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First ecological notes on the Waray Dwarf Burrowing Snake, *Levitonius mirus* Weinell et al. 2020, from the shore of a crater lake in Burauen, Leyte, Philippines

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The Philippine-endemic snake family Cyclocoridae (formerly part of Lamprophiidae) includes five genera, eight species, and three subspecies, and was only recently recognised as a distinct evolutionary lineage (Weinell and Brown, 2018; Zaher et al., 2019). The group was initially described as comprising four genera:

1. *Cyclocorus* (Triangle-spotted Snakes), which is distributed on the islands of Sibuyan and Tablas as well as on multiple islands within the Luzon, Mindanao, and Panay Negros Pleistocene Aggregate Island Complexes (PAICs), the Babuyan Island Group, and the islands of Camiguin Sur, Lubang, Mindoro, and Siquijor (Leviton et al., 2018; Pili and del Prado, 2018) and includes two allopatrically-distributed species, *C. lineatus* (Reinhardt, 1843) and *C. nuchalis* Taylor, 1923;
2. *Hologerrhum* (Striped-lipped Snakes), with two species, *H. philippinum* Günther, 1858 and *H. dermali* Brown et al., 2001, and is restricted to the islands of the Luzon PAIC (Luzon, Marinduque, Catanduanes, and Polillo), Panay Island of the Panay Negros PAIC, and Sibuyan Island of the Romblon Island Group (Leviton et al., 2018);
3. *Oxyrhabdium* (Philippine Burrowing Snakes) with two species, *O. leporinum* (Günther, 1858) and *O. modestum* (Duméril, 1853), which occur on multiple islands within the Luzon, Mindanao, and Panay Negros PAICs, the Babuyan Island Group, and the islands of Camiguin Sur, Lubang, Mindoro, and Siquijor (Leviton et al., 2018; Weinell and Brown, 2018); and
4. *Myersophis* (Philippine Mountain Snakes) which consists of a single poorly known species, *M. alpestris* Taylor, 1963, known only from the mountains of northern and central Luzon Island (Leviton et al., 2018).

Recently, Weinell and colleagues described a new genus and species of cyclocorid from the Philippines, the Waray Dwarf Burrowing Snake, *Levitonius mirus* Weinell et al., 2020. An endemic snake recorded only on the islands of Samar and Leyte (Weinell et al., 2020; Diesmos, 2022; Sy, 2023). *Levitonius mirus* is miniaturised (Weinell et al., 2020) and is the smallest species in the Elapoidea lineage. Individuals of *L. mirus* may be confused with juveniles of species of *Cyclocorus*, *Hologerrhum*, *Myersophis*, and *Oxyrhabdium*, as well as adults and juveniles of species of *Calamaria* and *Pseudorabdion*, due to their superficially similar appearance and fossorial habitat. However, *L. mirus* differs from all species of *Calamaria*, *Myersophis*, *Oxyrhabdium*, and *Pseudorabdion* by possessing unpaired subcaudal scales (Weinell et al., 2020) and is distinct from all species of *Cyclocorus* and *Hologerrhum* (which also have unpaired subcaudals) by having a smaller adult body size, a narrower snout, five supralabials (vs. seven or eight), and 15 longitudinal rows of dorsal scales (vs. 17).

Levitonius mirus was described from three museum specimens that had previously been misidentified as members of *Calamaria* or *Pseudorabdion*. The holotype, an adult male, was collected in the Barangay San Rafael, Taft, Eastern Samar Province, Samar Island, Philippines (elevation 187 m above sea level) in June 2014 (Weinell et al., 2020). The two paratypes, an adult female and an adult male, were found in Sitio San Vicente, Barangay Kilim, Baybay City, Leyte, Philippines (490 m elevation) in January 2007, and in the Taft Forest of Barangay San Rafael, Taft, Eastern

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Samar, Philippines (188 m elevation) in June 2006, respectively. Currently, the conservation status of this recently-described species is "Data Deficient", as no other specimens, records or sightings have been reported (Diesmos, 2022; Sy, 2023). Here, we report an encounter with a live individual of *Levitonius mirus* along the shore of Lake Mahagnao, Mahagnao Volcano Natural Park in Burauen, Leyte, Philippines. This discovery provides additional data on the distribution and is the first documented live individual of this species.

