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Occurrence, distribution, and new records of Elmidae genera (Coleoptera: Elmidae) in Honduras

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ABSTRACT

Introduction: The family Elmidae consists of cosmopolitan aquatic beetles that primarily inhabit lotic environments, especially in fast-flowing areas, which is why they are known as riffle beetles. In Honduras, the earliest species records date back over 50 years, with some genera being mentioned in studies of aquatic macrofauna. However, a systematic review of their diversity and distribution had never been conducted.

Objective: To characterize the occurrence of Elmidae genera in Honduras, presenting data on their abundance and distribution along new records.

Methods: We conducted surveys from 2017 to 2023 at 63 sites, ranging from 97 to 1 644 meters above sea level, across both the Atlantic and Pacific slopes. Additionally, we conducted a literature review that included peer-reviewed papers, as well as theses and technical reports.

Results: A total of 1 948 adult organisms were identified, and eleven genera were recorded. Nine of these belonged to the subfamily Elminae: *Austrolimnius*, *Cylloepus*, *Heterelmis*, *Macrelmis*, *Microcylloepus*, *Neocylloepus*, *Neelmis*, *Stenelmoides* and *Xenelmis*, and two to the subfamily Larainae: *Phanocerus* and *Hexanchorus*. The distribution range of six genera was extended, and three were recorded for the first time in Honduras.

Conclusion: Current knowledge of Elmidae in Honduras is still limited, as most records come from adult specimens collected on the Pacific slope. Expanding sampling efforts to include the Atlantic slope, larval stages, and a wider range of lotic and lentic microhabitats, combined with species-level identification and molecular approaches, will be essential to achieve a more comprehensive understanding of the diversity, distribution, and ecological patterns of Elmidae in the country.

Key words: benthic insect; new records; tropical rivers; altitudinal gradient; biodiversity conservation.



RESUMEN

Presencia, distribución y nuevos registros de géneros de Elmidae (Coleoptera: Elmidae) en Honduras

Introducción: La familia Elmidae está compuesta por escarabajos acuáticos cosmopolitas que habitan principalmente en ambientes lóticos, especialmente en áreas de corrientes rápidas, razón por la cual se les conoce como “escarabajos de los rápidos”. En Honduras, los primeros registros de especies datan de hace más de 50 años, con algunos géneros mencionados en estudios sobre macrofauna acuática. Sin embargo, nunca se había realizado una revisión sistemática de su diversidad y distribución.

Objetivo: Caracterizar la presencia de los géneros de Elmidae en Honduras, presentando datos sobre su abundancia y distribución, junto con nuevos registros.

Métodos: Se realizaron muestreos entre 2017 y 2023 en 63 sitios, abarcando un rango altitudinal de 97 a 1 644 metros sobre el nivel del mar, en ambas vertientes, Atlántica y Pacífica. Además, se efectuó una revisión bibliográfica que incluyó artículos revisados por pares, así como tesis y reportes técnicos.

Resultados: Se identificaron un total de 1 948 individuos adultos, pertenecientes a once géneros. Nueve de ellos corresponden a la subfamilia Elminae: *Austrolimnius*, *Cylloepus*, *Heterelmis*, *Macrelmis*, *Microcylloepus*, *Neocylloepus*, *Neelmis*, *Stenelmoides* y *Xenelmis*; y dos a la subfamilia Larainae: *Phanocerus* y *Hexanchorus*. Se amplió el rango de distribución de seis géneros y se registraron tres por primera vez en Honduras.

Conclusión: El conocimiento actual sobre Elmidae en Honduras sigue siendo limitado, ya que la mayoría de los registros proviene de ejemplares adultos recolectados en la vertiente del Pacífico. Ampliar los esfuerzos de muestreo para incluir la vertiente del Atlántico, las etapas larvales y una mayor variedad de microhábitats lóticos y lénticos, junto con identificaciones a nivel de especie y el uso de herramientas moleculares, será esencial para lograr una comprensión más completa de la diversidad, distribución y patrones ecológicos de Elmidae en el país.

