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Preliminary List of Carabidae and Cicindelidae (Coleoptera) Fauna in Lake Holon, T'boli, South Cotabato, Philippines

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Abstract

Lake Holon in T'Boli, South Coatabato is one of the least entomologically explored areas in Mindanao Island. Through the Biodiversity Assessment of Lake Holon project, a rapid coleopterological assessment was conducted in the lake between April 7-14, 2019 and October 14-18, 2019. Collections were carried out in five stations particularly on the west part of the lake. Hand-netting, standard light-trapping, and leaf-litter sifting were employed. The hand-netting and leaf-litter sifting methods were utilized for diurnal species. A total of 13 species belonging to 9 genera were documented of which seven (7) or 54% belonging to family Carabidae and six (6) or 46% from the family Cicindelidae. None of the collected species under the family Carabidae are endemic. However, four out of the six (6) Cicindelidae species are endemic in the Philippines wherein three (3) species are strictly confined in Mindanao. In addition, 3 species of tiger beetles are listed as Threatened based on DAO (2019), namely *Calomera mindanaoensis* Cassola, 2000, *Heptodonta nigrosericea* (W. Horn, 1930) and *Therates coracinus coracinus* Erichson, 1834. For Carabidae, none of the identified species are considered threatened. More coleopterological surveys is needed to increase this list and strengthened implementation of its conservation initiatives should be conducted.

***Keywords**:* Assessment, Ground Beetles, Lake Holon, Mindanao, Tiger Beetles.

Introduction

Philippines, alongside Indonesia and Malaysia, is one of the Southeast Asian member countries that is included in the 18 megadiverse countries in the world in terms of species richness and endemicity (Heaney & Regalado, 1998; Myers, Mittermeier, Da Fonseca, & Kent, 2000; Posa, Diesmos, Sodhi, & Brooks, 2008; Keong, 2015). The country is made up of 7,641 islands (Suh & Pomeroy, 2020), which are inhabited by a unique and diverse species of flora and fauna. Entomologically, the Philippines is still poorly explored wherein the majority of the insect groups are significantly understudied (Medina et al., 2019) resulting in data deficiency to most beetle families including Carabidae (ground beetles) and Cicindelidae (tiger beetles) (Cabras & Wiesner, 2016; Kavanaugh et al., 2014).

Carabidae has over 40,000 identified species (Lövei and Sunderland, 1996) and is considered the largest family in the suborder Adephaga (Kromp, 1999). In the Philippines, over 626 extant

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species belonging to 164 genera under 20 subfamilies (Anichtchenko, 2020) were documented. Species to this family are characterized by their predatory behavior feeding mostly on other insects and arthropods (Kromp, 1999). Family Cicindelidae (tiger beetles) were once classified under the subfamily Cicindelinae in the family Carabidae (Gough et al., 2018), but with an extensive morphological and molecular analysis, it is placed as a separate family Cicindelidae (López-López & Vogler, 2017; Duran et al., 2018). In the Philippines, there are 155+ tiger beetle species recorded from the Philippines represent about 5.0% of the 2,840 species known worldwide with 90% endemism (Cabras et al., 2016; Zettel & Wiesner, 2018; Medina et al., 2019; Anichtchenko & Medina, 2019) mostly occupying unique and restricted habitats (Medina et al., 2019; Cabras et al, 2016;).

Mindanao, the second largest island in the Philippines, located at the southern portion of the country is home to unique species of flora and fauna occupying different habitat types. Based on faunal and floral distributional range, the island is divided into four sub-regions, including Eastern Mindanao, Bukidnon Highlands, Zamboanga, and Cotabato (Diesmos & Brown, 2009). One of the most ecologically rich areas in Mindanao is the Allah Valley mountain range which is comprised of 4,250.37 km^2 that traverses South Cotabato and Sultan Kudarat (Alampay et al., 2016). It is home to various magnificent landscapes and waterscapes such as mountains, caves, waterfalls, hot springs, and lakes which are not previously entomologically explored.

Part of the Allah Valley mountain range is the highly coveted-tourist area - The Lake Holon [6°06'00"N, 124°53'20" E, 1,339 meters above sea level] in Mt. Parker or locally known as Mt. Melibengoy in Barangay Salacafe, T'Boli, South Cotabato Philippines. It is a stratovolcano that runs along the Sangihe volcanic arc part of the quaternary volcanic chain that stretches from Sulawesi in Indonesia up to Central Mindanao (Bayon & Salonga, 1992). Lake Holon is a 300-hectare wide placid body of water formed by the eruption of Mt. Parker in 1641.

