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Annotated list of tiger beetles (Coleoptera, Cicindelidae) in Calanasan, Apayao Province, Luzon, Philippines

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Abstract
The forests of Apayao Province are one of the remaining and relatively unexplored areas in the Philippines. With the aim to make Calanasan in Apayao province a UNESCO biosphere reserve as a mechanism in protecting its species, an expedition to document the biodiversity was conducted. This paper presents an annotated list of the 12 species of tiger beetles found in Calanasan. The beetles were mostly collected through opportunistic sampling. In Calanasan, 75% of the tiger beetle species collected are endemic, which shows the high value in preserving this area. Thus, the nomination of Calanasan as a UNESCO biosphere reserve is highly recommended.

Keywords
Biosphere, conservation, diversity, endemic species, first records.

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Introduction

Apayao Province is the northernmost province of the Cordillera Administrative Region in the Philippines and lies in the northernmost flank of the Cordillera Mountain Range. It is surrounded by the provinces of Ilocos Norte and Abra in the west, Kalinga in the south, and Cagayan in the north-east. This landlocked province is made up of seven municipalities, including Calanasan. The municipality of Calanasan is the largest in the province. Unlike many other first-class municipalities in the country, it has a huge tract of primary lowland forest, which remains poorly studied, especially for beetles.

The Philippines is considered one of the megadiverse countries (Heaney and Regalado 1998; Catibog-Sinha and Heaney 2006), and up to the present, it has very few entomological expeditions particularly in the municipality of Calanasan which makes the majority of the insect groups poorly understood, especially tiger beetles (Cassola 2000).

Previously, tiger beetles belonging to the subfamily Cicindelinae, but due to morphological structures of the larvae and comprehensive molecular data, they are now treated separately in the family Cicindelidae (Duran et al. 2018; Herr Jürgen Wiesner pers. comm. 26–27 July 2019). We are herein following this latest classification. These beetles are often used as biological indicators of the health and disturbance of ecosystems (Cabras et al. 2016), as most species are vulnerable to forest destruction (Cassola and Pearson 2000; Cassola and Ward 2004).

They can also be used as control of possible insect-borne diseases, like dengue, as they feed on small living insects, such as mosquitoes(Larochelle 1974; Pearson and Vogler 2001; Cabrera et al. 2018).

Currently, Calanasan province is bidding for the recognition of its forest as a UNESCO biosphere reserve, and floral and faunal studies are underway to generate information for the biodiversity profile. This paper reports the tiger beetles obtained opportunistically during one such biodiversity expedition in Calanasan.

Methods

Opportunistic sampling was conducted from September to October 2018 using a hand net to capture diurnal and nocturnal tiger beetles in selected areas in Calanasan (Fig. 1). Because tiger beetles exhibit distinct habitat preferences (Cabras et al. 2016a), sampling was done in all possible habitats, like shrubs and trees, near rivers and roads, and in open riparian areas (Santos 2014; Cabras et al. 2016a). The specimens were killed in ethyl acetate and deposited in the Coleoptera Research Center of the University of Mindanao Davao City (UMCRC). Materials from Museum fur Tierkunde Dresden (Germany) and J. Wiesner collections (Wolfsburg, Germany) were also examined for comparison.

Materials were examined using a Euromex stereomicroscope and identifications were made by comparing morphological characters using the taxonomic keys and published works of Wiesner (1980, 1988, 1989, 1992), Cassola (2000), and Cassola and Ward (2004). Species confirmation was made by Dr Jürgen Wiesner, the expert in Philippine Cicindelidae. Photo-documentation of species habitus was also employed using a StackShot automated focus stacking macro rail with Canon MP-E 65mm super macro lens and processed using Helicon Focus software version 7.7.6. Canon EOS 800D was also used to photograph species habitat for further analysis and comparison (Jumawan et al. 2012).

Results

A total of 80 individuals representing two subtribes, seven genera, and 12 species were documented. Ten species in six genera belong to the subtribe Cicindelina, and two species belong to a single genus in the subtribe Theratina. In this paper, the seven genera of Cicindelidae, namely *Calomera*, *Cylindera*, *Heptodonta*, *Prothyma*, *Therates*, *Lophyra*, and *Thopeutica*, are presented and annotated.