Palabras clave: insectos bentónicos; nuevos registros; ríos tropicales; gradiente altitudinal; conservación de la biodiversidad.

INTRODUCTION

The family Elmidae Curtis, 1830, also known as riffle beetles, comprises aquatic beetles predominantly found in lotic environments (Brown, 1987). These beetles generally inhabit fast-flowing waters at depths of less than two meters (Elliott, 2008). However, some species occur in lentic environments (Hinton, 1940), subterranean habitats (Spangler, 1981), or thermal waters (Brown, 1987). All Elmidae species have aquatic larvae that undergo six to eight instars, depending on the genus, followed by a pupal stage that is always terrestrial (Elliott, 2008). The complete life cycle of Elmidae can span between two to five years or longer (Seagle, 1980). Elmidae is divided into two subfamilies, Elminae and Larainae, comprising together 149 genera (Jäch & Balke, 2008) and 1 500 species to date (Jäch et al., 2016). In the Neotropical region, 51 genera and approximately 500 species are known (Polizei et al., 2022). However, our understanding of Elmidae in the Neotropics remains limited, primarily due to

the small number of researchers focusing on this group (Manzo, 2013).

Honduras is located in Central America, covering a territorial area of 112 777 km², and is politically divided into 18 departments. It is bordered by the Caribbean Sea to the North, Nicaragua to the East, the Gulf of Fonseca, El Salvador, and Nicaragua to the South, and Guatemala and El Salvador to the West. The family Elmidae has not been extensively studied in Honduras, with taxonomic knowledge primarily based on records by Brown (1970), Spangler & Santiago (1985), and Spangler & Perkins (1989). Additional studies have reported some genera within the context of water quality bioassessment. To date, the literature references a total of eight genera and four species. However, a comprehensive review of the presence and distribution of this group in Honduras is still lacking.

Our study aims to characterize the occurrence of Elmidae genera in Honduras, presenting data on their abundance and distribution through new records. This study represents

the first attempt to organize and synthesize the existing knowledge of the group, providing a valuable tool for the management and conservation of biodiversity in the country.

MATERIALS AND METHODS

Study area: Honduras features an altitudinal range that varies from sea level up to 2 849 meters above sea level, with average annual precipitation fluctuating between 902.2 and 3 297.7 mm (Oviedo et al., 2017). The country has 25 basins, subdivided into 133 sub-basins and 6 845 micro-basins, distributed across two main drainage slopes: the Atlantic and the Pacific (Monserate et al., 2017). For this study, data were collected from sampling conducted at 63 sites distributed across the Atlantic and Pacific slopes of the national territory (Fig. 1). The samplings took place between October 2017 and January 2023, covering eight basins and 15

sub-basins within an altitudinal range between 97 to 1 644 meters above sea level.

Sampling and Elmidae occurrence

records: At each site, a 15 m section was established, where sampling was conducted using a 500 µm mesh D-frame hand net. Samples were collected from three different substrates: cobble and organic debris in riffles (CODR), root mats and organic debris accumulations in riparian zones (RODRZ), and sand and silt deposition in low-velocity zones (SSLVZ). Each substrate was sampled for five minutes, with the collected material placed in high-density plastic bags filled with 70 % ethanol. Each bag was labeled with the site code, date, and microhabitat.