At around 08:30 h on 5 February 2022, we encountered a small female snake in a pitfall trap (Fig. 2-A) of an array trap set up for a Biodiversity Assessment and Monitoring System (BAMS) activity in the Mahagnao Volcano Nature Park (10.8709°N, 124.8536°E, elevation 438 m elevation) in Burauen, Leyte (Fig. 1). Because we were unfamiliar with the snake, we collected the individual for further investigation. It was eventually preserved in the Visayas State University Museum of Natural History (catalogue number VBM-REP-124).

The ground colouration of the snake's dorsal region, including the lateral surfaces of the head, body, and tail, is brown to pale black, with mottled patches of black pigment on every scale visible to the naked eye. The dorsal scales are smooth and iridescent. Anterior temporal scales and a pair of internasal scales are present. A preocular scale is absent. A loreal scale is present and not in contact with the eye. A mental scale is present and in contact with the anterior chin shields. The subcaudal scales are undivided. An unpigmented transverse bar is present on the head posterior to the eyes which crosses the parietals, anterior temporal, and the fourth and fifth supralabial scales (Fig. 2). Characteristics mentioned above match the description of *L. mirus* by Weinell et al. (2020).

In addition to aspects of the colouration and pattern that agree with the specimens described by Weinell et al. (2020), we describe additional features of colouration and pattern. The snake had a pale black-pigmented dashed line running dorsolaterally on each side from the posterior of the head to the tail (Fig. 2A); a vibrant orange colouration to the ventral scales from the posterior of the head to the end of the tail, with a notable black semi-solid straight line bordering each side of most of the

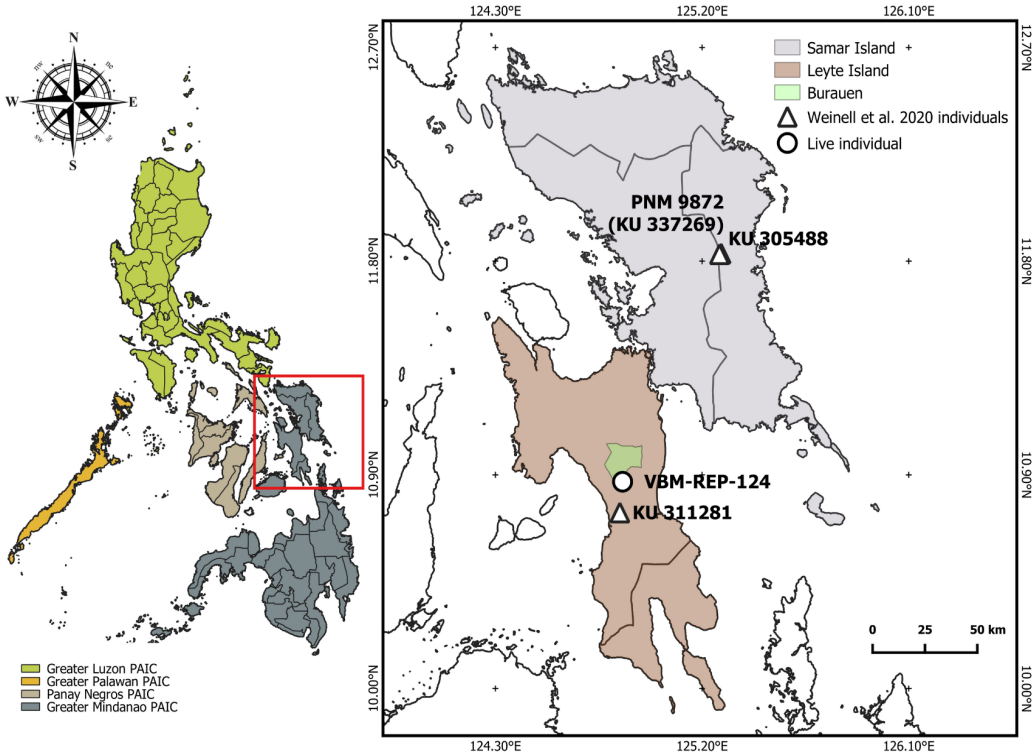

Figure 1. Map showing the recorded locations of the recently discovered new genus and species *Levitonius mirus* in Leyte and Samar Island, Philippines.

