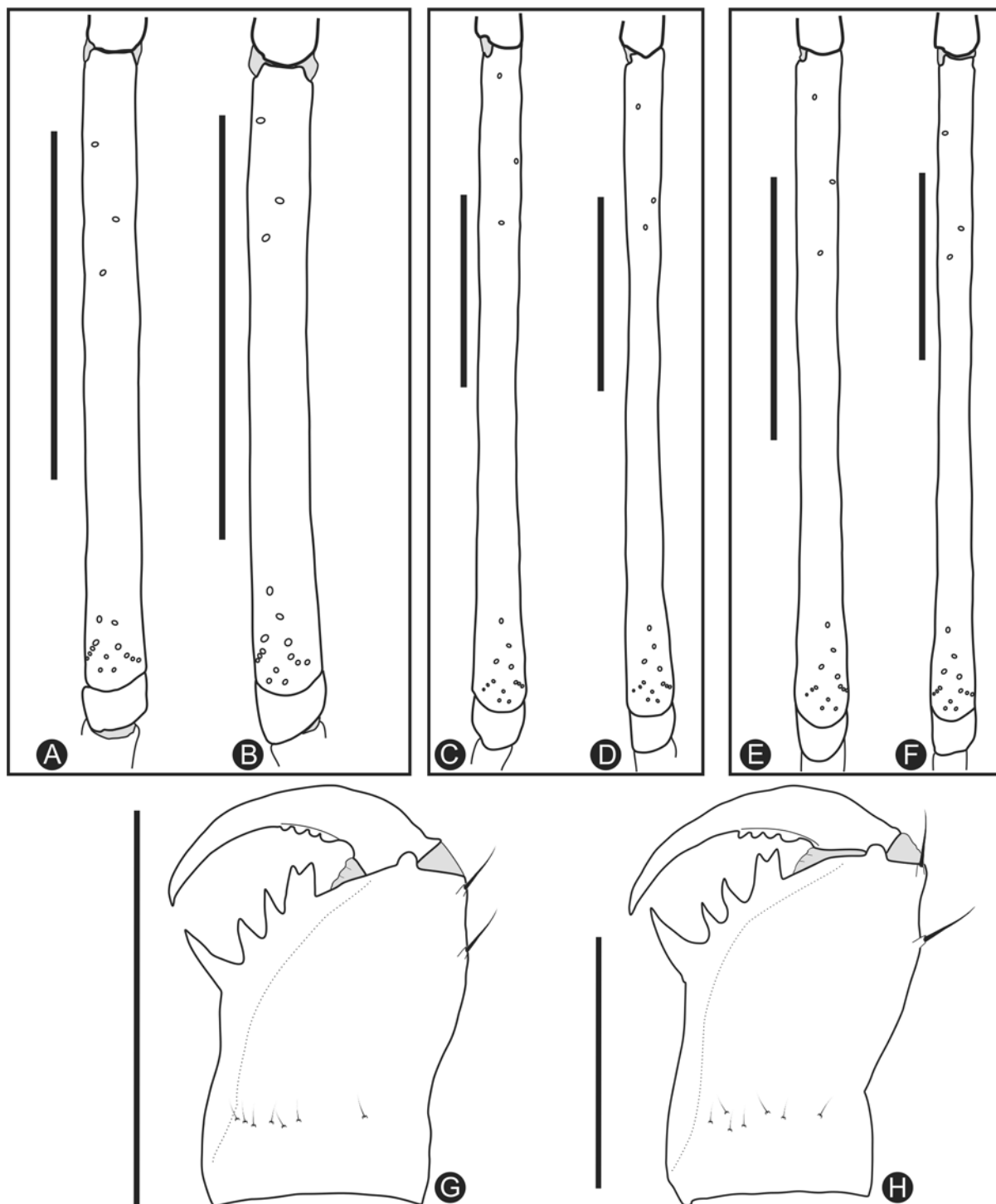


FIGURE 5. Leg IV trichobothriotaxy and chelicerae of *Charinus belizensis* **sp. nov.** (A–B, G) and *C. reddelli* **sp. nov.** (C–F, H). A: left leg of *C. belizensis* **sp. nov.** male holotype (HUJINVAMB 117). B: left leg of *C. belizensis* **sp. nov.** female paratype (HUJINVAMB 118). C: left leg of *C. reddelli* **sp. nov.** female holotype (HUJINVAMB 115). D, E, F: left leg of *C. reddelli* **sp. nov.** female paratypes from Waterfall cave (HUJINVAMB 116) and Footprint Cave (HUJINVAMB 114, HUJINVAMB 113), respectively. G: right chelicerae of *C. belizensis* **sp. nov.** (HUJINVAMB 118). H: right chelicerae of *C. reddelli* **sp. nov.** (HUJINVAMB 116). Scale bars: 1 mm.