At present, there is no available data on Carabidae and Cicindelidae fauna for Lake Holon. Hence, this paper provide the baseline list of Carabidae and Cicindelidae fauna in the area.

Materials and methods

Pursuant to the Republic Act 9147 otherwise known as Philippine Wildlife Resources Conservation and Protection Act of 2004, a wildlife Gratuitous Permit (GP) was secured before the data collection. The permit was acquired by the third author. Lake Holon campsite is a 2-hour trek from the receiving area through the Salacafe trail. The sampling periods was conducted on April 7-14, 2019 and October 14-18, 2019. Collections was carried out in five stations on the west part of Lake Holon including Kutong Busaw viewdeck (6°06'02"N 124°52'48"E), main campsite (6°05'49"N 124°52'57"E), Kule Trail (6°05'42"N 124°52'47"E), the river that drain the lake (6°06'27"N 124°52'31"E), and an area in the south-western portion of the lake (6°05'29"N 124°53'10"E) (Fig. 1). Hand-netting, standard light-trapping, and leaf-litter sifting were employed in specimen collections. The hand-netting and leaf-litter sifting methods were utilized for diurnal species (Cabras et al., 2016; Koivula, 2011). Light-traps were installed in Kutong Busaw view deck and in the main campsite for nocturnal species.

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Voucher specimens were placed in 60ml vial containing 95% ethanol, air dried, pinned, and card-mounted for storage at the Coleoptera Research Center of the University of Mindanao (UMCRC), Davao City Philippines. Specimens were examined and identified using monographs, taxonomic keys, and compared with the recent literatures on tiger beetles (Medina et al., 2020a, 2020b) and carabid beetles in the Philippines (Hackel & Anichtchenko, 2015; Anichtchenko, 2018). Photographs were taken and processed using a Canon EOS 6D camera with a StackShot macro rail package and edited using Adobe Photoshop CS6.

