INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 21, No. 1, p. 16-30, 2022
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Field documentation of Ground Beetles (Carabidae) and Tiger Beetles (Cicindelidae) in the Forest of Lake Danao, Leyte, Philippines

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Article published on July 15, 2022

Key words: Ground beetles, Tiger beetles, Lake Danao, Endemic, Ecology

Abstract

A pioneer study of ground beetles and tiger beetles was conducted in the protected forest of Lake Danao, Leyte, Philippines. A total of 1647 ground and tiger beetle individuals belonging to 26 species were collected. A total of 19 endemic species were recorded of which 12 are Philippine endemic while six (6) and one (1) are endemic to Leyte and Samar, respectively. This result serves as a baseline data of ground and tiger beetles in the forest of Lake Danao. The most dominant tribe recorded is Brachinini under Subfamily Carabinae with 8 species and followed by Cecindelini with 6 species. Tribe Collyridini consists of 5 species while both Lebiini and Chlaeniini have four species each. Most tribes garnered two and one species respectively. New additions in Leyte are *Brachinus leytensis, Trigonotoma goeltenbothi, Pheropsophus lumawigi, Pheropsophus azoulayi, Pheropsophus uliweberi, and Pheropsophus sp*. The last three species were discovered and identified in this study. Ecological notes were also presented for the species as well as their distribution and occurrence. Conservation should be conducted to the carabid beetles especially the rare and endemic ones in some forests. Strengthened implementation of protection in both protected landscapes against mining, illegal logging, slash and burn farming and human settlements should also be done.

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Introduction

Tropical forests as the most varied and the most biologically complex ecosystem provide apparently over 33% all species considered (Raven 1980; Wilson 1992) and assume an excessively vast part in worldwide carbon and other nutrient cycles (Detwiler & Hall 1988). In view of its high heterogeneity, i.e. more prominent assortment of microhabitats, a wider scope of microclimates and expanded resource range could happen. It can likewise offer a rich diversity of invertebrates and vertebrates (Huston 1993; Townsend *et al.*, 2008). Most studies on biodiversity loss have focused on mammals (Dirzo & Raven 2003; Gonzalez 2013), birds (Gregory *et al.*, 2005; de Lima *et al.*, 2013; Boyer & Jetz 2014) and plants (Wood *et al.*, 2013; Newbold *et al.*, 2014). However, the decline and extinction rates of insects, which comprise the majority of terrestrial biodiversity, are inadequately quantified and poorly understood in different parts of the world (Dunn 2005; Thomas 2005; Runge *et al.*, 2014).

Of all the insect orders, Order Coleoptera dominates and constitutes 40% of the total number. The family Carabidae, comprises of ground beetles and tiger beetles, is composed of approximately 40,000 known species and are arranged into 86 tribes (Erwin 1985). It is the biggest adephagan family and a standout amongst the beetle families. The suborder Adephaga is a comparatively large group of beetle that is morphologically described by having of six abdominal ventrites, pygidial defense glands in adult, and fluid-feeding mouthparts in the larvae stage (Lawrence and Britton 1991). They are proportional cursorial beetles with noticeable mandibles and palps, long thin legs, striate elytra, and sets of punctures with tactile setae. They commonly contain an antenna-cleaning organ and big pubescent reception antennae. The mature carabids generally dark colored, sparkly or matte. Others have brilliant or metallic hues, and some are pubescent. The larvae are campodeiform, have all around developed legs, antennae, and mandibles, and bear settled urogomphi (Crowson 1981). Several authors grouped carabids into various subfamilies; with the exception of the tiger beetles (Pearson 1988), where environmental information is still inadequate concerning subfamilies outside the Carabinae (Lawrence and Britton 1991). The abundance, richness, and alluring color of numerous species have made carabids well known objects of study for both expert and beginner entomologists. Carabids can be seen around the world, with species richness recorded highest in the tropical areas. They live in about in every accessible environment, though few species are associated with specific habitats, i.e. meadows, forests, or harvest fields. Because of habitat specificity of few species, carabids can be utilized as biological indicators to evaluate land use changes in various biological communities (Erwin 1985).