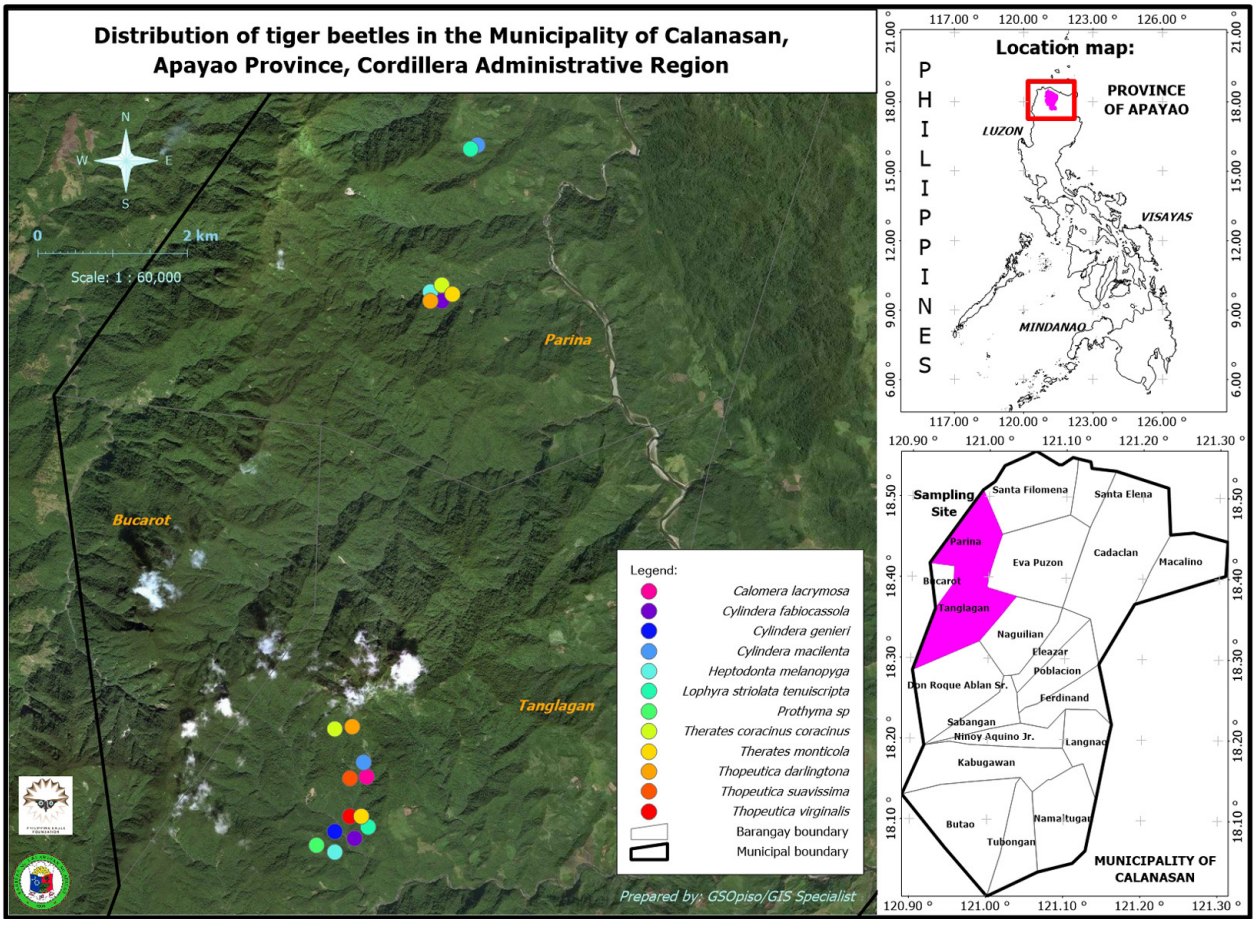

Figure 1. Map of study sites. **A.** Map of the Philippines showing the province of Apayao. **B.** Map of Apayao province showing the location of Calanasan. **C.** Map of the distribution of species in Calanasan.

Annotated list

Calomera lacrymosa (Dejean, 1825)

Material examined. 1 male, PHILIPPINES, Apayao Province, Municipality of Calanasan, Brgy. Tanglagan, [18.3737°N, 120.9610°E], IX.2018, coll. R.J.T. Villanueva (Fig. 2); UMCRC01011.

Identification. This species is very similar to *Calomera mindanaoensis* Cassola, 2000 in appearance and size, the absence of visible elytra punctuation, and in the labrum with more than 10 marginal setae. However, *C. lacrymosa* has elaborate markings on the side compared to *C. mindanaoensis*. Both species have their pronotum and elytra metallic green and red in color, but *C. lacrymosa* has a larger anterior lateral dot, and in that species the discal dot is somewhat connected with a narrow lineole. Moreover, the aedeagus of *C. mindanaoensis* is arc-shape and slightly tapering at the apex, but the aedeagus of *C. lacrymosa* is also arc-shaped but much longer and thinner towards the apex.

Endemism and distribution. An Oriental species; Philippines (Luzon, Palawan, Sibuyan, Balabac, Mindoro, Homonhon, Bucas Grande) and Indonesia (Sulawesi), although this range is still under investigation (Cabras et al. 2016b).

Remarks. This species was observed at only one of the nine sites explored. It was found perching on the ground on a sun-exposed road in an agricultural area. It was rather rare in the area. Cassola (2000) gave an excellent historical account of this species and a brief description under the name *Lophyridia lacrymosa* (Dejean, 1825). Later, Cassola (2011) considered *Lophyridia* Jeannel, 1946, as junior synonym of *Calomera* Motschulsky, 1862, and hence, *L. lacrymosa* is now *C. lacrymosa*. This species is widespread in the Philippines, from Luzon south to Mindanao. Cabras et al. (2016) listed several major islands in the distributional range of the species, with a questionable account from Sulawesi.