The collected organisms were separated and cleaned using a stereoscopic microscope. Adult Elmidae were identified using the taxonomic key by Passos et al. (2018) and original genus descriptions by Brown (1970). Given the lack of reference collections and species

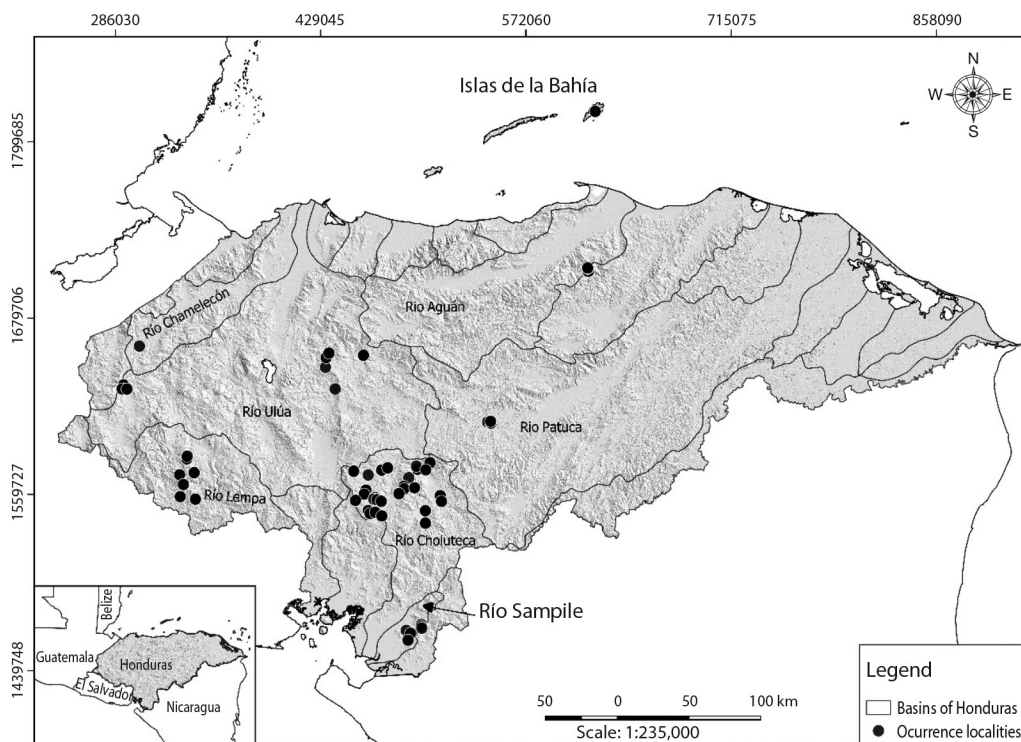


Fig. 1. Occurrence data of Elmidae genera in Honduras.

taxonomic keys for species occurring in Honduras, identification was limited to the genus level. Specimens were deposited in the aquatic macroinvertebrate collection of the Hydrobiology Laboratory at the National Autonomous University of Honduras (UNAH).

We conducted a literature review to complement the data obtained from the collections, focusing on previous studies that recorded Elmidae genera in Honduras. Abundance graphs were generated for each genus, basin, sub-basin, and substrate. Additionally, we constructed an altitudinal range graph for the recorded genera. To evaluate sampling completeness and compare diversity patterns between slopes, individual-based rarefaction and extrapolation curves were generated using the iNEXT package (Hsieh et al., 2016), considering Hill numbers of order $q = 0$ (genera richness), $q = 1$ (Shannon–Wiener diversity), and $q = 2$ (Simpson diversity) based on abundance data. All analyses were performed within the R statistical programming environment v.4.5.2 (R Core Team, 2025). A map of genus occurrence sites in Honduras was produced using QGIS v.3.44.7 (QGIS Development Team, 2026).

RESULTS

From the conducted samplings, 1 948 organisms were identified, representing a total of nine genera, eight from the subfamily Elminae and one from the subfamily Larinae. The most abundant genera were *Microcylloepus* Hinton, 1935, with 936 individuals (48.05 %), and *Heterelmis* Sharp, 1882, with 503 individuals (25.82 %) (Fig. 2). In contrast, the least abundant genera were *Phanocerus* Sharp, 1882, with three individuals (0.15 %), followed by *Austrolimnius* Carter & Zeck, 1929, with seven individuals (0.36 %) and *Cylloepus* Erichson, 1847 with 20 individuals (1.03 %).