the apophysis, a bit curved inwards. **Femur** (Fig. 2C–H, 3B): three dorsal spines in the left pedipalp and four in the right pedipalp (the last spine very small) [in one male (HUJINVAM 116) the left pedipalp have four spines and the right three; two female paratypes (HUJINVAM 116) have four spines in both pedipalps, the last one very tiny (Fig. 2 G, H)] with two prominent setiferous tubercle before the first spine (I>II>III>IV); three ventral spines (I>II>III)

with one small setiferous tubercle before the first spine. **Tibia** (Fig. 2C–F; 3B): three dorsal spines (I>II>III); one spine distal to I (about one fourth the size of I); one small setiferous tubercle proximal to spine III; spine II two thirds spine I and spine III one third spine I; spine I and II with two setiferous tubercle on its basal third; spine III with one setiferous tubercle in its half. Two ventral spines [the female paratype (HUJINVAM 116) have three, the last (proximal) very tiny]; second spine half size of the first. **Basitarsus** (Fig. 2C–F): two dorsal spines, the basal 2/3 the size of the distal. One ventral spine at the distal half, 2/3 the basal spine dorsal. **Distitarsus** (Fig. 3D): two large curved spines, the distal half the size of the article and pointed forward; the proximal one third the size of the distal and pointed upward. Cleaning organ about half of the article length. **Claw** (Fig. 3D): long, with an acute, curved tip.

Legs: All setose. Ventral corner of the proteral face of femora II–IV projecting in a distinct spiniform process. **Femur length:** I>III>II>IV. Tibia I with 23 articles; distal segments with two small trichobothria, one on the dorsal and one in the lateral (ectal) side of the segment; on the left leg, one trichobothria in the second, third and fourth (from distal to proximal) segments, close to the distal border, the trichobothria on the third segment more lateral, the others more dorsal [in the paratypes they are ventral]; the right leg has two trichobothria in the third segment, one dorsal and one mesal; no trichobothria on the other segments. Tarsus (basitarsus+distitarsus) I with 41 articles; proximal segment 1.7 times longer than the next (Fig. 4B).

Leg IV: Basitibia: divided into three pseudo-articles, with one trichobothrium on the first third of the last pseudo-segments (trichobothrium *bt*). **Distitibia** (Fig. 5C–F): three proximal and 13 distal trichobothria (total of 16); trichobothrium *bc* midway to *bf* and *sbf* [in the paratypes, *bc* is closer to *sbf* than to *bf*]; *sf* and *sc* with five trichobothria. **Basitibia-distitibia length** DT>BT1>BT4>BT3>BT2. **Tarsus:** with very strong mark of the white ring in the distal part of the second segment of distitarsus IV (Fig. 4D).

Measurements (in mm): **Female** (n=3): **Carapace:** Length: 2.84 (2.48–3.05), Width: 4.02 (3.40–4.40). **Pedipalp:** Femur 2.74 (2.13–3.09), Tibia 2.72 (1.88–3.28), Basitarsus 1.54 (1.13–1.88), Distitarsus 0.99 (0.80–1.10), Tarsal claw 0.94 (0.73–1.08). **Leg I:** Femur 9.35 (6.90–11.41), Tibia 15.60 (15.40–15.80), Tarsus 15.25 (14.00–16.50). **Leg II:** Femur 6.27 (5.12–6.96), Basitibia 4.44 (3.60–5.00), Distitibia 3.14 (2.64–3.50), Basitarsus 1.67 (1.28–1.92), Other tarsal articles 0.95 (0.78–1.12). **Leg III:** Femur 7.12 (6.00–7.76), Basitibia 5.63 (4.80–6.08), Distitibia 3.51 (3.12–3.80), Basitarsus 1.97 (1.44–2.40), Other tarsal articles 0.93 (0.80–1.00). **Leg IV:** Femur 6.36 (5.25–7.04), Basitibia I 3.32 (2.81–3.75), Basitibia II 1.04 (0.81–1.20), Basitibia III 1.63 (1.25–1.85), Distitibia 3.43 (2.69–4.00), Basitarsus 2.66 (1.58–4.30), Other tarsal articles 1.28 (0.85–2.00).