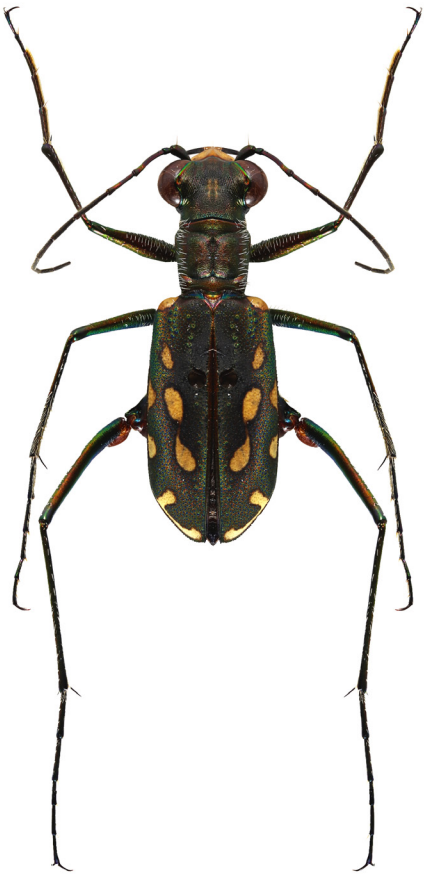

Figure 2. *Calomera lacrymosa* (Dejean, 1825).

Cylindera (*Ifasina*) *macilenta* (Schaum, 1862)

Material examined. PHILIPPINES, Apayao Province, Municipality of Calanasan, 10 ♂♂, 4 ♀♀ Brgy. Tanglagan [18.3754°N, 120.9606°E] 3♂♂, 1♀, Brgy. Parina [18.4462°N, 120.9742°E], IX-X.2018 coll. R.J.T. Villanueva; UMCRC01012, UMCRC01013, UMCRC01014, UMCRC 01015, UMCRC01016, UMCRC01017, UMCRC01018, UMCRC01019, UMCRC010110, UMCRC010111, UMCRC 010112, UMCRC01013, UMCRC01014, UMCRC01015.

Identification. This species is similar in appearance with the other species of *Ifasina*—*C. mouthiezi* Dheurle, 2015—in having a labrum with six to 10 marginal setae and a metallic bluish-green head. However, these species differ in their elytral markings of which *C.macilenta* having a thinner anterior maculation compared to *C. mouthiezi*.

Endemism and distribution. A Philippine endemic; Luzon, Leyte, and Mindanao (Cabras et al. 2016; Wiesner and Dhuerle 2018).

Remarks. *Cylindera* (*I.*) *macilenta* (Schaum, 1862) and *C.* (*I.*) *fabiocassola* Weisner,1989 are the most abundant tiger beetle species encountered in this study. The two species occur together in the same habitat. They were both found on well-exposed to partly shaded stream banks, particularly along the sandy/gravel portion of the bank.

Cylindera (*Ifasina*) *fabiocassola* Wiesner, 1989

Material examined. PHILIPPINES, Apayao Province, Municipality of Calanasan, 7♂♂, 8♀♀ Brgy. Tanglagan [18.3667°N, 120.9595°E], 4♂♂, 4♀♀ Brgy. Parina [18.4283°N, 120.9699°E], IX-X.2018, coll. R.J.T. Villanueva (Fig. 3A); UMCRC010116, UMCRC01017, UMCRC010118, UMCRC010119, UMCRC010120, UMCRC010121, UMCRC 010122, UMCRC010123, UMCRC010124, UMCRC010125, UMCRC010126, UMCRC010127, UMCRC010128, UMCRC 010129, UMCRC010130, UMCRC010131.

Identification. The elytral markings of the materials examined is as described for the species by Wiesner (1989). Two transverse, white markings are present at the side of each elytron, one in the middle and one near the elytral tip. This species is most similar to *C. viduata* (Fabricius, 1801) in size and color of the elytra but differs from it in having two small, white dots near the middle of the elytra (one mark in *C. viduata*). The aedeagus in the materials examined is fusiform, with slightly arc, and tapering at the apex, which conforms to that of *C. fabiocassola* Wiesner, 1989.