Carabid beetle fauna (ground and tiger beetles) is a standout amongst the exceptional organisms on the planet in spite of its small geographical area. Philippines positions fifth as far as its lavishness and third on the level of endemism after Madagascar and Australia (Cassola and Pearson 2000; Cassola and Ward 2004; Cassola 2011). Philippines lands number one as far as endemism per unit area. Yet, little consideration has been given to the nation's carabid fauna, to their conservation status, and the presumable impact of environmental changes and human activities on these groups. Initial collections started way back 1859 - 1865 by C.G. Semper and 1913-1919 by G. Boettcher. These carabid beetles were introduced by European entomologist, Schaum (1860, 1862, 1863) and Horn (1907, 1908, 1909, 1923, 1924, 1937). Latest publication and review on the carabid fauna of the Philippines were conducted by Ceniza (1994), Cassola (2000, 2011), Cassola and Ward (2004), Cassola and Zettel (2006), Deuve (2015), Dheurle (2015), Naviaux (1992, 2002), Wiesner (1980, 1988a, 1988b, 1989, 1992a, 1992b, 2015). The identification of new *species Thopeutica milanae* by Weisner in 1992 in Leyte, marked the beginning of carabid study in Eastern Visayas, and is continuously being given an attention because of its promising endemic species. Additional four carabid species were identified from Leyte in succeeding years namely: *Elaphropus schawalleri, E. surrulipennis, E. martensi* and *Paratachys leytensis* Baehr (2016). Still, new species of carabids from Leyte and Cebu

were identified by Lassalle & Schnell (2018) namely: *Brachinus bendanilloi* and *Pheropsophus (Stenaptinus) azoulayi*. Similar recommendations were given in these studies, and that is to continue collecting for the discovery of new species and conduct collections in other forests of Eastern Visayas.

The study aims to document the different species of carabid and tiger beetles found in the forest of Lake Danao, Leyte, Philippines. Specifically, it aims to collect samples, describe, classify and catalogue the different species found.

Materials and methods

Site Selection

The study was conducted in the forests of Lake Danao National Park of Ormoc City, Leyte. The different sites in the forest were chosen based on: (a) slope position (incline extending from ≥8-18% can be utilized for regular and lasting yield generation), (b) cultivated area is nearby the forest; (c) portion of the forest has been formed by kaingin (slash- and-burn) practices; and (d) under current cultivation.

Collecting methods

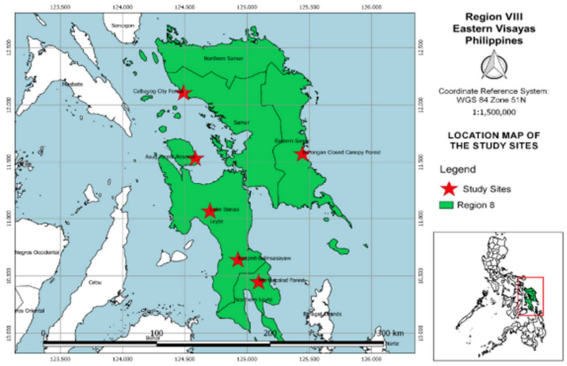


Fig. 1. Map of Region 8 and Location of Study Sites.

Ground and tiger beetles were collected using two methods, namely pitfall trapping (PT) and handpicking and/or searching on the ground (GS). With pitfall trapping, plastic containers comprising of two settled 500ml. plastic tubs (11.4cm in measurement; 8cm top to bottom) were half-filled with bait substance and were buried in the ground. There were 100 pitfall traps set-up in every habitat type at each forest. A total of 200 pitfall traps were placed in every study site. The traps were arranged in square grids with 20m between traps to avoid the "digging in" effect (Hoekman *et al.*, 2017). Each trap was secured with a metal rooftop (13cm x 13cm) to shield from rain, litter-fall and unsettling influence by animals. Traps were emptied and refilled two times every week. After a two-week trial of baits to be used, the researcher decided to use vinegar, vinegar with catsup, fermented fish with vinegar, and ground meat. With these new bait materials, the pit-fall traps have captured carabid beetles compared with the previous set of baits which did not catch any beetles at all. All samples gathered from every trap in every forest were taken to the laboratory for sorting and proper identification. Labels were prepared to avoid mixed-up of carabid beetles from different forests.