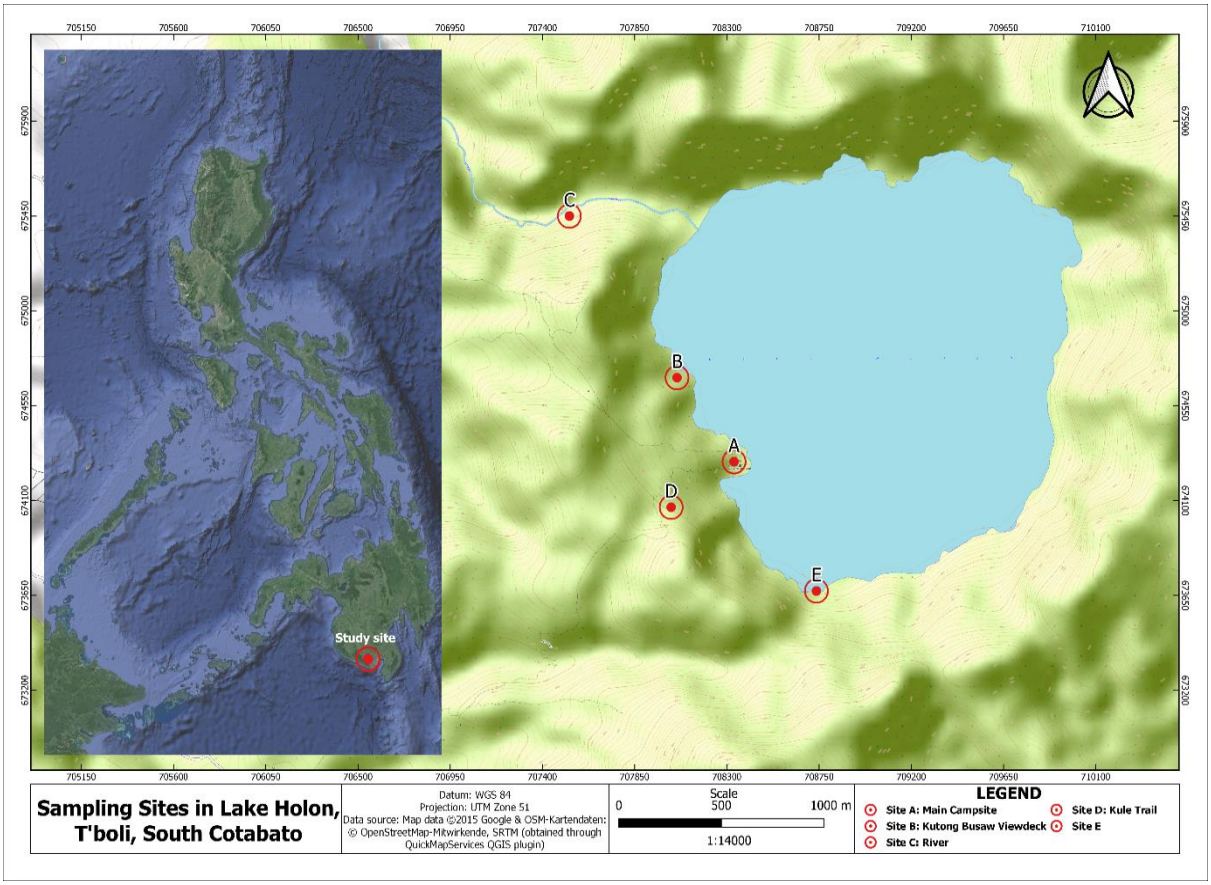

Figure 1. Map of the Philippines showing the location of Lake Holon (right); Study areas in Lake Holon, T'boli, South Cotabato (Left).

Results and discussion

Annotated List of Species

FAMILY CARABIDAE LATREILLE, 1802
Subfamily Platyninae Bonelli, 1810

***Colpodes cf. bennigseni* Sloane, 1907 (Fig. 2A)**
Materials examined. (8 male, 7 female), PHILIPPINES, Mindanao, South Cotabato, Mt. Parker, Lake Holon, [6°06'00"N, 124°53'20" E], 07-14.iv.2019, CRC team leg., UMCRC.

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Distribution. Oriental region: Indonesia (Bali, Java, Celebes), Australian Region: New Guinea (Sloane, 1907; Dobler, 1975), Solomon Islands (Darlington, 1952), Philippines (New Record)
Remarks: This species was collected through a light-trapping method.

***Colpodes cf. laetus* (Erichson, 1834) (Fig. 2B)**
Materials examined. (4 male, 2 female), PHILIPPINES, Mindanao, South Cotabato, Mt. Parker, Lake Holon, [6°06'00"N, 124°53'20" E], 14-18.x.2019, CRC team leg., UMCRC.
Distribution. Oriental region: Philippines (Andrews, 1930), Celebes, Australian Region: New Guinea, Solomons, New Hebrides, Bonin Is. (Darlington, 1970)
Remarks. This species was collected through a light-trapping method. This arboreal species has also been documented to thrive in foliage (Darlington, 1970).

***Colpodes metabolus* Andrews, 1937 (Fig. 2D)**
Materials examined. (1 female), PHILIPPINES, Mindanao, South Cotabato, Mt. Parker, Lake Holon, [6°06'00"N, 124°53'20" E], 07-14.iv.2019, CRC team leg., UMCRC.
Distribution. Oriental Region: Philippines, Indonesia (Bali, Java) (Louwerens, 1956)
Remarks. This species was collected through a light-trapping method. It was also found on a shrub approximately 3 meters away from the riverine area.

***Colpodes sp.* (Fig. 2C)**
Materials examined. (4 female), PHILIPPINES, Mindanao, South Cotabato, Mt. Parker, Lake Holon, [6°06'00"N, 124°53'20" E], 14-18.x.2019, CRC team leg., UMCRC.
Distribution. Oriental region: Philippines: Mindanao (Catigan, Davao City)
Remarks. This species was mainly collected through a light-trapping method. It was also found on a shrub approximately 3 meters away from the riverbank.

***Nesiocolpodes saphyrinus* (Chaudoir, 1879) (Fig. 2E)**
Materials examined. (1 female), PHILIPPINES, Mindanao, South Cotabato, Mt. Parker, Lake Holon, [6°06'00"N, 124°53'20" E], 14-18.x.2019, CRC team leg., UMCRC.
Distribution. Oriental region: Indo-Chinese subregion (Darlington, 1952), Philippines (Mindanao: Chincona Forest Reserve) (Torrejos et al., 2020), Sunda Island, Borneo, Celebes, Australian Region: New Guinea (Jeannel, 1948; Darlington, 1952)
Remarks. This species was collected through a light-trapping method.

Subfamily Harpalinae Bonelli, 1810

***Stenolophus (Egadroma) quinquepustulatus* Wiedemann, 1823 (Fig. 2G)**
Materials examined. (1 male, 1 female), PHILIPPINES, Mindanao, South Cotabato, Mt. Parker, Lake Holon, [6°06'00"N, 124°53'20" E], 07-14.iv.2019, CRC team leg., UMCRC.
Distribution. Oriental region: Pakistan (Jedlicka, 1963), Philippines (Mindanao: Mt. Talomo) (Torrejos et al., 2020), Paleartic region (Southeastern), Australian Region (Northern parts) (Jaeger & Ahmed, 2017).
Remarks. This species was found underneath stone along from the riverbank. An opportunistic sampling method was employed in collecting the specimen.