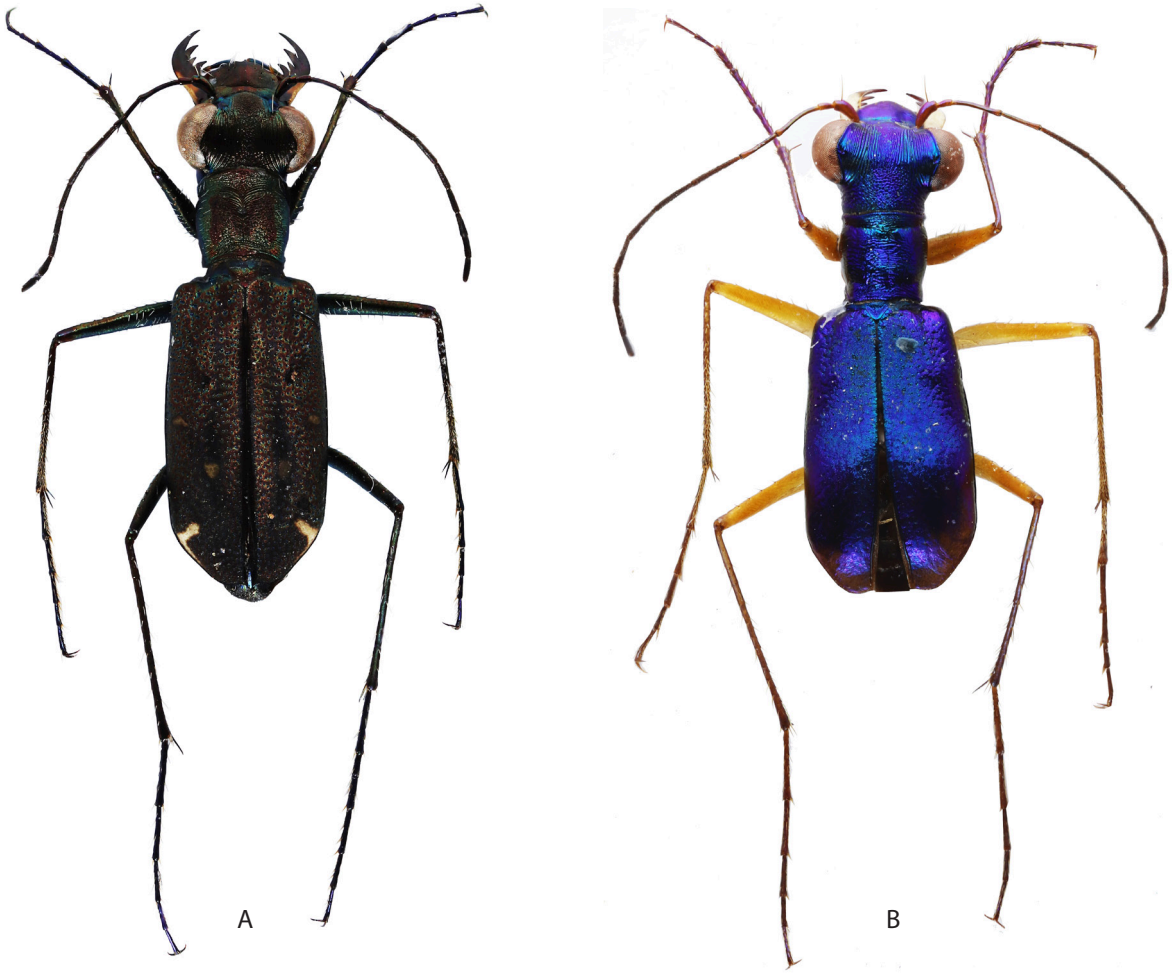

Figure 3. A. *Cylindera fabiocassola* Wiesner, 1989. **B.** *Cylindera genieri* Cassola & Werner, 2003.

Endemism and distribution. A Philippine endemic; northern Luzon (Cassola 2000; Cabras et al. 2016b; Wiesner and Dheurle 2018).

Cylindera (Cylinderina) genieri Cassola & Werner, 2003

Material examined. PHILIPPINES, Apayao Province, Municipality of Calanasan, 1♂, 1♀, Brgy. Tanglagan [18.3674°N, 120.9571°E], IX.2018, coll. R.J.T. Villanueva (Fig. 3B); UMCRC010132, UMCRC010133.

Identification. This species is very similar to *C. werneri* Wiesner, 1988 and *C. vanderberghei* Dheurle, 2016, in having the head shiny, bluish-violet above and metallic green to bluish-green on the clypeus, frons, antennal plates, and genae (Cassola and Werner 2003). However, brown pigmentation is present at the tip of each elytron in *C. genieri* but absent in both *C. werneri* and *C. vanderberghei*. The aedeagus of *C. genieri* and *C. werneri* have the inner sac with a long, narrow flagellum whose upper convolution is crossed by a V-shaped sclerite (Cassola and Werner 2003), but the aedeagus of *C. genieri* is fusiform, with a straight, blunt apex compared to the slightly tapering apex of *C. werneri*.

Remarks. This species was found on a steep slope along a forest trail. It was perching atop a fallen dried leaf on the ground. Unlike other species of tiger beetle encountered during this study, which climb into the insect net, when a net is positioned above an individual of this species, it tends to drop to the ground and crawl under a leaf or sometimes into a small crevice in the ground.

Heptodonta melanopyga Schaum, 1862

Material examined. PHILIPPINES, Apayao Province, Municipality of Calanasan, 2♂, 5♀, Brgy. Parina [18.4293°N, 120.9686°E], 3♂♂, 2♀♀ Brgy. Tanglagan [18.4965°N, 120.9946°E], IX-X.2018, coll. R.J.T. Villanueva (Fig. 4A); UMCRC010134, UMCRC010135, UMCRC010136, UMCRC010137, UMCRC010138, UMCRC 010139, UMCRC010140.

Identification. This species is very similar to *Heptodonta analis* Fabricius, 1801 in having immaculate elytra but differs in the color of the elytra. *Heptodonta analis* is easily distinguished from *H. melanopyga* by its greenish body and paler ventral side. In addition, *H. melanopyga* has metallic coppery brown elytron. The black pronotum of *H.melanopyga* is tinge with green on the sides, while *H. analis* is entirely metallic green. In both species, the aedeagus is almost the same size, with a slightly curved, tapering apex.

Endemism and distribution. A Philippine endemic; Sibuyan, Nueva Viscaya, Ilocos Norte (Adams), Batan, Mindanao (Cabras et al. 2016b, 2016c; Cassola 2000).