Sampling effort was greater in the Pacific slope, where 45 sites were surveyed and a total of 1 480 individuals were recorded, whereas 18 sites were sampled in the Atlantic slope, yielding 468 individuals. A total richness of nine genera was recorded in both slopes (Fig. 3). The genera rarefaction / extrapolation curve reached an asymptote in the Pacific slope, indicating that sampling effort was sufficient to adequately characterize genera richness in this region, in contrast to the Atlantic slope, which exhibited a steeper curve. Rarefaction / extrapolation curves for the Shannon–Wiener (H') and Simpson

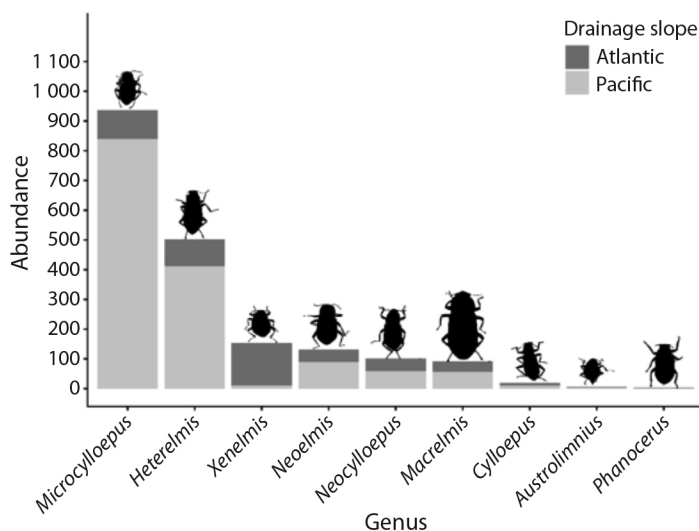


Fig. 2. Occurrence data of Elmidae genera in Honduras.

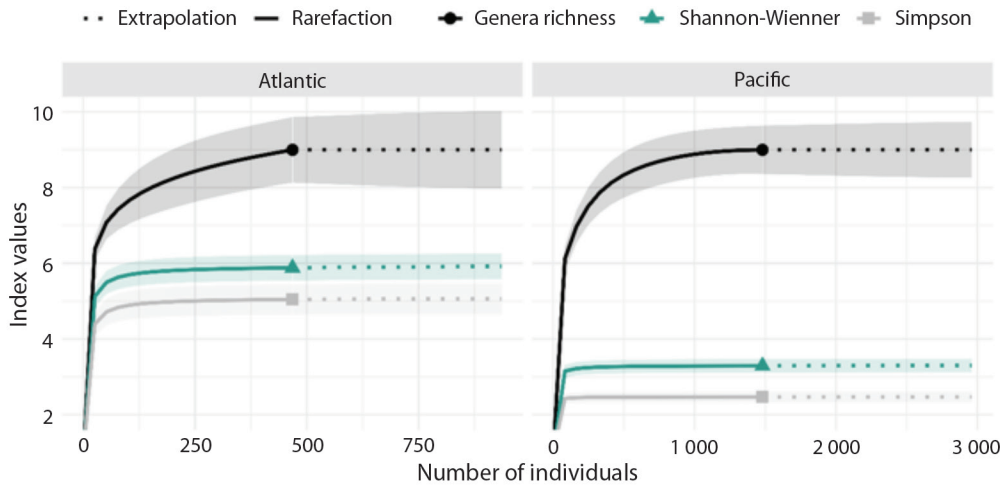


Fig. 3. Accumulation curve of genera in each drainage slope.