Measurements: Male (n=1): **Carapace:** Length: 2.64, Width: 3.80. **Pedipalp:** Femur 2.75, Tibia 2.59, Basitarsus 1.44, Distitarsus 0.93, Tarsal claw 0.90. **Leg I:** Femur 9.30, Tibia 17.18, Tarsus 15.40. **Leg II:** Femur 6.16, Basitibia 4.24, Distitibia 3.04, Basitarsus 1.53, Other tarsal articles 0.80. **Leg III:** Femur 6.80, Basitibia 5.36, Distitibia 3.44, Basitarsus 1.84, Other tarsal articles 0.84. **Leg IV:** Femur 6.00, Basitibia I 4.00, Basitibia II 1.35, Distitibia 3.45, Basitarsus 1.75, Other tarsal articles 0.85.

Color Pattern (in alcohol): Chelicerae, pedipalps, carapace and abdomen yellowish-brown. Legs tibia and tarsus lighter colored. Color in live animals is similar, except for the chelicerae that are burgundy.

Genitalia: Female gonopod (Figs. 6B, C, E, F, H): posterior margin of genital operculum straight, with few setae along its margin and on its surface. Gonopods oval, cushion-like, placed close to the border of the genital operculum, with a soft projection in the shape of a claw-like flap that covers the genital operculum. Internal border of the external flap is serrated, with abundant cusps close to each other. The gonopod of the female from FC (Fig. 6F) is retracted to hold the sperm sac. A layer of sediment was present in the border of genital operculum of one specimen (detail of Fig. 6B); part of this sediment was removed to the observation of the gonopods; the presence of this cover may have a biological purpose (e.g. maintenance of moist to the book lungs or the gonopods), but cannot be inferred by now. Male gonopod with distal border of fistula sclerotized; PI curved; Lol1 long and fimbriated.

Natural history. *C. reddelli* sp. nov. was found in two karst caves located in the valley of the Caves Branch river in central Belize: Footprint Cave, and Waterfall cave (Actun Lubul Ha). Both caves are decorated with stalagmites, stalactites and columns of dense flowstone. Footprint cave has a stream flowing straight through it, confined to the lower passage of the cave. It emerges out of the cave's entrance and joins the Caves Branch river about 2km away. Only one entrance to the cave is known. Although we found several small-sized arthropods in this cave (isopods, diplurans), the most frequently encountered prey items were nymphs of *Mayagrillus apterus* Desutter-Grandcolas and Hubbell, 1993 (Orthoptera: Gryllidae) and *Belicenochnus peckorum* Armas and Viquez, 2010 (Schizomida: Hubbardiidae). The Waterfall cave has a stream flowing between two entrances separated by ca.

2km of passage and divided by a series of cascades. This cave contains many dry cavities, and has more abundance of insects (*M. apterus*, cockroaches) and other arthropods (isopods, spiders, soft ticks). The population of *C. reddelli* **sp. nov.** in the Waterfall caves appears larger (more specimens were recorded) in comparison to the Footprint cave. Individuals were never found close to each other. The egg sac contains 4–10 eggs measuring 1.5–1.64mm in diameter. At 25°C, egg development takes ca. 150 days. The hatching praenymphae are white and measure 2.2–2.5mm. They climb and stay on the mother's back for 14 days, after which they molt into protonymphae measuring 2.8mm in length.