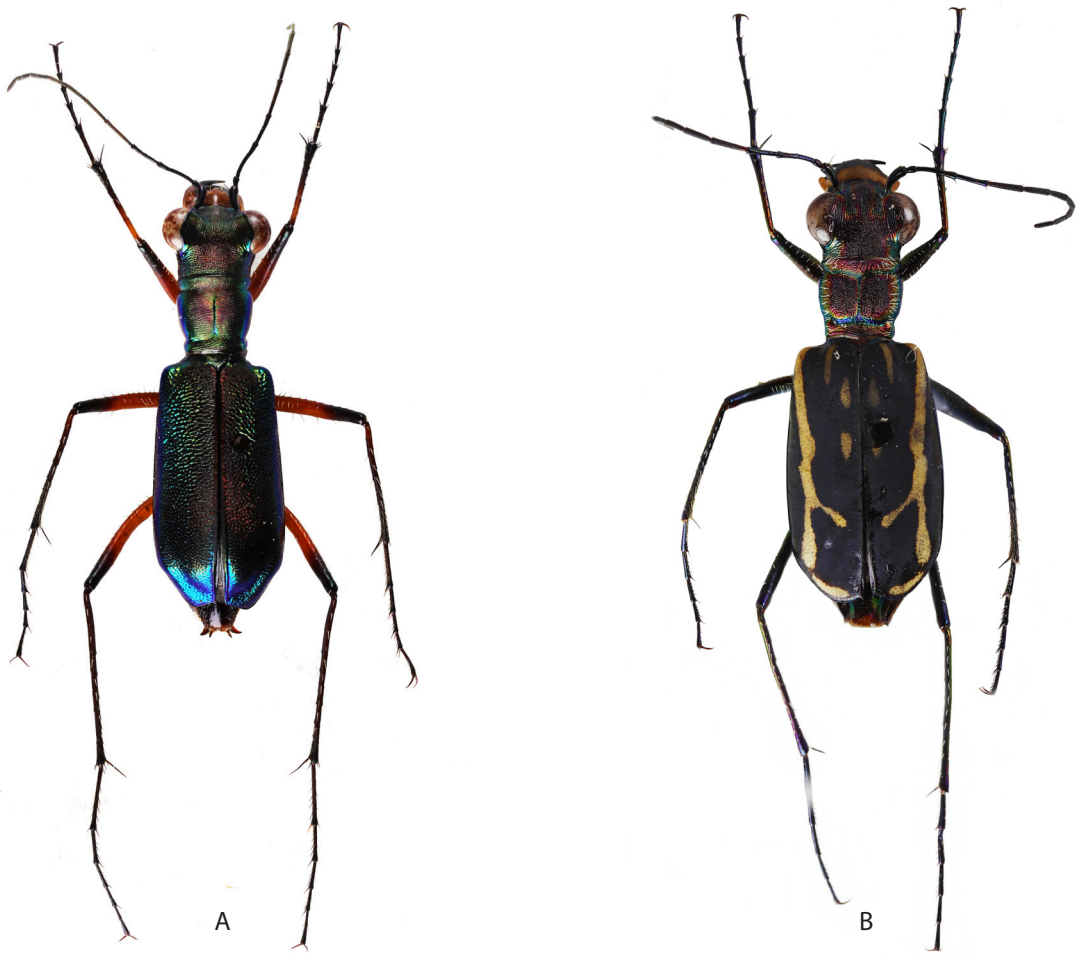

Figure 4. A. *Heptodonta melanopyga* Schaum, 1862. **B.** *Lophyra striolata tenuiscripta* Fleutiaux, 1893.

Remarks. This species is very abundant, found forming a colony on well-exposed sandy ground near the irrigation dam in Sitio Maranas. Interestingly, this species was seen in the upper and lower stretch of the rivers of Barangay Tanglagan and Barangay.

Lophyra (*Spilodia*) *striolata tenuiscripta* (Fleutiaux, 1893)

Material examined. PHILIPPINES, Apayao Province, Municipality of Calanasan, 2♀♀, Brgy. Tanglagan [18.4457°N, 120.9734°E], IX-X.2018, coll. R.J.T. Villanueva (Fig. 4B); UMCRC010141, UMCRC010142.

Identification. This species is very similar to the three other subspecies of *L. striolata* in the Philippines—*L.* (*S.*) *striolata dorsolineolata* (Chevrolat, 1845), *L.* (*S.*) *striolata striolata* (Illiger, 1800), and *L.* (*S.*) *striolata uniens* (W. Horn, 1896)—in having a head with decumbent setae clustered dorsally at posterior margin of each eye, lateral margins of pronotum setose but it is different on the humeral lunule which forms a narrow crescent, and connected middle and posterior maculation forming an even band (Wiesner et al. 2017). The other three *Lophyra* species have entirely different elytral patterns—*L.uniens* having middle maculation forming a single band, *L. dorsolineolata* having a lateral maculation that stretches from the anterior to posterior end of the elytron, and *L. striolata* having isolated markings and not forming an even band.

Endemism and distribution. A widespread Oriental species; India (Maharashta, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Uttar Pradesh, Himachal Pradesh, Bihar, Orissa, Western Bengal, Arunachal Pradesh, Meghalaya, Assam, Sikkim), Nepal, Bangladesh, Myanmar, Thailand, Malaysia (Malacca, Borneo), Laos, Cambodia, Vietnam, China (Guangxi, Hainan, Yunnan), Indonesia (Sumatra, S. Utara, S. Barat, Bengkulu, S. Selatan), Jawa, Bali, Sulawesi (S. Selatan, S. Tenggara), Philippines (Cabras et al. 2016b; Wiesner et al. 2017).