(D) indices reached asymptotes in both slopes; however, higher diversity values were observed in the Atlantic ($H' = 5.88$, $D = 5.04$) compared to the Pacific ($H' = 3.29$, $D = 2.46$)

The highest abundance of individuals among the sampled basins was recorded in the río Choluteca, with 1 390 individuals (71.31 %), followed by the río Aguán basin, with 318

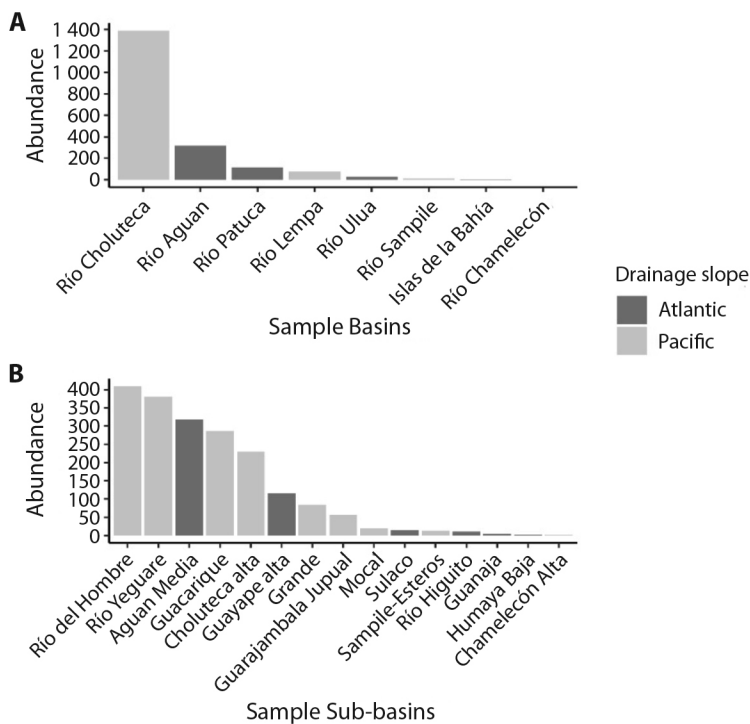


Fig. 4. Abundance of Elmidæ in Honduras. **A.** Abundance of Elmidæ family in each basin in Honduras. **B.** Abundance of the Elmidæ family in each sampled sub-basin in Honduras.



individuals (16.32 %) (Fig. 4A). Conversely, the lowest number of individuals were collected in the río Chamelecón and Islas de la Bahía basins, with one individual (0.05 %) and five individuals (0.25 %), respectively. Regarding the sub-basins, the highest abundance was observed in the río del Hombre, with 409 individuals (20.99 %), followed by the río Yeguaré and Aguán media, with 380 individuals (19.90 %) and 318 individuals (16.32 %), respectively (Fig. 4B). In contrast, the sub-basins with the lowest abundance were Chamelecón alta, with one individual (0.05 %), Humuya baja, with two individuals (0.10 %), and Guanaja, with five individuals (0.26 %).

Except for *Phanocerus*, all genera showed higher abundance in the CODR, where 1 464 individuals (75.15 %) were recorded (Fig. 5). In the RODRZ, 456 individuals (23.41 %) were recorded. In contrast, only 28 individuals (1.44 %) were observed in the SSLVZ microhabitat.

Elmidae genera were distributed across an altitudinal range of 97 to 1 644 meters above sea level. *Heterelmis* (202-1 644 m.a.s.l.) and *Microcylloepus* (257-1 644 m.a.s.l.) exhibited the widest altitudinal ranges (Fig. 6). In contrast, the genera with more restricted altitudinal ranges were *Austrolimnius* (590-1 313 m.a.s.l.) and *Xenelmis* Hinton, 1936 (590-1 327