Conversely, hand picking/searching on the ground (GS) was carried out by the proponent together with the help of research assistants and farmers after being given instructions in the field on how to recognize carabid beetles and to use simple collecting methods. Collecting involved actively searching for the beetles on the ground, in leaf litter, under logs and other substrates, under tree barks, and in rotting deadwood. This was mostly done during night time since most carabid beetles are nocturnal. A 0.5cm mesh size sifter was used to sift dry leaf litter for carabid beetles. Moist leaf litter was scooped onto white clothing and a pair of forcep was used to get the carabid beetles.

Likewise, resting and running beetles were sampled by manual searching under logs, stones and tree barks. Collecting took place both during the day and at night. All specimens were transferred into a killing agent preservative (9.0:0.5:0.5 parts of 70% ethyl alcohol, table vinegar and ethyl acetate by volume) (Hoekman *et al.*, 2017). Collections were done four times a month for a period of six months (i.e., June-December 2019).

Site and plot sampling

The traps were arranged in square grids with 5m distance between traps to avoid the "digging in" effect (Hoekman *et al.*, 2017) (Fig. 2.2).

It was distributed across the open forest and agricultural land types to best represent the different habitats present at each site while maintaining sufficient replication within each vegetation type (Hoekman *et al.*, 2017).

Fig. 2. A diagram of the arrangement of traps within each plot. Four traps (referred to by their cardinal orientation; i.e., N for north, etc.) are installed within each distributed base plot at least 20 m apart.

The number of plots per vegetation type was proportional to the percent cover of that type at the site. This stratified approach was appropriate in the ground beetle sampling because vegetation cover is an important predictor of ground beetle composition (Dufrene and Legendre 1997, Work *et al.*, 2008). The important ground beetle species present at a site were more likely to be encountered and recorded especially when sampling effort was spread across the site's dominant vegetation types. The location of the pitfall traps within each distributed plot was the same for each site, with each trap positioned on the midpoint of a plot edge. Each plot was cardinally oriented, referred to in the data by their cardinal direction for convenience (i.e., north, south, east and west). This organization results in trap placement at least 25 m from any other trap within the same plot. This level of trap replication provided a sufficiently large sample to characterize the assemblage of ground beetles, including rare species, and is greater than or comparable to the sampling effort employed by other large-scale pitfall trapping schemes (Dufrene and Legendre 1997, Vanbergen *et al.*, 2005, Work *et al.*, 2008, Brooks *et al.*, 2012). Collectively, all individuals captured in the pitfall traps will represent the ground beetle assemblage at the plot level and plots will be far enough apart to represent independent samples of the beetle community at a site level (Digweed *et al.*, 1995).

Taxonomic Classification

Identification of carabids was done up to species level if conceivable and was based on accessible published studies (Thiele 1977; Lindroth 1949; Scholtz 2005; Luff 1987; Kirschenhofer 2008; Trautner *et al.*, 1987). After which, identification was affirmed and corrected by carabid experts Dr. Bernard Lassale, a pioneer of French Entomological Society in France, and Dr. Rainer Schnell, a professor in the University of Duisburg Essen, Germany, who have been identifying and publishing studies about carabid beetles. The voucher samples were stored in the laboratory.

Permit(s)

Prior to the collection of the specimens, Gratuitous Permit (GP) from the DENR was sought. Communication and letter of request were sent to respective municipal mayors and barangay chairpersons where collection was conducted.

Results and discussion

A total of 1647 individuals belonging to 28 species under 25 genera, 9 tribes, and two (2) subfamilies were recorded in the forests of Lake Danao. Table 1 lists the different species caught together with their occurrence, geographical distribution and habitat type.

A total of 19 endemic species were recorded of which 12 are Philippine endemic while six (6) and one (1) are endemic to Leyte and Samar, respectively. This result serves as a baseline data of carabid beetles for all study sites in this study. Pheropsophus hassenteufeli, Pheropsophus lumawigi, Tricondyla aptera punctipennis, Tricondyla ovicollis, and

Tricondyla conicicollis were found in all six forests. These species were observed to be the most abundant and found in all forests both in natural forest and agricultural habitat types which infers the high distribution of these species and their resilience to anthropogenic disturbances. These species were observed to prefer open riparian ecosystems with different vegetation, a characteristic of all study sites where they were all recorded.*Paratachys leytensis, Tachys sp., Trigonotoma goeltenbothi, Oodes sp., Pentagonica sp were only found i in Lake Danao while Catascopus aequatus, Cicindela sp, and Lebia sp. were only recorded in Mt. Nacolod. There were species shared by Lake Danao and Mt. Nacolod like Pheropsophus fumigatus, Pheropsophus nigerrimus, Pheropsophus uliweberi, Catascopus elevates, Pentagonica ruficollis, and Therates fasciatus pseudolatreillei.*

Table 1. List of Carabid beetles in Leyte and Samar with their occurrence, geographical distribution and habitat type.