Remarks. This species was only seen in Barangay Tanglagan, where it was sunning itself along the road in a lowland area near the forest edge.

Therates coracinus coracinus Erichson, 1834

Material examined. PHILIPPINES, Apayao Province, Municipality of Calanasan, 3♂♂, 3♀♀ Brgy. Tanglagan [18.3792°N, 120.9571°E], 1♂, 2♀♀ Brgy. Parina [18.4301°N, 120.9699°E] IX-X.2018, coll. R.J.T. Villanueva (Fig. 5A); UMCRC010143, UMCRC010144, UMCRC010145, UMCRC010146, UMCRC010147, UMCRC010148.

Identification. Most similar to this species are *T. fasciatus pseudolatrellei* W. Horn, 1928 and *T. fulvipennis*

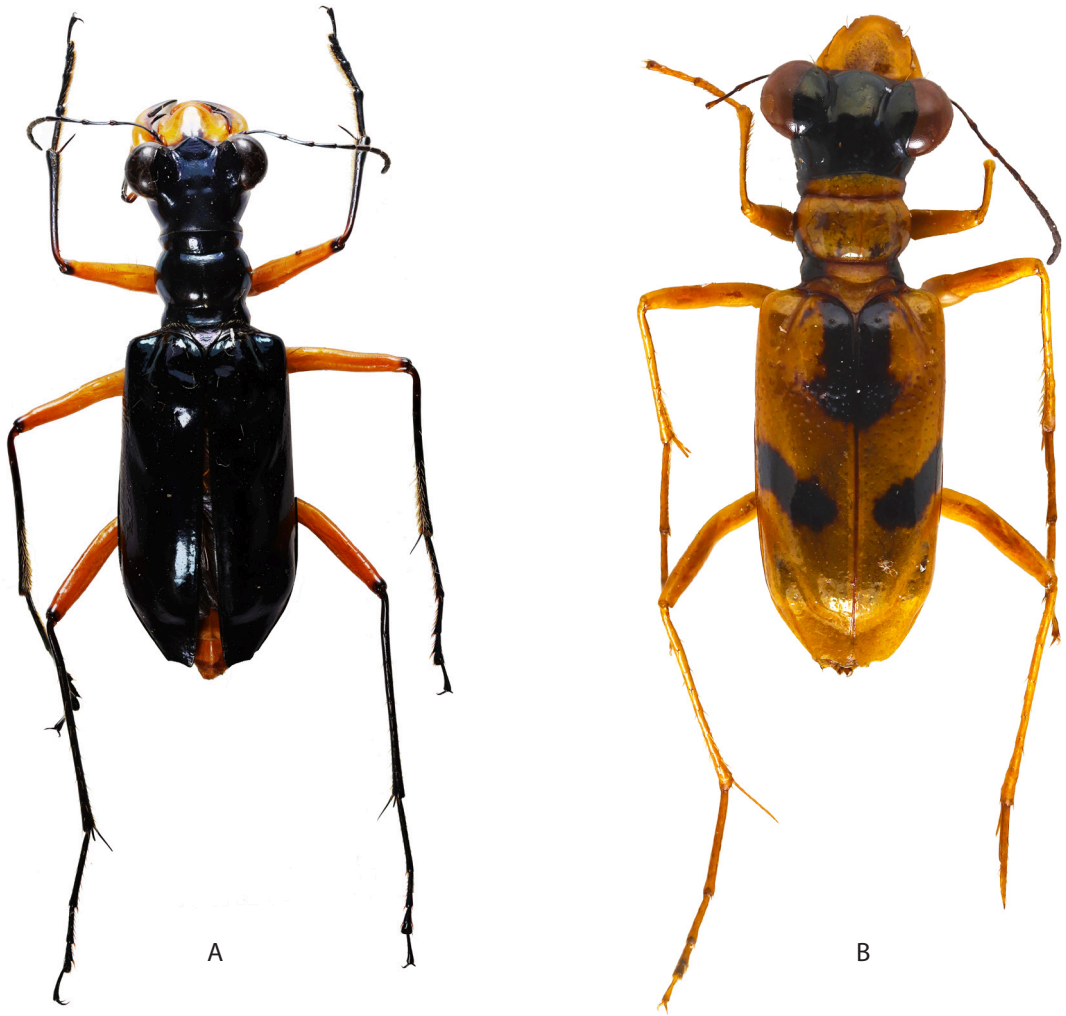

Figure 5. A. *Therates coracinus coracinus* Erichson, 1834. **B.** *Therates monticola* Zettel & Pangantihon, 2017.

everetii Bates, 1878 in having a long labrum, the galea of the maxilla reduced to one segment, a highly reduced 4th tarsal segment. However, *Therates coracinus coracinus* is easily recognized by its shiny black upperparts (Wiesner 1988), whereas the other two species have either an orange-and-black combination or an entirely orange elytron. In size, it is similar with *T. fulvipennis fulvipennis* W. Horn, 1928.

Endemism and distribution. An Oriental species. Philippines (Luzon, Mindoro, Romblon, Samar, Leyte, Panay, Negros, Palawan, Balabac, Mindanao), Indonesia (Sulawesi, Talaud), Moluccas (Halmahera, Bacan) (Cabras et al. 2016b; Cassola 2000).

