A New Species of the Genus *Cybaeus* (Araneae: Cybaeidae) from a Cave in Northeastern Central Honshu, Japan

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A new species of *Cybaeus* L. Koch, 1868, *C. eremospelyngus* sp. nov., is described from Osawa-shonyudo Cave, Niigata Prefecture, northeastern central Honshu, Japan. This species has pale body coloration and relatively small eyes, which may be adapted to subterranean environments. In addition, *C. eremospelyngus* sp. nov. constructs a 'Y-shaped' retreat with three openings. This is the first record of a *Cybaeus* species that builds a retreat with three openings from central Honshu.

Key Words: Arachnida, Osawa-shonyudo Cave, retreat, RTA Clade, subterranean.

Introduction

The cybaeid spiders of the genus *Cybaeus* L. Koch, 1868 are epigean or subterranean, and inhabit the Holarctic regions (Western Europe to the Caucasus, Japan, Korean Peninsula, China, and North America) (World Spider Catalog 2025). High species richness has been revealed in western North America and the Japanese Archipelago (Copley et al. 2009; Ihara et al. 2021); at present, approximately 90 species of *Cybaeus* have been described from Japan (Sugawara et al. 2024; World Spider Catalog 2025).

Cybaeus spiders are sometimes found in caves (Ihara 2009a; Bennett 2017), and several of these cave inhabitants are known to possess morphological characters adapted to subterranean environments, e.g., pale coloration and small eyes (Komatsu 1968; Ono 2008; Ihara 2009a). In addition, such troglobitic species, e.g., C. zenifukiensis (Komatsu, 1968), C. inagakii Ono, 2008, C. ishikawai (Kishida, 1940), and C. itsukiensis Irie, 1998, are endemic to Japan, and were mainly described from large karst regions such as northern, central, and western parts of Honshu, Shikoku, and Kyushu in the Japanese Archipelago (Komatsu 1940, 1968; Irie 1998; Ono 2008). Almost half of the Japanese Cybaeus species are known to construct tube-like silken retreats on the undersides of stones and wood (Ihara et al. 2021). The retreats of most of those spiders are defined as being 'V-shaped' with two openings (Ihara 2006). Conversely, fewer Cybaeus species construct retreats with three openings, which are defined as 'Y-shaped,' or hexagonal (Komatsu 1961, 1968; Ihara 2003, 2009b; Ihara et al. 2021). Previous studies have revealed that Cybaeus species known from caves in northern Honshu and Shikoku construct these 'Y-shaped' retreats (Komatsu 1961, 1968), but nonetheless, the recent molecular phylogeny showed that the 'Y-shaped' feature of retreats may have evolved in parallel within the Japanese *Cybaeus* spiders (Sugawara et al. 2024).

Recently, we found a *Cybaeus* species with characters supposedly adapted to underground environments from Osawa-shonyudo Cave in the northeastern part of central Honshu, which is isolated from large karst regions in Japan. We herein describe it as a new subterranean species of the genus *Cybaeus*.

Materials and Methods

Samples and morphological examination. Cybaeus spiders were collected from Osawa-shonyudo Cave, northeastern part of central Honshu, Japan (Fig. 1) in 2023. Specimens were preserved in 70% ethanol. The epigyne was dissected from a female specimen and then cleared to observe its internal structure following the method described by Matsuda et al. (2020). Examination of the specimens was conducted using a stereoscopic microscope (M125C, Leica Microsystems, Wetzlar, Germany). Images of the specimens were captured with a Leica MC170 HD digital camera mounted on the Leica M125C and analyzed using Leica Application Suite (LAS) v. 4.12, and with a digital microscope (VHX-5000, KEYENCE, Osaka, Japan). Measurements were taken to the nearest 0.01 mm in LAS. All specimens examined in this study have been deposited in the Zoological Collection of Kyoto University (KUZ).