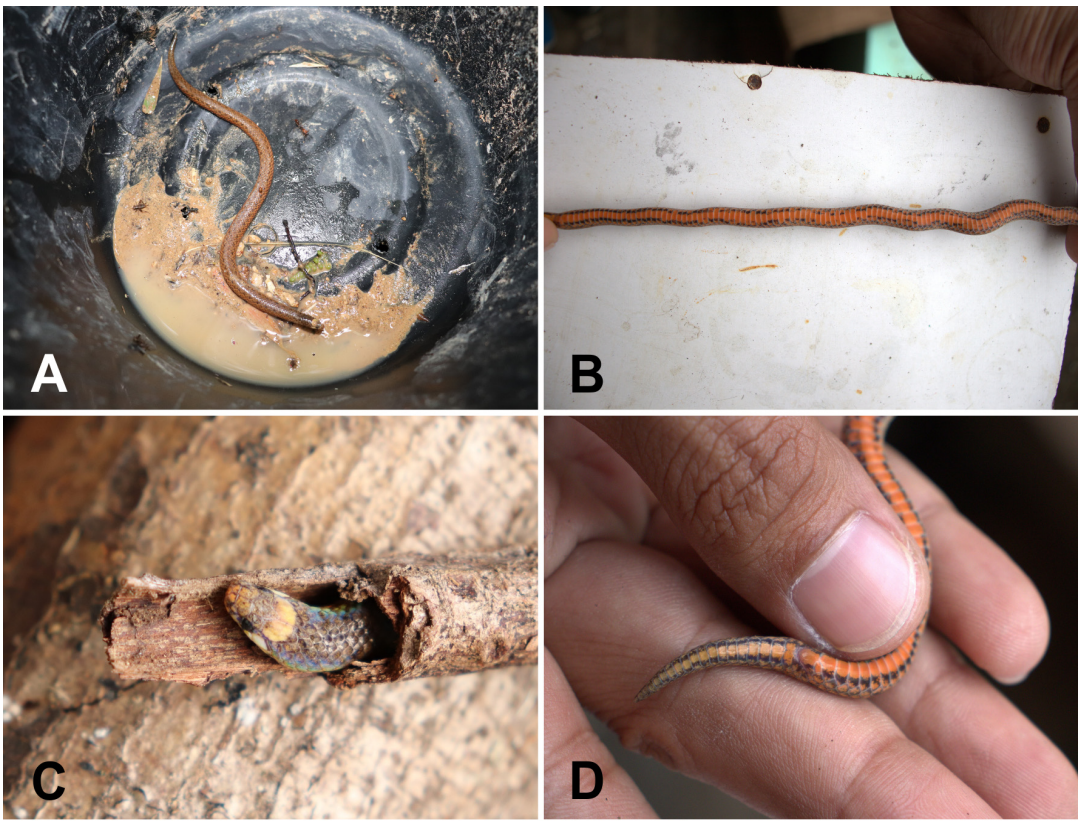

Figure 2. Photos of the live *Levitonius mirus*. (A) Female *L. mirus* captured in the pitfall trap of a single-array trap positioned along the shore of Lake Mahagnao in Burauen, Leyte, Philippines. (B) Ventral view showing orange colour with semi-solid black line bordering ventral scales from head to tail including subcaudal scales. (C) Dorsal view of the head showing its narrow shape, which is characteristic of the genera *Levitonius*, *Myersophis*, and *Oxyrhabdium* (Weinell et al., 2020). (D) Ventral view of the tail showing half ventral scale, unpaired subcaudal scales and undivided anal scale. Photos by Chester Breech Cuta (A, B) and Ris Menoel Modina (C, D).

Table 1. Comparison of meristic and mensural data of the Lake Mahagnao *Levitonius mirus* individual (VBM-REP-124) to the specimens of Weinell et al. (2020); scale counts: longitudinal dorsal scale rows (anterior body: midbody: posterior body); ventral scales; subcaudal scales; supralabial scales; and infralabial scales.