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Subfamily Licininae Bonelli, 1810

***Chlaenius (Lissauchenius) cf. tetragonoderus* Chaudoir, 1876 (Fig. 2F)**
Materials examined. (1 male, 1 female), PHILIPPINES, Mindanao, South Cotabato, Mt. Parker, Lake Holon, [6°06'00"N, 124°53'20" E], 07-14.iv.2019, CRC team leg., UMCRC.
Distribution. Oriental region: Indonesia (Celebes (Macassar) (Chaudoir, 1876), Mentawai Is., Labuan Bajau (Kirschenhofer, 2013), Sumatra, Java, Moluccas, Borneo (Darlington, 1970), Batjan (Louwerens, 1956), Timor (Darlington, 1970), Siberut Island (Kirschenhofer, 2013), Burma, Philippines (Luzon Island) (Darlington, 1970).
Remarks. Collected during opportunistic sampling through handpicking. This species was previously reported to thrive in rainforest particularly on the ground and not highly restricted in wet areas (Darlington, 1970).

FAMILY CICINDELIDAE LATREILLE, 1802

***Calomera mindanaoensis* Cassola, 2000 (Fig. 3H)**
Materials examined. (14 male, 3 female), PHILIPPINES, Mindanao, South Cotabato, Mt. Parker, Lake Holon, [6°06'27"N 124°52'31"E], 14-18.x.2019, CRC leg.,UMCRC.
Distribution. Mindanao Endemic (Mt. Hamiguitan Range Wildlife Sanctuary; Davao City; Sta. Cruz, Davao Del Sur; Davao De Oro; Mati, Davao Oriental), South Cotabato, Bukidnon, Zamboanga del Norte (Medina et al., 2020; Cabras et al., 2016)
Remarks. This species both epigeic (Medina et al., 2020) and riparian (Medina et al., 2020). was collected using a hand-net while ensconcing on the unshaded portion of the sand 2 meters away from the riverbank. This species has also been previously documented to thrive in patches of secondary forest proximate to open and sandy riverine areas (Cabras & Wiesner, 2016). It was also found in farmland planted with *Zea mays* adjacent to a secondary forest in Salacafe.

***Therates coracinus coracinus* Erichson, 1834 (Fig. 3K)**
Materials examined. (4 male, 3 female), PHILIPPINES, Mindanao, South Cotabato, Mt. Parker, Lake Holon, [6°06'00"N, 124°53'20" E], 7-14.iv.2019, CRC team leg., UMCRC.
Distribution. Oriental species. Philippines: Luzon (Calanasan; Mindoro; Romblon; Palawan; Balabac), Visayas (Samar; Leyte; Panay; Negros), Mindanao (Davao de Oro; Mt. Hamiguitan Range Wildlife Sanctuary; Mati, Davao Oriental; Mt. Apo), Indonesia (Sulawesi, Talaud, Moluccas (Halmahera, Bacan) (Cabras et al. 2016b; Cassola 2000; Medina et al., 2020)
Remarks. This arboreal species (Medina, et al., 2020) was collected using a hand-net while resting on a shrub leaf approximately 1 meter above the ground and 4 meters away from the riverbank. As a riparian species (Medina et al., 2020), it shared a common habitat preference with *Calomera mindanaoensis* (Cassola, 2000) and *Thopeutica rolandmuelleri* (Cassola, 2000). This species has also been reported to thrive in lowland agro-ecosystem particularly in shrubs in shaded riparian areas (Cabras & Wiesner, 2016).

***Therates fasciatus pseudolatreillei* Horn, 1928 (Fig. 3L)**
Materials examined. (2 male, 3 female), PHILIPPINES, Mindanao, South Cotabato, Mt. Parker, Lake Holon, [6°06'00"N, 124°53'20" E], 14-18.x.2019, CRC team leg., UMCRC.
Distribution. Philippines: Mindoro, Mindanao (Zamboanga, Misamis Occidental (Malindang Range) (Horn, 1928; Ballentes et al., 2006; Cabras et al., 2016)

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Remarks. This species was found on a shrub leaf approximately 1 meter above the ground and at least 4 meters away from the riverbank. It was captured using a hand net. This species has also been reported to thrive in agricultural ecosystems (Ballentes, et. al, 2006)