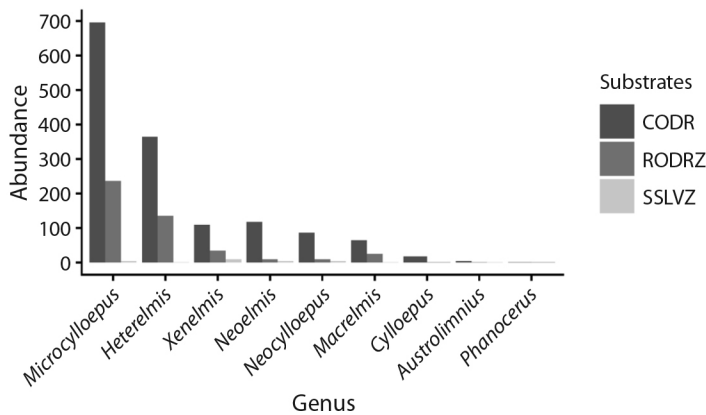


Fig. 5. Abundance of Elmidae genera by substrates. Cobble and organic debris in riffles (CODR), root mats and organic debris accumulations in riparian zones (RODRZ), sand and silt deposition in low-velocity zones (SSLVZ).

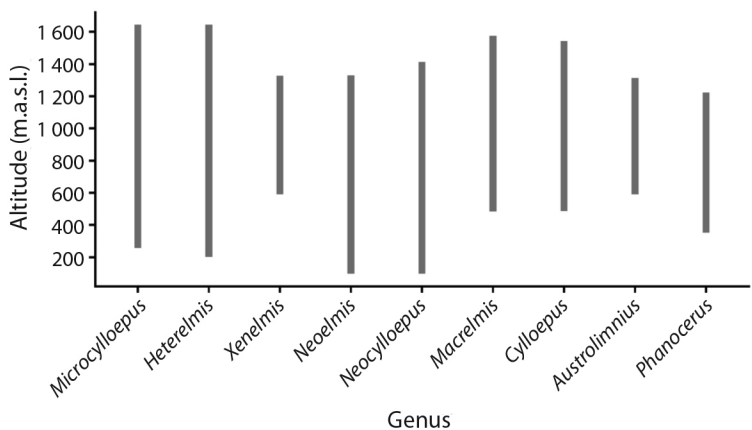


Fig. 6. Altitudinal distribution range of each Elmidae genus in Honduras.

Table 1
Occurrence of Elmidae genera in basins of Honduras.

Family Elmidae	Reference	Basins							
		CHO	AGU	PAT	LEM	ULU	SAM	IBA	CHA
Sub family Elminae									
* <i>Austrolimnius</i> Carter & Zeck, 1929	New record								
* <i>Cylloepus</i> Erichson, 1847	New record								
<i>Heterelmis</i> Sharp, 1882	López et al. (2010)								
<i>Macrelmis</i> Motschulsky, 1859	Spangler & Santiago (1985)								
<i>Microcylloepus</i> Hinton, 1935	López et al. (2010)								
<i>Neocylloepus</i> Brown, 1970	Brown (1970)								
* <i>Neelmis</i> Musgrave, 1935	New record								
<i>Stenhelmoides</i> Grouvelle, 1908	Spangler & Perkins (1989)								
<i>Xenelmis</i> Hinton, 1936	López et al (2010)								
Sub family Larainae									
<i>Hexanchorus</i> Sharp, 1882	López et al. (2010)								
<i>Phanocerus</i> Sharp, 1882	Spangler & Santiago (1992)								

Shaded boxes indicate genus presence, while “*” indicates new records for the country. CHO (río Choluteca), AGU (río Aguán), PAT (río Patuca), LEM (río Lempa), ULU (río Ulua), SAM (río Sampile), IBA (Islas de la Bahía), CHA (río Chamelecon). Distribution maps for the nine Elmidae genera collected during this study are available in supplementary material (SMF1).

m.a.s.l.). *Neocylloepus* Brown, 1970 and *Neelmis* Musgrave, 1935 also showed broad altitudinal ranges; additionally, these were the genera recorded at the lowest altitude (97 m.a.s.l.).

The genera *Heterelmis*, *Macrelmis* Motschulsky, 1859, and *Microcylloepus* were collected in 67 % of the sampled basins (Table 1). In contrast, *Stenhelmoides* Grouvelle, 1908 and *Hexanchorus* Sharp, 1882 were found in only one basin each. Most genera were recorded in the basins of río Choluteca (CHO), río Aguán (AGU), and río Patuca (PAT), whereas fewer were found in the río Chamelecón (CHA) and Islas de la Bahía (IBA) basins (Table 1).