Remarks. This species was frequently encountered in a cold, well-shaded to partly shaded stream. Several individuals were seen flying and perching on twigs, logs, and leaves near the stream, and they sometimes perched on exposed boulders along the stream. They were very abundant in areas with no or little human activity. Cassola (2000) regarded this to be a widespread Philippine endemic species (with two subspecies). However, Cabras et al. (2016b) included some eastern islands of Indonesia as part of the range of the species. Additional study of the many species of *Therates* in the Philippines is needed to determine their taxonomic status.

Therates monticola Zettel & Pangantihon, 2017

Material examined. PHILIPPINES, Apayao Province, Municipality of Calanasan,1♂, 3♀♀ Brgy. Tanglagan [18.3692°N, 120.9603°E], 2♂♂, Brgy. Parina [18.4291°N, 120.9713°E] IX–X.2018, coll. R.J.T. Villanueva (Fig. 5B); UMCRC010149, UMCRC010150, UMCRC010151, UMCRC010152.

Identification. *Therates monticola* is easily distinguished by the color pattern of its elytra and its smaller size compared to the most similar species of *Therates*, namely *T. fasciatus fasciatus* (Fabricius, 1801), *T. pseudosemperi* W. Horn, 1928, and *T. negrosicola* Zettel & Pangantihon, 2017. *Therates monticola* is very similar to *T. semperi* Schaum, 1860 in size but morphologically differs in having reduced punctation of the elytra, an entirely orange prothorax and mesoepisternum, an absent or small black circumscutellary mark, and large black medial marks on the elytra. *Therates monticola* has a black central mark of its elytron but it is short located near the apex (Zettel and Pangantihon 2017). The

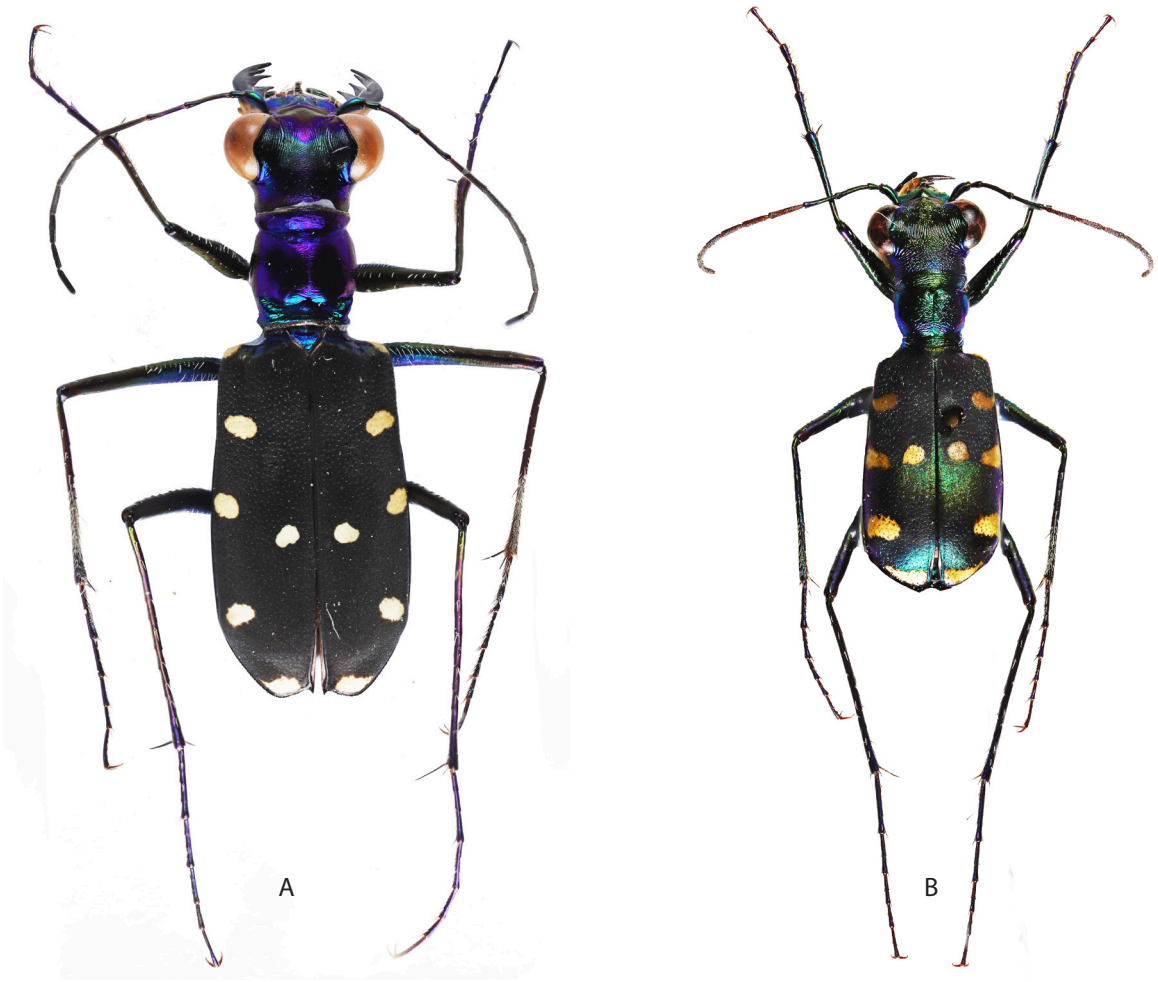

Figure 6. A. *Thopeutica virginalis* (W. Horn, 1901). **B.** *Thopeutica suavissima* (Schaum, 1862).

aedeagus is moderately slender, and its dorsal side is not emarginated.