Subfamily Carabinae	Species	Occurrence	Geographic Distribution	Habitat Type
Tribe Brachinini	*Brachinus leytensis* (LASSALE/SCHENELL, 2018)	LD, MN, KF	Leyte, Philippine Endemic	Natulra forest and mixed agricultural ecosystem
	Pheropsophus fumigatus (DEJEAN, 1825)	LD, MN	Oriental	Natural forest and mixed agricultural ecosystem
	Pheropsophus nigerrimus (JEDLICKA, 1935)	LD, MN	Oriental	Natural forest
	Pheropsophus hassenteufeli (STRANEO 1960)	LD, MN, KF, AF, CC, CF	Leyte, Philippine Endemic	Natural forest and agricultural land
	Pheropsophus azoulayi (LASSALLE + SCHNELL, 2018)	LD, MN, KF, AF	Philippine Endemic	Natural forest and mixed agricultural ecosystem
	Pheropsophus lumawigi (HRDLICKA 2019 sp nov.)	LD, MN, KF, AF, CC, CF	Philippine Endemic	Natural forest and mixed agricultural ecosystem
	Pheropsophus uliweberi (LASSALLE + SCHNELL, 2019 sp nov.)	LD, MN	Leyte, Philippine Endemic	Natural forest and mixed agricultural ecosystem
	Pheropsophus sp. (LASSALLE + SCHNELL, 2019 sp nov.)	MN, LD	Leyte, Philippine Endemic	Natural forest
Tribe Bembidiini	*Paratachys leytensis* (BAEHR 2016)	KF, LD	Leyte, Philippine Endemic	Natural forest and mixed agricultural ecosystem
	Tachys sp 1.	LD, KF, CF, CC	Worldwide	Natural forest and mixed agricultural ecosystem
Tribe Chlaeniini BRULLÉ 1834	*Chlaenius sp*. 1 (BONELLI 1810)	LD, MN, CF, CC	Worldwide	Natura forest and mixed agricultural ecosystem
	Chlaenius sp. 2	LD, CC	Philippine Endemic	Natural forest and mixed agricultural ecosystem

Subfamily Carabinae	Species	Occurrence	Geographic Distribution	Habitat Type
	Haplochlaenius femoratus philippinus	LD, MN, CC	Oriental	Natural forest and mixed agricultural ecosystem
	Trichotichnis sp. Sg. Bottchrus (JEDLICKA) 1935	LD, MN, KF, AF	Worldwide	Natural forest and mixed agricultural ecosystem
	Oodes sp. (BONELLI 1892)	LD, KF, CC	Philippine Endemic	Natural forest
Tribe Harpalini s.str. BONELLI 1810	*Orthogonius luzonicus (CHHAUDOIR)*	LD, CC	Philippine Endemic	Natural forest
	*Catascopus aequatus (*DEJEAN, 1831)	LD, MN	Philippine Endemic	Natural and mixed agricultural ecosystem
Tribe Anisodactylini LACORDAIRE 1854	*Pentagonica ruficollis SCHAUM*	LD, MN	Oriental	Natural forest
Tribe Orthogoniini s.str. SCHAUM 1857	*Pentagonica sp.*	LD, MN	Oriental	Natural and mixed agricultural ecosystem
Tribe Lebiini s.str. BONELLI 1810	*Drypta lineola philippinensis CHAUDOIR*	LD	Philippine Endemic	Natural forest
Subfamily Cicindeliae				
Tribe Collyridini BRULLE, 1834	*Tricondyla aptera punctipennis* CHEVROLAT, 1841	LD, MN, KF, AF, CF, CC	Oriental	Natural forest and mixed agricultural ecosystem
	Tricondyla ovicollis MOTSCHULSKY, 1864	LD, MN, KF, AF, CF, CC	Worldwide	Natural forest and mixed agricultural ecosystem
	Tricondyla conicicollis CHAUDOIR, 1844	LD, MN, KF, AF, CF, CC	Worldwide	Natural forest and mixed agricultural ecosystem
Tribe Cicindelini LATREILLE, 1802	*Therates fasciatus pseudolatreillei* HORN, 1928	LD, MN	Philippine Endemic	Natural forest and mixed agricultural ecosystem
	Prothyma sp.	LD, MN, AF, CC	Worldwide	Open forest and mixed agricultural ecosystem
	Thopeutica sp.	LD, MN, KF, CF	Philippine Endemic	Open forest and mixed agricultural ecosystem
	Cicindela sp.	LD, MN, CF	Philippine Endemic	Open forest and mixed agricultural ecosystem