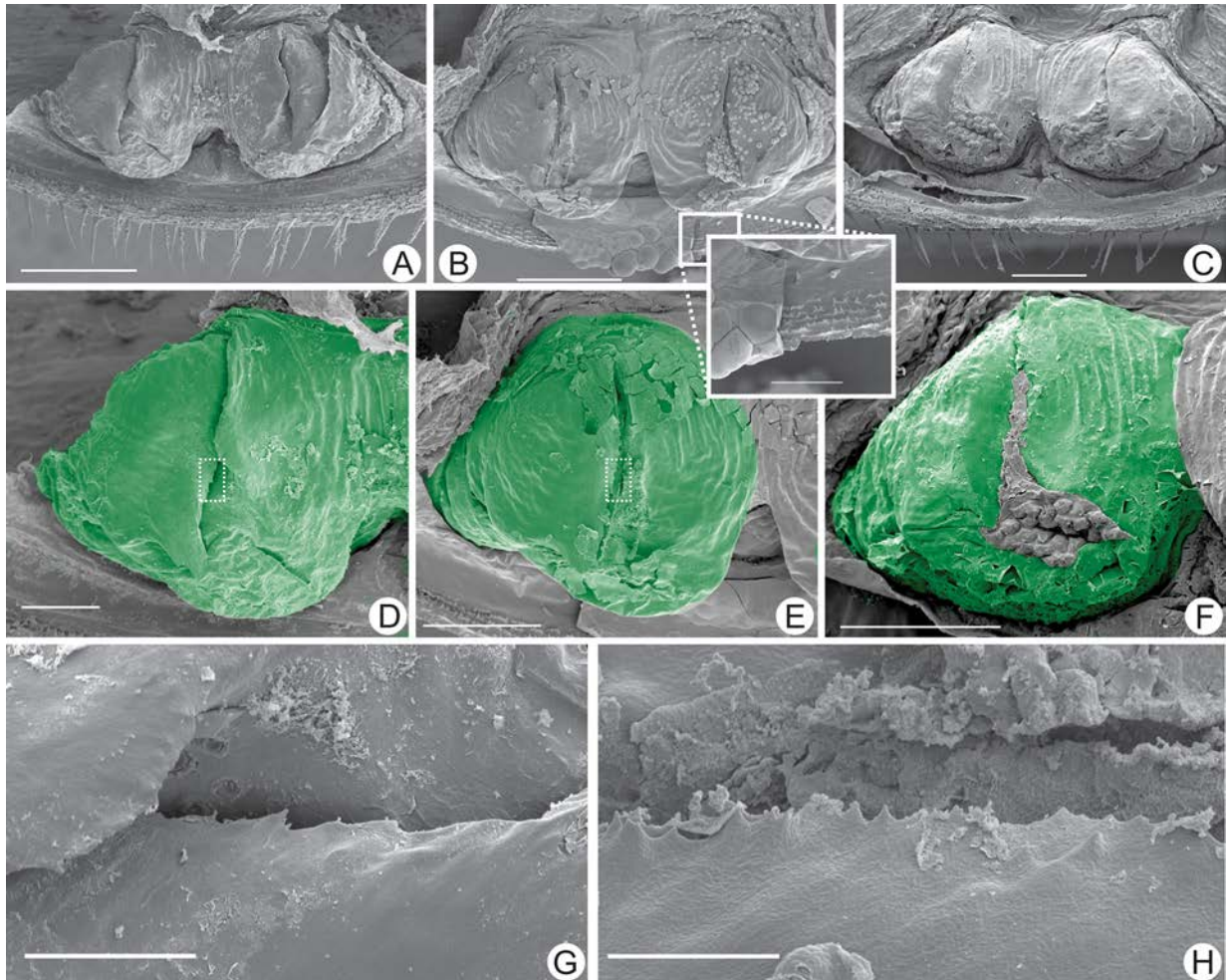


FIGURE 6. Female gonopod of *Charinus belizensis* **sp. nov.** (A, D, G) and *C. reddelli* **sp. nov.** (B, C, E, F, H). A: dorsal view of *Charinus belizensis* **sp. nov.**. B: dorsal view of *C. reddelli* **sp. nov.** from Waterfall cave. C: dorsal view of *C. reddelli* **sp. nov.** from Footprint cave. D: detail of the left side of the gonopod of *C. belizensis* **sp. nov.**. E: detail of the left side of the gonopod of *C. reddelli* **sp. nov.** from WC. F: detail of the left side of the gonopod of *C. reddelli* **sp. nov.** from FC. G: detail of the internal border of the gonopod of *C. belizensis* **sp. nov.**. H: detail of the internal border of the gonopod of *C. reddelli* **sp. nov.**. Scale bars: A, B: 150µm; C, D, detail of figure B: 50µm; E, F: 100µm; G: 20µm; H: 15µm.