Terminology of morphological characters and the chaetotaxy of leg macrosetae follows Ihara et al. (2021). The following are the abbreviations used for macrosetae: p, prolateral; r, retrolateral; v, ventral. The following are the abbreviations used for other characters: AER, anterior eye

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row; AME, anterior median eyes; BG, Bennett's gland; CD, copulatory duct; CL, carapace length; CP, copulatory pore; CW, carapace width; EM, embolus; EPPM, posterior margin of epigynal plate; FD, fertilization duct; PA, patellar apophysis; PCO, proximal arm of conductor; PER, posterior eye row; PP, primary pore; RTA, retrolateral tibial apophysis; SB, spermathecal base; SH, spermathecal head; SS, spermathecal stalk; TibIL, length of leg I tibia.



Fig. 1. Map showing the collection locality of samples in the present study. Star indicates the location of the collected specimens of *Cybaeus eremospelyngus* sp. nov. Shoreline data were based on Wessel and Smith (1996).

PCR and DNA sequencing. The following two markers were obtained from the non-type subadult material (KUZ Z5088) to aid future phylogenetic studies: the third region of mitochondrial cytochrome *c* oxidase subunit I (COI) and the posterior part of nuclear 28S rRNA (28S).

The methodology for genomic DNA extraction, polymerase chain reactions (PCR), and cycle sequencing (CS) reactions was conducted as described by Matsuda et al. (2020). The primer sets used for COI were LCO_Osw_561 (5'-TTATCTTTACCTGTTTTAGC-3'; newly designed) and COIARAR (Ihara et al. 2021), and for 28S were 28Sa and 28Sb (Whiting et al. 1997). The DNA sequences obtained in the present study were deposited with the International Nucleotide Sequence Databases (INSD) through the DNA Data Bank of Japan.

Taxonomy

Genus *Cybaeus* L. Koch, 1868 *Cybaeus eremospelyngus* sp. nov. [New Japanese name: Gosen-namihagumo] (Figs 2–5)

Diagnosis. Body length reaching ~5 mm [="small-" to "medium-sized" Japanese *Cybaeus*, sensu Ihara (2004); Fig. 2A]. The female of *C. eremospelyngus* sp. nov. is most simi-



Fig. 2. *Cybaeus eremospelyngus* sp. nov., male holotype (KUZ Z5306: A) and female paratype (KUZ Z5307: B, C). A, Habitus (left palp dissected); B, prosoma, dorsal view; C, abdomen, dorsal view. Scale bars: A, 2 mm; B, C, 500 μm.



Fig. 3. *Cybaeus eremospelyngus* sp. nov., male holotype (KUZ Z5306). A, Left palp, retrolateral view; B, patellar apophysis of left palp, dorsal view; C, patellar apophysis of left palp, retrolateral view; D, cymbium of left palp, dorsal view; E, bulb of left palp, ventral view. Abbreviations: EM, embolus; PA, patellar apophysis; PCO, proximal arm of conductor; RTA, retrolateral tibial apophysis. Scale bars: A, 500 µm; B–E, 200 µm.



Fig. 4. *Cybaeus eremospelyngus* sp. nov., female paratype (KUZ Z5307). A, Epigyne, ventral view; B, spermathecae, dorsal view. Abbreviations: BG, Bennett's gland; EPPM, posterior margin of epigynal plate; FD, fertilization duct; SB, spermathecal base; SH, spermathecal head; SS, spermathecal stalk. Scale bars: A, B, 100 μm.

lar to that of *C. inagakii* in the shapes of their spermathecae with SH, SS, and SB, all of which are bulbous, and their arrangement. However, the female of this new species can be clearly distinguished from the latter by the atrium, which is wider than long, whereas that of *C. inagakii* is longer than



Fig. 5. *Cybaeus eremospelyngus* sp. nov., schematic drawing of the epigyne and spermathecae of the female paratype (KUZ Z5307). A, Ventral view; B, dorsal view. Abbreviations: BG, Bennett's gland; CD, copulatory duct; CP, copulatory pore; EPPM, posterior margin of epigynal plate; FD, fertilization duct; PP, primary pore; SB, spermathecal base; SH, spermathecal head; SS, spermathecal stalk. Scale bar: 100 μm.

wide (see fig. 14 in Ono 2008). The male of *C. eremospelyngus* sp. nov. is distinguishable by the shape of its PA, which is directed anteriorly, while that of *C. inagakii* expands retrolaterally (see fig. 12 in Ono 2008). Furthermore, *C. eremospelyngus* sp. nov. is clearly distinguishable from *C. inagakii* by its possession of eight eyes (originally six reduced eyes in *C. inagakii*; fig. 8 in Ono 2008).