Among the species shared by Lake Danao and other selected forests in Leyte are *Pheropsophus azoulayi, Haplochlaenius femoratus philippinus* The most dominant tribe recorded is Brachinini under Subfamily Carabinae with 8 species and followed by Cecindelini with 6 species. Tribe Collyridini consists

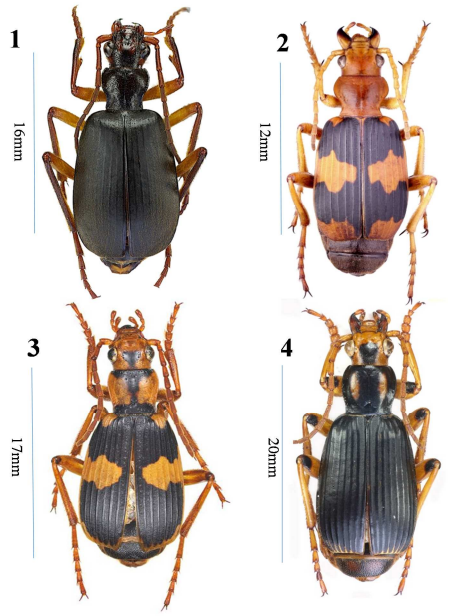
of 5 species while both Lebiini and Chlaeniini have four species each. Most tribes garnered two and one species respectively.

Discoveries of new species continue in Leyte and Samar. New additions in Leyte are Brachinus leytensis, Trigonotoma goeltenbothi, Pheropsophus lumawigi, Pheropsophus azoulayi, Pheropsophus uliweberi, and Pheropsophus sp. The last three species were discovered and identified in this study. Also, addition to Samar carabids is Lesticus samarensis which is also collected and identified during this study.

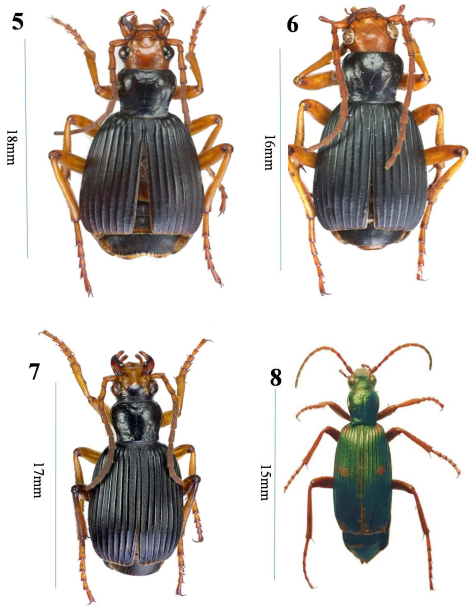
The higher number of carabid beetles in Leyte forests can be attributed to its remaining sparse vegetation cover in selected areas sampled as compared to the forests of Samar. The preference of some carabid beetles like tiger beetle to sandy soil with sparse vegetation was also mentioned by Hoback *et al.* (2000) who said that sandy areas provide more ease for females' reproduction. Since this study on carabid distribution is first in Leyte and Samar, no other studies can be used as point of comparison. More field surveys should be conducted to determine the actual geographic distribution of these species which seems to be endemic and rare to Eastern Visayas.