***Thopeutica rolandmuelleri* Cassola, 2000 (Fig. 3M)**
Materials examined. (3 female), PHILIPPINES, Mindanao, South Cotabato, Mt. Parker, Lake Holon, [6°06'00"N, 124°53'20" E], 14-18.x.2019, CRC team leg., UMCRC.
Distribution. Mindanao Endemic: Compostela Valley; Mt. Hamiguitan Range Wildlife Sanctuary (Medina et al., 2020; Cabras & Wiesner, 2016)
Remarks. This epigeic species (Medina et al., 2020) was sighted resting on an unshaded sandy portion approximately 2 meters away from the riverbank. Hand-netting method was employed in the collection of this species. Also, it was previously documented to thrive in open and sandy riparian areas proximate to patches of secondary forest (Cabras & Wiesner, 2016).

***Tricondyla sp.* (Fig. 3J)**
Materials examined. (1 male), PHILIPPINES, Mindanao, South Cotabato, Mt. Parker, Lake Holon, [6°06'00"N, 124°53'20" E], 7-14.iv.2019, CRC team leg., UMCRC.
Remarks. This arboreal species (Medina et al., 2020) was found atop of a shrub plant along the lake and creeping on a branch 2 meters above the ground. It was collected using a hand-net.

***Heptodonta nigrosericea* (W. Horn, 1930) (Fig. 3I)**
Syn. H. lumawigi Wiesner, 1980 (Gorn, 2020)
Materials examined. (2 male, 1 female), PHILIPPINES, Mindanao, South Cotabato, Mt. Parker, Lake Holon, [6°06'00"N, 124°53'20" E], 7-14.iv.2019, CRC team leg., UMCRC.
Distribution. Philippine Endemic: Visayas: Panay (Cabras & Wiesner, 2016); Mindanao: Marilog District, Davao City (Medina et al., 2020), Bukidnon, Compostela Valley, Misamis Occidental, Misamis Oriental, Mt. Hamiguitan Range Wildlife Sanctuary (Cabras & Wiesner, 2016).
Remarks. This arboreal species (Medina et al., 2020) was collected using hand netting and perching among the leaves of shrubs near the secondary dipterocarp forests of Lake Holon.

A total of 13 species belonging to 9 genera were documented of which seven (7) or approximately 53% belong to the family Carabidae and six (6) or 46% belong to the family Cicindelidae. None of the collected species of the family Carabidae are endemic. However, out of the six (6) Cicindelidae species, three (3) species are endemic in Mindanao and one (1) species is Philippine Endemic. In addition, out of the six (6) Cicindelidae species, three (3) are listed as Threatened based on the list reported by DAO (2019), specifically *C. mindanaoensis*, *H. nigrosericea* and *T. coracinus coracinus*. For Carabidae, none of the identified species are considered as Threatened.

All the seven (7) species and four (4) genera of Carabidae documented in Lake Holon are found in both Oriental and Australian regions but significantly distributed in the former. Among the identified species, *C. (L) cf. tetragonoderus, C. cf. laetus, C. metabolus*, *N. saphyrinus* and *S. (E) quinquepustulatus* are common species between the Philippines and Indonesia. A new distribution record has been documented for *C. cf. bennigseni* which is previously known only to New Guinea, Indonesia, and Solomon Islands (Sloane, 1907; Darlington, 1952; Dobler, 1975). This species is typically large which ranges from 18 mm to 21 mm, and have strong green elytral coloration (Darlington, 1952). Recent records of *N. saphyrinus* and *S. (E) quinquepustulatus* have also been noted in Cinchona Forest Reserve, Mt. Kitanglad Range Natural Park, Bukidnon and Mt. Talomo, Davao City (Torrejos et al., 2020).