	Lake Mahagnao individual (VBM-REP-124)	**PNM 9872 (KU 337269)**	**KU 305488**	**KU 311281**
Type	live	holotype	paratype	paratype
Sex	female	male	male	female
Dorsal	15:15:15	15:15:15	15:15:15	15:15:15
Ventral	123	107	124	122
Subcaudals	19	30	31	17
Supralabials	5	5	5	5
Infralabials	6	6	6	6
Snout-vent length (mm)	168.0	136.0	137.7	153.0
Tail length (mm)	23.0	29.5	25.3	16.1
Total length (mm)	191.0	165.5	163.0	172.1

ventral scales (Fig. 2B); and a jet-black round eye (Fig. 2C). These characteristics were not observed by Weinell et al. (2020) as all three specimens had been subjected to ethanol-based preservation.

Furthermore, we compared our meristic and mensural data to those from the specimens of *L. mirus* from Weinell et al. (2020) (Table 1). We used the female paratype specimen KU 311281 for comparison because PNM 9872 and KU 305488 are males. In addition, specimen KU 311281 was collected from Baybay City, Leyte, approximately 14 km south of Mahagnao Volcano Nature Park on the other side of Mount Pangasugan. The total length (from tip of snout to end of tail) was 191.0 mm (vs. 172.1 mm for the paratype specimen KU 311281); snout-vent length 168.0 mm (vs. 153.0 mm); tail length 23.0 mm (vs. 16.1 mm); 15 longitudinal rows of dorsal scales (anterior body: midbody: posterior body) throughout the length of the body (same as KU 311281); 123 ventral scales (not including the half ventral scale anterior to the anal scale; Fig. 2D) (vs. 122); 19 unpaired subcaudal scales (vs. 17); and five supralabial and six infralabial scales.

The location of the single-array trap was approximately 15 meters from the lake shoreline. Moderate to heavy rainfall occurred the night before. The water-saturated soil around the lake could have led the *L. mirus* to emerge from underground and become trapped. The dominant vegetation along the lake was mainly composed of *Schizostachyum lumampao* (locally known as Bagakay) (Fig. 3). Other common flora includes *Eleocharis dulcis, Metroxylon sagu*, *Cocos nucifera, Ficus septica, Caryota* sp.*, Diplazium esculentum, Calamus* sp., and *Senna alata* (DENR, 2022). A thick layer of dead leaves from *S. lumampao* matching the colour of the snake would have made it almost impossible for observers to notice the snake during any visual encounter survey in the area. If not for the array trap, it is unlikely that we would have documented the species during our survey.

The new locality is located in one of three legislated protected areas on Leyte Island, which is under the protection of RA 11038 or the Expanded National Integrated Protected Areas System (ENIPAS) Act of 2018. Nonetheless, this legal protection is not fully guaranteed as several anthropogenic threats such as illegal settlers, structures within the 10-meter buffer zone, improper solid waste disposal, and the presence of concrete roads in the perimeter of the lake are present. Snakes are vulnerable to habitat fragmentation by roads (*e.g.,* Row et al., 2007; Blais et al., 2023), though assessing specific threats to *L. mirus* is probably premature.

Figure 3. The location of the single-array trap where the Levitonius mirus was captured in one of the pitfall traps positioned along the shore of Lake Mahagnao. Note the thick vegetation of Schizostachyum lumampao. Photo by Kevin Ray Memoracion.

This study adds to the very limited natural history information for this recently recognised cyclocorid species. Moreover, the discovery of this inconspicuous species highlights the importance of employing multiple methods, including both active and passive sampling, in biodiversity assessments, especially when knowledge of species composition and distribution is an essential step in establishing conservation measures (Hartel et al., 2010). We hope that our observation will strengthen the implementation of existing environmental laws within the protected area by the concerned agencies, including proper regulation and appropriate mitigation measures addressing current threats within the natural park. Finally, we highly recommended conducting more rapid biodiversity assessments in known localities and nearby areas to determine the extent of distribution of *L. mirus* in order to properly protect and conserve this data deficient new endemic snake species.

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