Notwithstanding the diverse anthropogenic disturbances in the six forests, carabid beetles still flourish, which shows how these species are adapting to their environment. Be that as it may, the conversions, disturbances as well as human settlements stripping the forest because of unlawful logging of timber poses a colossal threat to the carabid beetles found in the six forests. Slash and burn farming which destroys the steepest slopes poses further threat to the species dwelling in these ecosystems. Some carabid beetles which are habitat specific and has a narrow geographic distribution should be a subject of priority especially in the conservation as the current loss of our forests ecosystems has a profound effect in their survival in the wild. Special attention should be given to species which are endemic, rare and with narrow distribution which is at high risk of extinction.

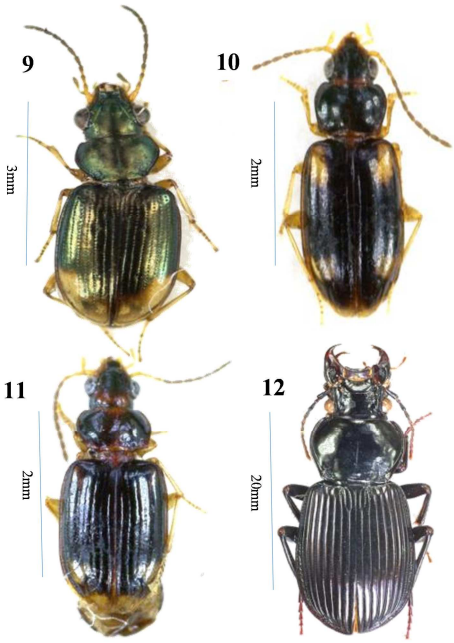
A. Carabid beetles found in Leyte



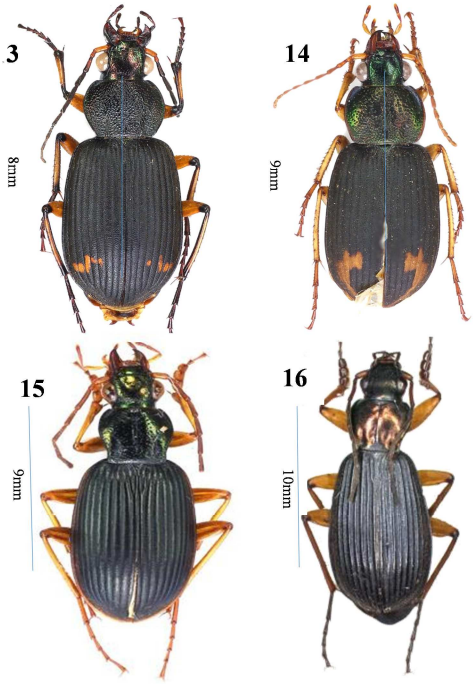
Figs. 1-4. Digital photographs of dorsal habitus.
Fig. 1. *Brachinus leytensis* (LASSALE/SCHENELL, 2018).
Fig. 2. *Pheropsophus fumigatus* (DEJEAN, 1825).
Fig.3. *Pheropsophus nigerrimus*(JEDLICKA, 1935).
Fig. 4. *Pheropsophus hassenteufeli* (STRANEO 1960)
Photo credit: B. Lassalle (2019)



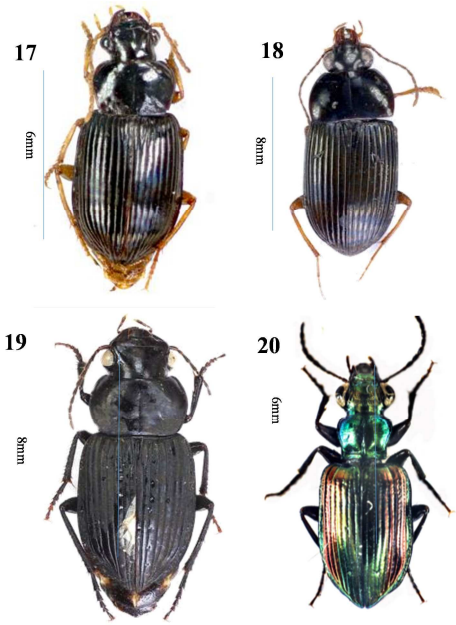
Figs. 5-8. Digital photographs of dorsal habitus.
Fig. 5. *Pheropsophus azoulayi* (LASSALLE + SCHNELL, 2018).
Fig. 6 *Pheropsophus lumawigi* (HRDLICKA 2019 sp nov.)
Fig.7. *Pheropsophus uliweberi* (LASSALLE + SCHNELL, 2019 sp nov.).
Fig. 8. *Pheropsophus sp.* (LASSALLE + SCHNELL, 2019 sp nov.)
Photo credit: B. Lassalle (2019)