Discussion

The *Charinus* species from the Caribbean and Central America known so far are very homogeneous in their morphology. All have a similar number of spines on the pedipalp (three spines on the dorsal and ventral borders of the femur and dorsal side of the tibia, two on ventral tibia, and two on dorsal distitarsus), the same number of articles on basitibia IV (three), and, on average, similar sizes. Pedipalp spines can vary in size, but not significantly to justify specific differentiation. However, differences in the following structures are useful to tell apart the 12 species of the region: (1) the number of articles on leg I tibia and tarsus, (2) the length of the proximal article of tarsus I, (3) the size relation of the bifid tooth on the basal segment of the chelicerae, and (4) the presence or absence of median eyes and tubercle (see Table 1).

TABLE 1. Summary of the differential characters among the Caribbean and Central American species of *Charinus*. Measurements in millimeters. p: proximal; d: distal. The number after the species name refers to the following references: Armas (2006a¹, 2006b², 2010³, 2014⁴), Armas and Ávila Calvo (2000)⁵, Armas and Pérez González (2001)⁶, Armas and Teruel (1997)⁷, Quintero (1983)⁸, Quintero (2011)¹⁰ and Viquez *et al.* (2012)¹¹.

Species	Habitat	Median eyes and tubercle	Carapace median length	Carapace median width	Peipalp femur length	N° of articles in tibia I	N° of articles in tarsus I	Length of the proximal article in relation to the second article of tarsus I	Number of articles on basitibia IV	Number of teeth on the cheliceral claw	Size relation of the bifid tooth in the basal segment of the chelicerae
<i>Charinus reddelli</i> sp. nov. F.C	troglobite	absent	2.50	3.50	2.22	23	41	1.9 times longer	3	4	p=d
<i>Charinus reddelli</i> sp. nov. W.C	troglobite	absent	2.82	3.98	2.58	23	41	1.4 times longer	3	4	p=d
<i>Charinus belizensis</i> sp. nov.	epigean	absent	1.82	2.65	1.99	23	41	3–4 times longer	3	4	p=d
<i>C. acosta</i> ^{2,4,8}	epigean	present	2.25	2.95	4.50	23	41	1.4 times longer	3	5	p<d
<i>C. centralis</i> ^{2,4,5}	epigean	absent	1.85	2.45	4.09	23	41	2.4 times longer	3	-	p<d
<i>C. cubensis</i> ^{2,4,5,8}	troglophile	absent	1.80	2.60	3.90	21	37	1.8 times longer	3	-	p>d
<i>C. decu</i> ^{2,4,8}	troglophile	absent	1.70	2.30	3.60	21	39	4.0 to 4.5 times longer	3	4	p>d
<i>C. wanlessi</i> ^{2,4,8}	troglophile	absent	2.40	3.20	6.00	21	33	2.8 times longer	3	-	p>d
<i>C. tomasmicheli</i> ^{1,4}	possibly troglobite	absent	2.65	-	2.05	21	37	1.1 times longer	3	4	p=d
<i>C. caribensis</i> ^{2,4,9}	possibly troglobite	absent	2.51	-	-	21	37	-	2	-	p>d
<i>C. dominicanus</i> ^{2,4,6}	epigean	absent	1.87	2.70	1.35	21	33	-	3	8	p<d
<i>C. victori</i> ³	troglophile	present, reduced	2.03	2.84	2.22	21	33–34	-	3	5	p>d
<i>C. perezassoi</i> ³	epigean	absent	2.01	2.75	1.39	21	37–39	-	3	5	p>d
<i>C. muchmorei</i> ^{2,4,7}	epigean	absent	1.75	2.40	1.10	23	37–39	3.3 times longer	3	-	p>d
<i>C. bruneti</i> ¹⁰	epigean	present	1.90	2.65	1.10	22	39	3.0 times longer	3	-	-
<i>Charinus</i> sp. (Panama) ¹¹	epigean	present	2.10	3.05	-	23	41	-	-	-	p<d



FIGURE 7. Photos of live specimens of *Charinus belizensis* sp. nov. (A) and *C. reddelli* sp. nov. (Waterfall cave: B; Footprint Cave: C).