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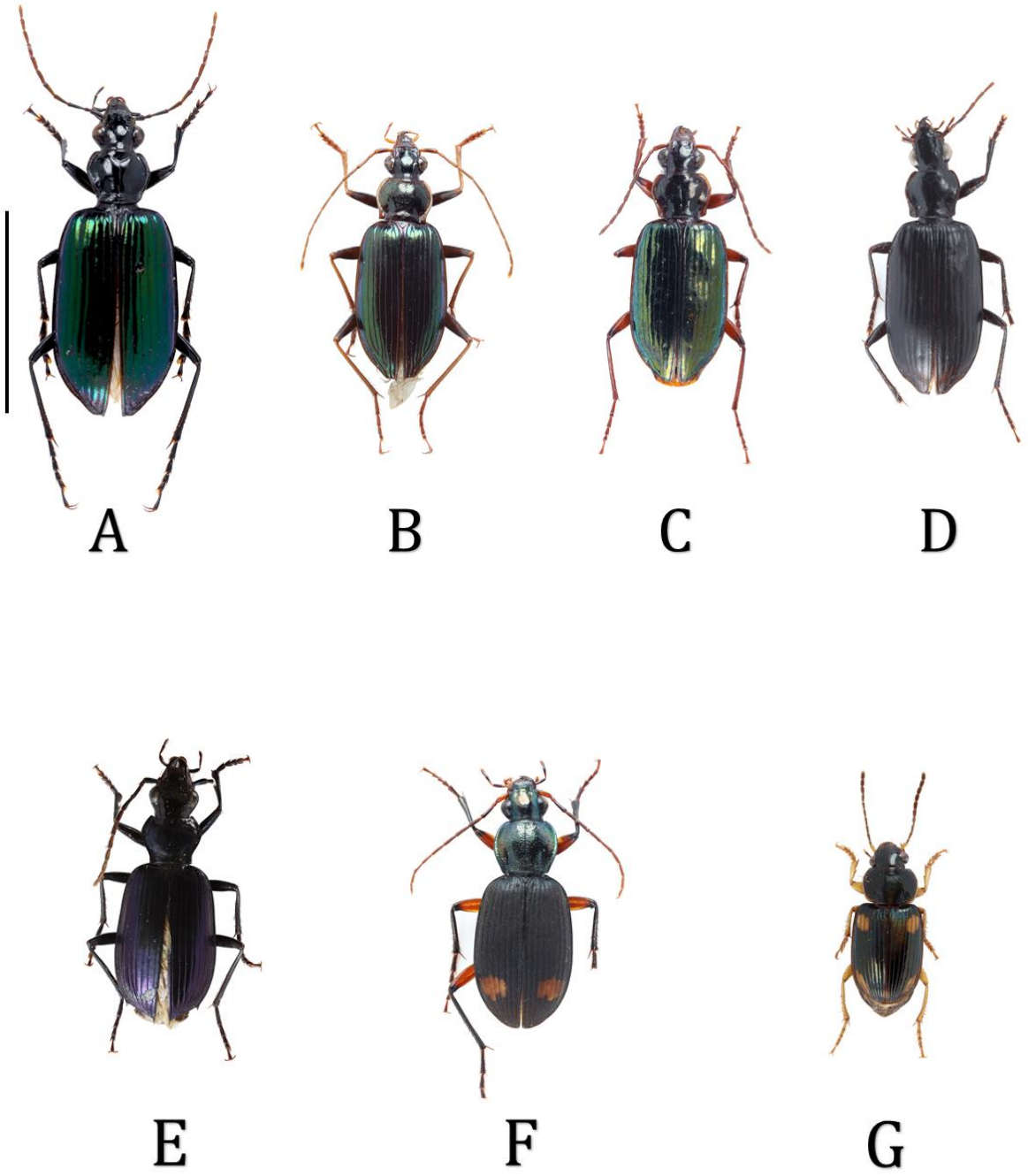

Figure 2A-G. Carabidae fauna in Lake Holon: **A.** *Colpodes cf. bennigseni* Sloane, 1907, **B.** *Colpodes cf. laetus* (Erichson, 1834), **C.** *Colpodes sp.*, **D.** *Colpodes metabolus* Andrews, 1937, **E.** *Nesiocolpodes saphyrinus* (Chaudoir, 1879), **F.** *Chlaenius (Lissauchenius) cf. tetragonoderus* Chaudoir, 1876, **G.** *Stenolophus (Egadroma) quinquepustulatus* Wiedemann, 1823. Scale bar 10 mm.