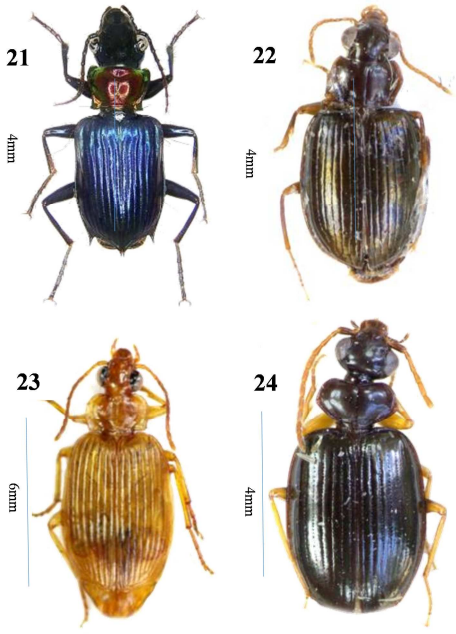
Figs. 9-12. Digital photographs of dorsal habitus.
Fig. 9. *Paratachys leytensis (*BAEHR 2016).
Fig.10. *Tachys sp*. **Fig.11**. *Tachys sp*.
Fig. 12. *Trigonotoma goeltenbothi (*LASSALLE, ROUX, SCHNELL, 2018*)*
Photo credit: B. Lassalle (2019)



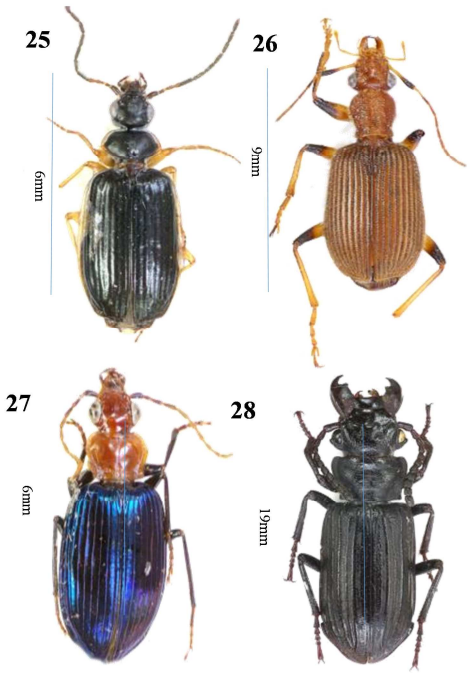
Figs. 13-16. Digital photographs of dorsal habitus.
Fig. 13. *Chlaenius sp*. (BONELLI 1810).
Fig.14. *Chlaenius sp*. **Fig.15**. *Chlaenius sp*.
Fig. 16. *Haplochlaenius femoratus philippinuus*
Photo credit: B. Lassalle (2019)



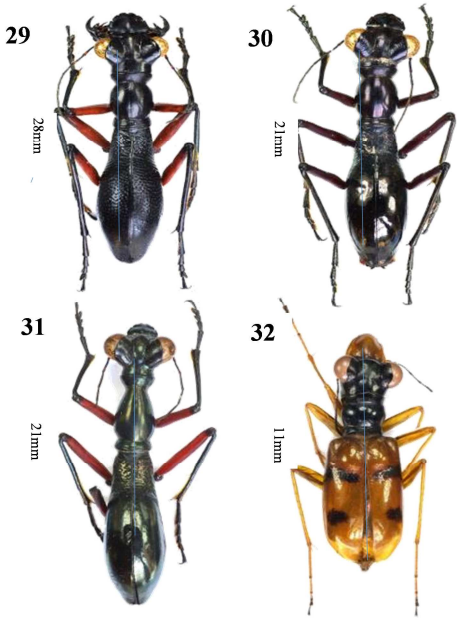
Figs. 17-20. Digital photographs of dorsal habitus.
Fig. 17. *Trichotichnis sp*. Sg. Bottchrus JEDLICKA 1935.
Fig.18. *Oodes sp*. (BONELLI 1892).
Fig.19. *Gnathaphanus impressipennis. (*W.S. MACLEAY 1825).
Fig. 20. *Catascopus elegans (*SCHMIDT GOEBEL 1846)
Photo credit: B. Lassalle (2019)