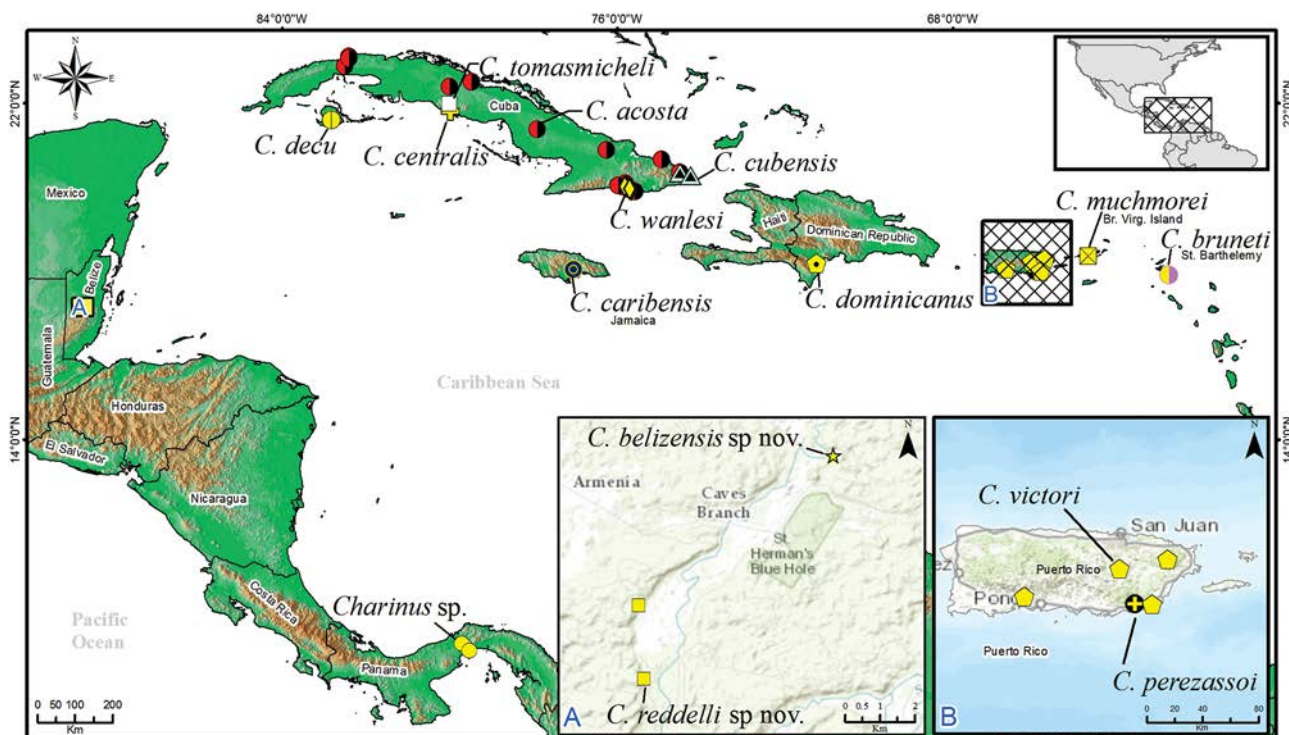


FIGURE 8. Distributional map of the Caribbean and Central American species of *Charinus*. F.C.: Footprint cave. W.C.: Waterfall cave.

Charinus belizensis sp. nov. and *C. reddelli* sp. nov. differ from *C. cubensis* (Quintero, 1983), *C. decu* (Quintero, 1983), *C. wanlessi* (Quintero, 1983), *C. toasmicheli* Armas, 2006, *C. caribensis* (Quintero, 1986), *C. dominicanus* Armas & Pérez González, 2001, *C. victori*, *C. perezassoi* Armas, 2010, *C. muchmorei* Armas & Teruel, 1997 and *C. bruneti* Teruel & Quest, 2011 by the number of articles on tibia and tarsus I (see Table 1). Besides that, *C. cubensis* is smaller, and the size relation of cuspids of the bifid tooth is $p>d$; *C. decu* is smaller, has the proximal segment of tarsus I longer, and the cuspids with relations $p>d$; *C. toasmicheli* has the proximal article of tarsus I shorter; *C. caribensis* is smaller, has basitibia IV with two articles, and cuspids with size relation $p>d$; *C. dominicanus* is smaller, and has cuspids with size relation $p<d$; *C. victori* has the median eyes, five teeth in the cheliceral claw, and cuspids relation $p>d$; *C. perezassoi* is smaller, also has five teeth in the cheliceral claw and cuspids relation $p>d$; *C. muchmorei* is smaller, has larger proximal tarsus I article, and cuspids relation $p>d$; *C. bruneti* has median eyes and cuspids relation $p<d$.