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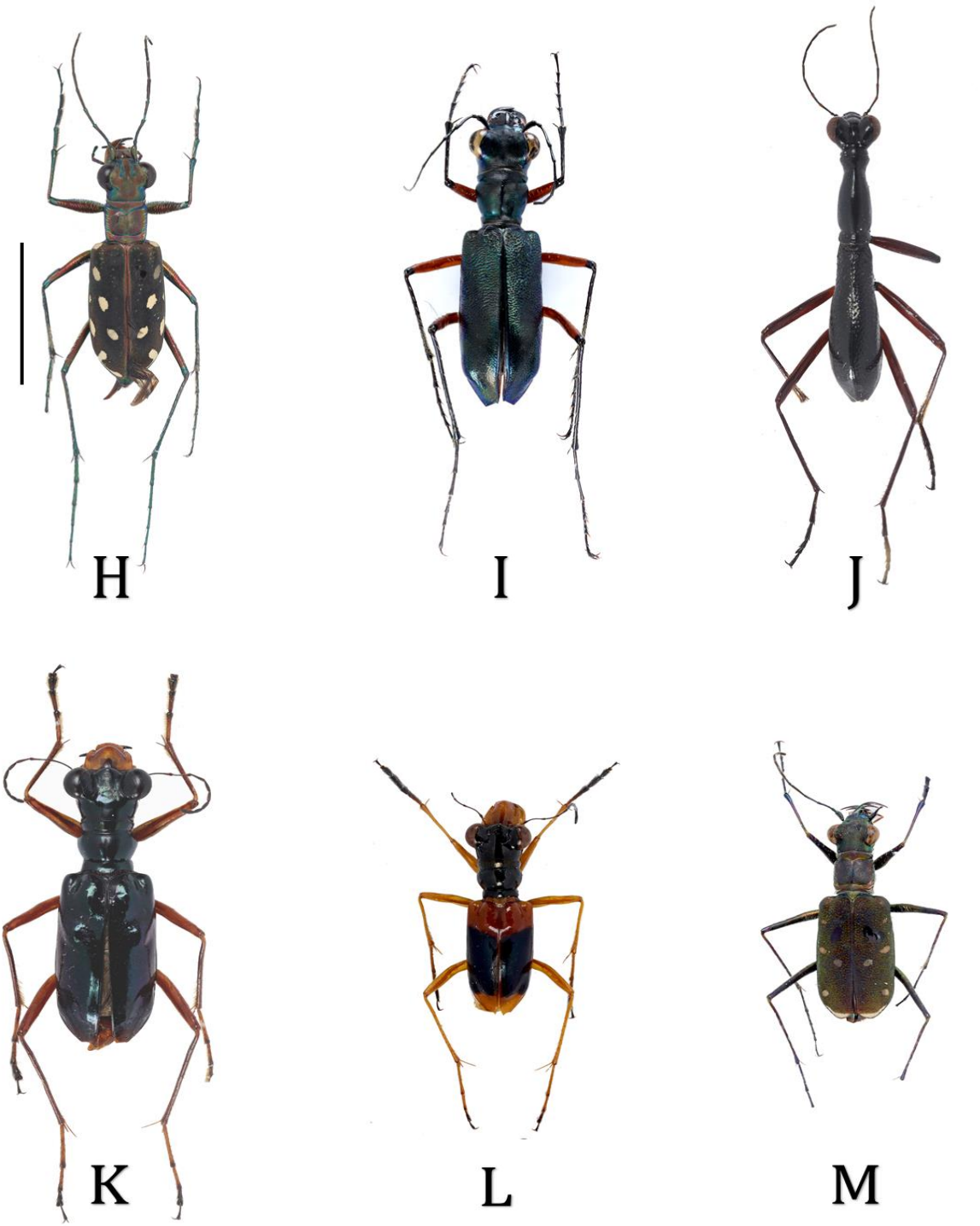

Figure 3H-M. Cicindelidae fauna in Lake Holon: **H.** *Calomera mindanaoensis* Cassola, 2000, **I.** *Heptodonta nigrosericea* (W. Horn, 1930), **J.** *Tricondyla sp*., **K.** *Therates coracinus coracinus* Erichson, 1834, **L.** *Therates pseudolatreillei* Horn, 1928, **M.** *Thopeutica rollandmuelleri* Cassola, 2000. Scale bar 7 mm.

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At least three (3) Cicindelidae species are significantly distributed in Mindanao Island especially *C. mindanaoensis, H. nigrosericea*, *and T. rolandmuelleri,* while *T. fasciatus pseudolatreillei* has been documented in the island of Luzon and Mindanao (Horn, 1928; Ballentes et al., 2006; Cabras et al., 2016). *T. coracinus coracinus*, on the other hand, is widely distributed in all the major islands of the country particularly in Luzon, Visayas, and Mindanao and in other parts of Indonesia. The number of Cicindelidae species documented in Lake Holon is much lower compared to species found in Compostela Valley Province (Cabras et al., 2016) and Calanasan, Apayao (Medina et al., 2020). Similarly, it is comparably lower than that of Davao region which has a total of 22 species under 9 genera (Medina et al., 2020).