Material examined. *Holotype*: male, KUZ Z5306, from Osawa-shonyudo Cave, Gosen, Niigata, Japan (cave entrance: 37.68254°N, 139.1011°E), collected by Yoh Ihara on 16 October 2023.

Paratype: one female, KUZ Z5307, same collection data as for holotype.

Additional material: one subadult female, KUZ Z5088,

same locality data as for holotype, collected by Takafumi Nakano on 20 September 2023.

Description. *Male* (holotype, KUZ Z5306: Figs 2A, 3). Measurements (mm): CL 2.29, CW 1.57; head 0.93 wide; abdomen 2.50 long, 2.25 wide; ocular area 0.19 long, 0.53 wide; sternum 1.17 long, 1.05 wide; CW/CL 0.69, TibIL/CL 0.92. Leg formula IV > I > II > III > II > II > II > III > II > II

Carapace (Fig. 2A). Head narrow, ~0.59× as wide as thoracic region; thoracic region almost as high as head. Eyes 8 in number; AER slightly recurved in frontal view; PER slightly recurved in dorsal view; AME smallest, <1/2 diameter of other eyes; ocular area ~2.8× wider than long. Clypeus as long as median ocular area.

Mouthpart. Chelicerae geniculate, promargin of fang furrow with 3 teeth (median one largest), retromargin with 4 teeth and 4 denticles, and basally with lateral condyle. Labium wider than long.

Leg macrosetae (left legs). Leg I: tibia p3, r2, v2-2-2-2; metatarsus p3, r1, v2-2-3. Leg II: tibia p4, r2, v2-2-1-2; metatarsus p4, r2, v2-2-3.

Abdomen (Fig. 2A). Colulus two groups of 1 or 2 setae.

Palp (Fig. 3). PA directed anteriorly, short digitiform in retrolateral view, retrolateral surface with 4 peg setae. Tibia as long as patella; RTA plate-like, occupying 1/2 of length of tibia. Cymbium ~2.6× longer than wide, slightly expanded prolaterally. Genital bulb almost circular in ventral view. Conductor: distal part short; PCO conical and curved prolaterally. EM simple, originating and terminating, respectively, at ~10 oclock and ~5 oclock.

Color (Fig. 2A). Carapace: head pale brown, with whitish weak reticulate markings; thoracic region pale beige, with pale brown weak radiating bands. Chelicerae, maxillary lobe, and labium orangish brown. Sternum pale beige, darker towards margins. Legs pale beige, darker distally, without annulations. Abdomen: pale gray, dorsally without chevron-like markings.

Female (paratype, KUZ Z5307: Figs 2B, C, 4, 5). Measurements (mm): CL 2.29, CW 1.47, head 0.88 wide; abdomen 2.71 long, 2.06 wide; ocular area 0.18 long, 0.54 wide; sternum 1.11 long, 1.04 wide; CW/CL 0.64, TibIL/CL 0.75. Leg formula IV > I > II > III > III; length of legs (femur + patella + tibia + metatarsus + tarsus): leg I 7.00 (1.89 + 0.73 + 1.72 + 1.56 + 1.10); leg II 6.68 (1.75 + 0.71 + 1.54 + 1.59 + 1.09); leg III 6.06 (1.64 + 0.64 + 1.28 + 1.52 + 0.98); leg IV 7.44 (1.99 + 0.64 + 1.75 + 1.89 + 1.17).

Carapace (Fig. 2B). Head narrow, ~0.60× as wide as thoracic region; thoracic region almost as high as head. Eyes 8 in number; AER slightly recurved in frontal view; PER slightly recurved in dorsal view; AME smallest, <1/2 diameter of other eyes; ocular area ~3.1× wider than long. Clypeus as long as median ocular area.

Mouthparts. Chelicerae geniculate, promargin of fang furrow with 3 teeth (median one largest), basally with lateral condyle, and retromargin with 5 teeth and 4 denticles on left side, 4 teeth and 6 denticles on right side. Labium wider than long.