The other species known from that region (*C. acosta*, *C. centralis* and *Charinus* sp. from Panama [Viquez *et al.*, 2012]) have leg I with 23 and 41 articles in tibia and tarsus I, as is counted in the new species. But *C. belizensis* sp. nov. and *C. reddelli* sp. nov. can be differentiated from *C. acosta* and *Charinus* sp. from Panama by the absence of median eyes and tubercle and by the size relation of the proximal and distal cuspids of the bifid tooth on the basal segment of the chelicerae ($p<d$ in *C. acosta* and *Charinus* sp., and $p=d$ in *Charinus* spp. nov.). Another difference between the two new species and *C. acosta* is the shape of the tetrasternum and pentasternum; in the new species they are formed by small rounded unique sclerotized plaques, and in *C. acosta* each segment is formed by a pair of small rounded plaques. The two new species differs from *C. centralis* by the size of the proximal article of tarsus I (*C. centralis* has this segment 2.4 times longer than the other articles, and *Charinus reddelli* sp. nov. has it 1.4–1.9 times longer), the larger size (the new species is larger than *C. centralis*; see Table 1), and the size relation of the cuspids of the bifid tooth of the basal segment of the chelicerae. Besides that, *C. reddelli* sp. nov. inhabits caves (Footprint and Waterfall caves in Belize) and *C. belizensis* sp. nov. inhabits rotting wood cavities, while *C. acosta*, *C. centralis* and *Charinus* sp. are epigeal (the first two in Cuba and the last in Panama; Fig. 8). Moreover, *C. acosta* is one of the few parthenogenetic species of whip spider (Armas, 2000).

Compared to the species out of the Caribbean and Central American region, *Charinus belizensis* sp. nov. and *C. reddelli* sp. nov. differ from the *bengalensis* and the *brasilianus* species group by the cushion-like gonopods,

instead of a finger-like or sucker-like gonopods, respectively. The new species can be distinguished from most species of the *australianus* species group by the presence of three articles in basitibia IV, instead of four; the only species of this group with three articles in basitibia IV is *Charinus vulgaris* Miranda & Giupponi, 2011, from which the new species can be distinguished by the size relation of the cuspids of the bifid tooth of the basal segment ($p > d$ in *C. vulgaris* and $p = d$ in both new species), and the habitat (*C. vulgaris* is synanthropic, while *C. belizensis* **sp. nov.** is epigeal and *C. reddelli* **sp. nov.** is troglobite).

The following six *Charinus* species inhabit caves around the world and considered troglolobious: *Charinus dhofarensis* Weygoldt, Pohl & Polak, 2002 from Tawi Atayr, Oman; *Charinus eleonora* Baptista & Giupponi, 2003 from Minas Gerais, Brazil; *Charinus omanensis* Delle Cave Delle Cave, Gradner & Weygoldt, 2009 from Jabal Akhdar, Oman; *Charinus socotranus* Weygoldt, Pohl & Polak, 2002 from Socotra Island (Hoq Cave), Yemen; *Charinus stygochthobius* Weygoldt & Van Damme, 2004 from Socotra Island (Ghiniba Cave), Yemen; *Charinus troglobius* Baptista & Giupponi, 2002 from Bahia, Brazil. All six belong to different species groups than that of *C. reddelli* **sp. nov.**, but share some troglomorphic similarities such as reduction of the eyes and elongation of body segments and appendages. Nevertheless, it is known that in most of the cases similar troglomorphic appearance is the result of convergent evolution (Bilandzija *et al.*, 2012; Delle-Cave *et al.*, 2009; Protas *et al.*, 2006).

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