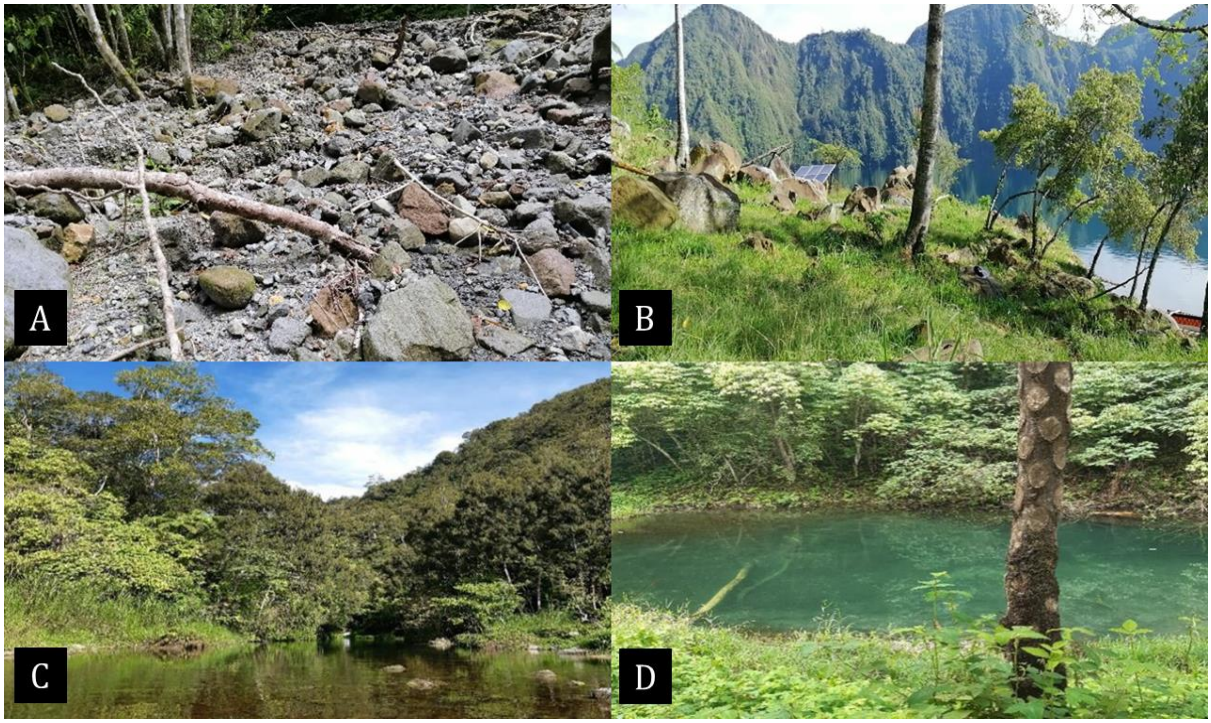

Figure 4A-D. Ground and Tiger Beetle microhabitat in Lake Holon. **A**. Sandy riverine area, **B.** An open grassy area proximate to the lake, **C.** Junction between the lake and the river, **D**. Shrubs and trees along the riverbank.

The documented Carabidae and Cicindelidae species were primarily collected using light-trapping method and opportunistic sampling through hand-netting and hand-picking. All species were mainly found in riparian areas within patches or near secondary forest. For Carabidae, arboreal species include, *C. cf. bennigseni*, *C. metabolus* and *C. cf. laetus*. While *N. saphyrinus*, *S. (E) quinquepustulatus*, and *C. (L) cf. tetragonoderus* prefer epigeic habitats. However, it has also been noted that *C. (L) cf. tetragonoderus* thrives in other areas not limited to water banks (Darlington, 1970). Additionally, arboreal Cicindelidae species include *Tricondyla sp., T. coracinus coracinus*, and *T. pseudolatreillei* (Medina et al., 2020) which were found on shrubs approximately 1 to 2 meters above the ground. *T. coracinus coracinus* and *T. pseudolatreillei* shared the same habitat preference as both species have been previously documented in agricultural ecosystems near riverine areas (Ballentes et al., 2006; Cabras & Wiesner, 2016). Epigeic species, on the other hand, include *C. mindanaoensis* and *T. rolandmuelleri* (Medina et al., 2020) collected from open, sandy areas along riverbanks (Cabras & Wiesner, 2016).

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Conclusion and Recommendation

This paper presents the preliminary list of Carabidae and Cicindelidae species in Lake Holon. The data presented adds up to the new distributional records of Carabidae and Cicindelidae species in the Philippines. Interestingly, the presence of Philippine endemic species imply the need for biological protection and conservation in the area. Being a tourist spot, efforts on conservation and habitat protection must be strengthened as the area becomes more susceptible to anthropogenic activities. Further explorations must also be conducted to areas not previously explored particularly in the eastern portion of the lake and its nearby environs.

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Competing interests.

The authors declared that no competing interests exist in the preparation of the manuscript.

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