Remarks. This species was living with *T. coracinus coracinus* in open to partially shaded streams. Zettel and Pangantihon (2017) described this species recently, with the type locality in the Cordillera Central, Mountain Province Philippines.

Thopeutica (*Thopeutica*) *virginalis* (W. Horn, 1901)

Material examined. PHILIPPINES, Apayao Province, Municipality of Calanasan, 2♂♂, Brgy. Tanglagan, IX.2018, coll. R.J.T. Villanueva (Fig. 6A); UMCRC 010153, UMCRC010154.

Identification. This species is very similar with *T. darlingtonia* Cassola & Ward, 2004 and *T. suavissima* Schaum, 1862 in having very fine sculpture on the frons and elytral maculation broken into dots; however, they differ in the color patterns of the pronotum. In *T. suavissima* the pronotum is metallic green, while in *T. virginalis* it is metallic blue, and in *T. darlingtonia* it is dark brown to black. *Thopeutica virginalis* has elongated, parallel-sided, dull greyish black to olive-green elytra, glossy black mirror spots in females, and a long, distinct sutural spine on the elytra. All three *Thopeutica* species have the aedeagus apically hooked.

Endemism and distribution. A Philippine endemic. Philippines (Luzon, Marinduque, Masbate, Panay, Negros, Leyte, Bohol, Cebu, Mindanao) (Cabras et al. 2016b; Cassola 2000).

Remarks. *Thopeutica virginalis*, *T. darlingtonia*, and *T. suavissima* were found along a stream bank, with the last species encountered least often. It is of interest that these species all inhabit the same habitat and locality.

Thopeutica (*Thopeutica) suavissima* (Schaum, 1862)

Material examined. PHILIPPINES, Apayao Province, Municipality of Calanasan, 2♂♂, Brgy. Tanglagan, IX.2018, coll. R.J.T. Villanueva (Fig. 6B); UMCRC 010155, UMCRC010156.

Identification. See *Thopeutica virgninalis*.

Endemism and distribution. A Philippine endemic. Luzon Island (Cabras et al. 2016b; Cassola 2000).

Thopeutica (*Thopeutica*) *darlingtonia* Cassola & Ward, 2004

Material examined. PHILIPPINES, Apayao Province, Municipality of Calanasan, 1♂, Brgy. Tanglagan; 3♀♀, Brgy Parina, IX.2018, coll. R.J.T. Villanueva (Fig. 7); UMCRC010157, UMCRC010158, UMCRC010159, UMCRC010160.

Figure 7. *Thopeutica darlingtonia* Cassola & Ward, 2004.

Identification. See *Thopeutica virgninalis*.

Endemism and distribution. A Philippine endemic. Philippines (Luzon, Cavite), Mindanao (Bukidnon, Impasug-ong) (Cabras et al. 2016b; Cassola 2000).

Discussion

The present list is the first for Calanasan (Apayao Province, Philippines) and includes nine of the 12 endemic tiger beetle species in the Philippines. However, more species of these beetles are expected to occur in this area, including members of the tribe Collyrina, such as *Tricondyla* spp. and *Neocollyris* spp. Additional thorough exploration in the area would likely add species to the present list.

The number of tiger beetle species is similar to that found in Compostela Valley Province by Cabras et al. (2016), who reported 12 species and 7 genera, including the tribe Collyrina and genus *Neocollyris*, which were not found in the present study in Calanasan. The rate of endemism in Calanasan is higher (75%) than in Mainit Hot Spring Protected Landscape in Mindanao (62.5%; Cabras and Wiesner 2016). A study in Northern Mindanao reported a similar rate of endemism (77% among 12 species in total) to the present study (R. Jaskula pers. comm., 10 July 2019). In all these studies, the species compositions differ. This can be explained, in part, because some members of the genus *Thopeutica* have a narrow geographic range and show a high preference of habitat (Cassola and Ward 2004; Cabras et al. 2016a, 2016c).

All species were collected near riverbanks, along the forest trails. The most common species documented were *Cylinder fabiocassola* and *C. genieri*. The oriental species include *Calomera lacrymosa*, *Therates coracinus coracinus*, and *Lophyra striolata*. The remaining species, *Cylindera macilenta*, *C. fabiocassola*, *C. genieri*, *Heptodonta melanopyga*, *Prothyma* sp., *Therates monticola*, *Thopeutica virginalis*, *T. suavisima*, and *T. darlingtona* are Philippine endemics (Fig. 2).

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Authors' Contributions

MNM examined the material, analyzed the data, and provided additional material. AC provided the photographs and assisted in the examination of the materials. JI help in the collection of specimens provided logistics support for the expedition team. GO helped in the collection of specimens and provided the GPS and GIS data of the paper. RJV helped in the collection of material and provide additional material from his collection. All authors contributed to writing the manuscript.

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