

[研究文章 Research Article]

<https://doi.org/10.5281/zenodo.7756847>

A Preliminary Faunistic Survey of Carabidae (Coleoptera) from Gaomei Wetlands Wildlife Refuge, Taichung City, Taiwan

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Abstract: A systematic survey of ground beetles (Coleoptera: Carabidae) was conducted at Gaomei Wetlands Wildlife Refuge. We discovered 19 carabid species in the study area and provide a complete list of them. Among four sampling sites, the northern side of the Dajia River estuary had the highest species richness, where 14 species of Carabidae were recorded. The species compositions were also different across sampling sites, probably caused by habitat heterogeneity in Gaomei Wetlands Wildlife Refuge. In addition, we provide notes on the two most abundant species. *Bembidion foochowense* Lindroth 1980 is rediscovered and represents the first recorded littoral ground beetle in central Taiwan. *Mastax brittoni* Quentin, 1952, the species with three different elytral color patterns but has a constant elytral color pattern in our survey and occurs sympatrically with ants. Our investigation was focussed on the carabid fauna of central Taiwan and implied the insufficient investigation of littoral ground beetles.

Keywords: Ocean-shore ground beetles, *Desarmatocillenus*, Dajia River's estuary

Introduction

Ground beetles (Carabidae) form a large family in Coleoptera and consist of over 40,000 species worldwide (Erwin, 1985; Lövei & Sunderland, 1996). More than 400 species have been recorded in Taiwan, but the total carabid fauna of the country is still unclear (Terada et al., 2005; Terada, 2006). The species composition and richness of carabid beetles are important bioindicators in assessing environment or biodiversity (Rainio & Niemelä, 2003). Therefore, the systematic investigation of local fauna is important and informative to make the database of Taiwan carabid fauna more complete.

The Gaomei Wetlands Wildlife Refuge is a tidal-dominated coastal wetland connected to the south of Dajia River estuary (Hsu et al., 2020). The habitat composition includes five types: tidal creek, swampland, sand, gravel, and grassland areas (Wu & Huang, 2013). The habitat diversity is suitable for different carabid faunas (Lövei & Sunderland, 1996; Rainio & Niemelä, 2003); however, *Tachys fomicatus* (Motschulsky, 1851) was the only carabid recorded so far in Gaomei Wetlands Wildlife Refuge (Terada et al., 2013).

In order to confirm and update the ground beetle diversity of Gaomei Wetlands Wildlife Refuge, we conducted a systematic faunistic survey of carabid from March to December in 2020. During this survey, we collected 19 species belonging to five subfamilies of Carabidae. In this article, we provide a species list of Carabidae of Gaomei Wetlands Wildlife Refuge.

Materials and methods

We selected four sites that represent different habitats and vegetation in Gaomei Wetlands Wildlife Refuge (Fig. 1A): the northern side of Dajia river estuary (site A; Fig. 1B), the southern side of Dajia river estuary (site B; Fig. 1C), the swampland with *Phragmites australis* (Cav.) Trin. ex Steud. near Huan-á-liâu sea wall (site C; Fig. 1D), and the swampland with *Sporobolus virginicus* (L.) Kunth and *Zoysia sinica* Hance near Gaomei number 2 sea wall (site D; Fig. 1E).

Collection methods included drift-fence funnel trapping, light trapping and hand collection from March to December in 2020. We set one drift-fence funnel trap in each site. For each set of the drift-fence funnel traps, three or two plastic plates (100 cm × 30 cm) were connected together and set up vertically on the ground. Two plastic funnel traps (12.5 cm diameter, 36 cm length) without bait were set at both ends of the plastic plate to become an I-shape. We checked each drift-fence funnel trap one week per month. The light traps were set up with 40W HID light bulb (4300K color temperature). We conducted the light trapping at each collection

site for 3 hours during the low tide period (about 18:00 p.m. – 21:00 p.m. according to the tide) in April and September. The hand collection was conducted for one hour at nighttime by one person per month.

Specimens were examined with a SMN 800N stereomicroscope and identified to species level by the first and the second authors. All specimens which examined in this study were deposited at National Museum of Natural Science, Taichung, Taiwan.