DISCUSSION

Previous records of Elmidae genera in Honduras included *Neocylloepus sculptipennis* (Brown, 1970), *Macrelmis leonilae* (Spangler & Santiago, 1985), *Stenhelmoides rufulus* (Spangler & Perkins, 1989), and *Phanocerus clavicornis* (Spangler & Santiago, 1992). Other genera, such as *Heterelmis*, *Hexanchorus*, *Microcylloepus*, and *Xenelmis* were mentioned in publications

related to aquatic macrofauna (López et al., 2010). This note adds three more genera for the country: *Austrolimnius*, *Cylloepus*, and *Neelmis*. Furthermore, the distribution range for six of the eight genera previously recorded in Honduras has expanded, except for *Stenhelmoides* and *Hexanchorus*, which were not collected during our study. *Austrolimnius* and *Cylloepus* have been previously recorded in Belize (Shepard, 2004), Guatemala, Costa Rica, and Panama (Sharp, 1882; Hinton, 1934; Hinton, 1971), while *Neelmis* had only been recorded in Guatemala (Sharp, 1882). *Stenhelmoides*, *Neocylloepus*, and *Phanocerus* are reported across the Central American region, except in El Salvador (Hinton, 1934; Spangler & Perkins, 1989). *Macrelmis* has occurrence records for Guatemala, Honduras, and Costa Rica (Sharp, 1882; Spangler & Santiago, 1985).

All genera were most abundant on substrates composed of cobble and organic debris in riffles. Elmidae aquatic beetles are primarily detritivores, feeding mainly on plant material (Elliott, 2008). Their increased abundance may be linked to the availability of this food source



and cobble substrates, which provide interstitial spaces for refuge and surfaces for algae and moss (Fujiwara et al., 2022). Regarding their altitudinal distribution, *Microcylloepus* and *Heterelmis* were the most abundant genera and showed the widest altitudinal ranges. The broad distribution of *Microcylloepus* in the Americas and its ability to occupy multiple substrates may partly explain its abundance in our study (González-Córdoba et al., 2020a). *Heterelmis* is commonly associated with shallow, fast-flowing habitats with coarse substrates, and its generalist habits and tolerance to reduced dissolved oxygen may allow it to persist under variable environmental conditions (Bowles et al., 2003; González-Córdoba et al., 2020b). In contrast, *Phanocerus* was the least abundant genus. As a member of the subfamily Larainae, *Phanocerus* adults are typically found in riparian zones or along the margins of water bodies (Brown, 1987). Because our sampling targeted primarily aquatic microhabitats (CODR, RODRZ, SSLVZ), we may have introduced a bias, potentially limiting the capture of *Phanocerus* individuals. Nevertheless, *Phanocerus* altitudinal range was not the narrowest, aligning with other studies conducted in the Neotropical region that report a wide altitudinal range for this genus (González-Córdoba et al., 2020a).

Current records of Elmidae genera so far are mainly limited to adult-stage specimens and samples from the Pacific slope, especially in basins located in the central, Southern, and Western regions of Honduras. To improve our understanding of Elmidae diversity and distribution in the country, future efforts should also include the larval stages and increase sampling efforts on the Atlantic slope, particularly in the Northern and Eastern regions. Additionally, species-level identifications are needed, as existing knowledge remains limited. Achieving this will require increased collaboration with taxonomic experts and the use of molecular techniques. Finally, we recommend that future studies sample a wider variety of microhabitats in lotic environments, such as the margins of water bodies and the transitions between

aquatic and terrestrial habitats, and consider lentic environments, favoring the probability of capturing Elmidae specimens with diverse ecological habits. This approach will provide a more comprehensive representation of Elmidae diversity in Honduras.

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See supplementary material
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