Leg macrosetae (left leg). Leg I: tibia p3, r1, v2-2-2-2; metatarsus p5, r2, v2-2-1. Leg II: tibia p4, r1, v2-2-1-2; metatarsus p5, r3, v2-2-1.

Abdomen (Fig. 2C). Colulus two groups of 3 setae.

Genitalia (Figs 4, 5). EPPM curved. Atrium located posteromedially on epigyne. CPs separated on anterior side of atrium; CD thick and short, running anteriorly and curved dorsally. SH developed, SH with PP located dorsally; SS bulbous, located retrolaterally to SH; SB bulbous, directed posteriorly; BG located on SS posteromedially around connection between SS and SB; FD running from SB, descending posteromedially, and then turned anterodorsally.

Color (Fig. 2B, C). Carapace: head pale brown, with whitish weak reticulate markings; thoracic region pale beige, with pale brown weak radiating bands. Chelicerae, maxillary lobe, and labium orangish brown. Sternum pale beige, darker towards margins. Legs pale beige, darker distally, without annulations. Abdomen: pale gray, with whitish reticulate markings, dorsally without chevron-like markings.

Subadult (KUZ Z5088). Measurements (mm): CL 2.22; abdomen 2.41 long.

Mouthparts. Chelicerae geniculated, promargin of 3 teeth (median one largest), with basally lateral condyle, and retromargin 4 teeth and 4 denticles on left side, 5 teeth and 4 denticles on right side. Labium wider than long.

Leg macrosetae (left leg). Leg I: tibia p3, r2, v2-2-2-2; metatarsus p4, r1, v2-2-2. Leg II: tibia p4, r0, v2-1-2-2; metatarsus p5, r2, v2-2-1.

Abdomen. Colulus two groups of 2 or 3 setae.

Color. Carapace: head pale brown, with whitish weak reticulate markings; thoracic region pale beige, with pale brown weak radiating bands. Chelicerae, maxillary lobe, and labium light orangish brown. Sternum pale beige, darker towards margins. Legs uniformly pale beige or slightly darker distally, without annulations. Abdomen: pale gray, dorsally without chevron-like markings.

Distribution. This species inhabits the subterranean environment in Osawa-shonyudo Cave, in Niigata Prefecture, Japan.

Retreat. *Cybaeus eremospelyngus* sp. nov. constructs a Y-shaped retreat (Fig. 6); 'V-shaped' retreats were not found in the cave.

Etymology. The specific name is a compound noun in the genitive case derived from the Ancient Greek "eremos" (solitary) and "spelynx" (cave). It refers to the type locality of this new species, which is isolated from large karst regions.

DNA sequences. In total, two sequences were obtained from the subadult specimen (KUZ Z5088), two sequences, COI (202 bp; INSD accession number, LC833823) and 28S (285 bp; LC833824). Due to the insufficient preservation of the specimen, short fragments only could be determined.

Remarks. Cybaeus eremospelyngus sp. nov. has pale body coloration and relatively small eyes. Therefore, this species is considered to be somewhat adapted to hypogean environments. Female morphological characteristics of the



Fig. 6. Retreat of non-type subadult specimen (KUZ Z5088) of *Cybaeus eremospelyngus* sp. nov. Abbreviation: OP, opening of retreat. Scale bar: 5 mm.

new species imply its close relationships with the cavernicolous *C. inagakii.* However, the locality where *C. eremospelyngus* sp. nov. is distributed is distant from the known locality of *C. inagakii*, which has been recorded only from Kurotengu-no-ana Cave, located in the southern part of central Honshu (Ono 2008). As *Cybaeus* species that construct retreats with three openings have never been reported from central Honshu, *C. eremospelyngus* sp. nov. is the first representative of spiders with 'Y-shaped' retreats from this region. A future study should determine DNA sequences of this new species, which are sufficient for estimating its phylogenetic position within the Japanese *Cybaeus*.

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Authors Contributions

Eitaro Matsushita: Data curation; Investigation; Visualization; Writing – original draft; Writing – review & editing. Yoh Ihara: Resources; Supervision; Validation; Visualization; Writing – review & editing. Takafumi Nakano: Conceptualization; Funding acquisition; Investigation; Resources; Supervision; Validation; Writing – review & editing.

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Declarations

Competing interests. The authors declare no conflicts of interest.

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