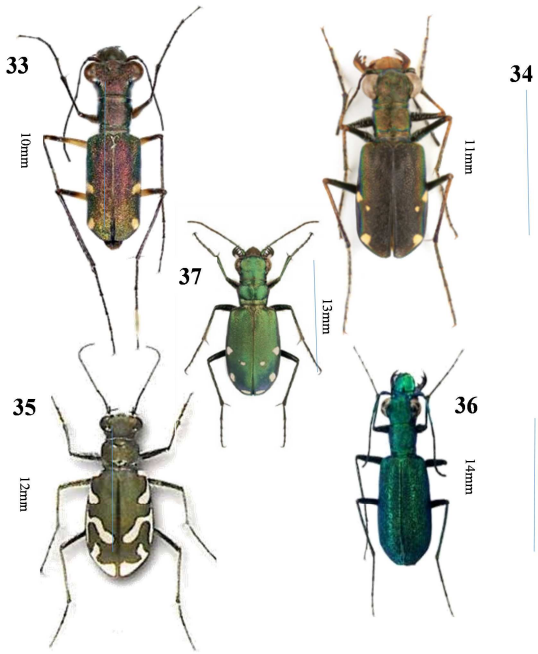
Figs. 21-24. Digital photographs of dorsal habitus.
Fig. 21. *Catascopus aequatus (*DEJEAN, 1831).
Fig. 22. *Dolichoctis gilvipes (*DEJEAN)
Fig. 23. *Lebia sp. (*LATREILLE 1802Sg. Poecilothais MAINDRON 1905). **Fig. 24.** *Pentagonica ruficollis* (SCHAUM 1863)
Photo credit: B. Lassalle (2019)



Figs. 25-28. Digital photographs of dorsal habitus.
Fig. 25. *Pentagonica sp*. (SCHAUM 1863).
Fig.26. *Drypta lineola philippinensis* (CHAUDOIR 1872).
Fig.27. *Dicranoncus philippinensis* (Jedlicka, 1935) .
Fig. 28. *Pseudozaena orientalis opaca* (Chaudoir 1868).
Photo credit: B. Lassalle (2019)



Figs. 29-32. Digital photographs of dorsal habitus.
Fig. 29. *Tricondyla aptera punctipennis (*CHEVROLAT, 1841).
Fig.30. *Tricondyla ovicollis (*MOTSCHULSKY, 1864).
Fig.31. *Tricondyla conicicollis (*CHAUDOIR, 1844).
Fig. 32. *Therates fasciatus pseudolatreillei* HORN, 1928
Photo credit: B. Lassalle (2019)



Figs. 33-37. Digital photographs of dorsal habitus.
Fig. 33, *Prothyma heteromallicollis (*HORN, 1909).
Fig.34. *Prothyma sp*. **Fig.35**. *Thopeutica sp.*
Fig. 36. *Cicindela sp*.**Fig. 37**. *Cicindela sp*.
Photo credit: B. Lassalle (2019)

Conclusion and recommendation

Despite the different anthropogenic disturbances experienced in the forests of Lake Danao, 26 species of carabid beetles of which 19 species are endemic to the Philippines and from which 7 are exclusively found in Eastern Visayas. There are beetles which are new records in Leyte and Samar, namely: Brachinus leytensis, Trigonotoma goeltenbothi, Pheropsophus lumawigi, Pheropsophus azoulayi, Pheropsophus uliweberi, and Pheropsophus sp. and Lesticus samarensis. These new species records signify the importance of the landscape in Eastern Visayas in hoarding rare and endemic species of carabid beetles.

In this regard, strengthened conservation efforts should be done in these protected landscapes which experienced a handful of anthropogenic disturbances related to slash and burn farming, illegal logging and human habitation. These disturbances should be regulated if not prevented in the protected landscape. More surveys and studies are recommended to the other unknown flora and fauna in the landscape to assess its remaining biodiversity.

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