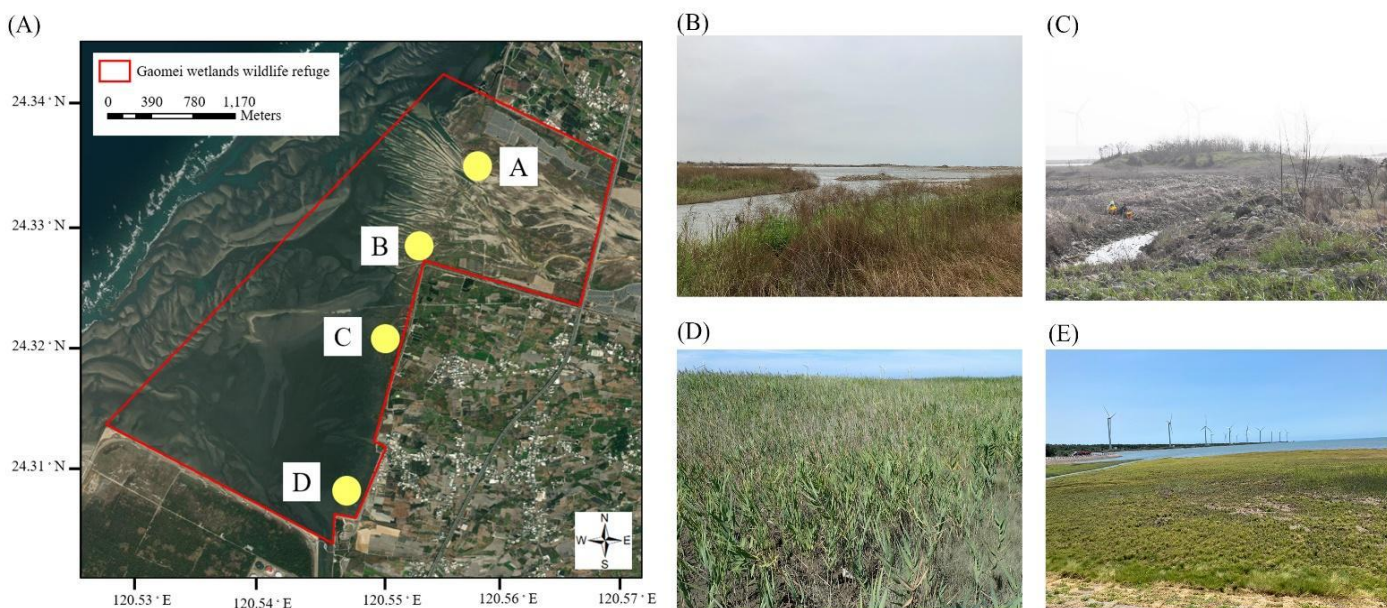


Figure 1. (A) Sampling sites of ground beetles in Gaomei Wetlands Wildlife Refuge, Taichung City, Taiwan. The habitat of (B) the northern side of Dajia estuary (site A), (C) southern side of Dajia estuary (site B), (D) Huan-á-liâu (番仔寮) sea wall (site C) and (E) Gaomei (高美) number 2 sea wall (site D).

Results

A total of 203 specimens belonging to 19 species of ground beetles were obtained from our survey in Gaomei Wetlands Wildlife Refuge. The drift-fence funnel trapping, light trapping and hand collection method collected 4, 8 and 11 species, respectively. A total of four species, *Calomera angulata* Fabricius, 1798, *Bembidion (Desarmatocillen)* *foochowense* Lindroth, 1980, *Bembidion (Trichoplataphus)* *taiwanum* Netolitzky, 1939 and *Anchomenus leucopus* (Bates, 1873), were collected from hand collection and light trapping. *Pheropsophus (Stenaptinus)* *javanus* (Dejean, 1825) was collected from hand collection and drift-fence funnel trapping (Table 1). Three of the most abundant species were *B. (D.) foochowense* (n = 48), *Mastax brittoni* Quentin, 1952 (n = 30), and *B. (T.) taiwanum* (n = 27; Table 1). The most carabid-abundant site in this area is the northern side of Dajia River estuary (site A), where 14 species were recorded (Table 1). No ground beetle was obtained at the site of Gaomei number 2 sea wall (site D) (Table 1). Four species were obtained from the southern side of Dajia River estuary and Huan-á-liâu sea wall, respectively (Table 1). Most species only occurred in a single site, while a few species were found in two different sites, such as *Galerita orientalis* Schmidt-Gobel, 1846 and *P. (S.) javanus* occurred on both sides of the Dajia River estuary, and the *Callytron inspeculare inspeculare* Horn, 1904 occurred in the southern side of the Dajia River estuary and Huan-á-liâu sea wall site.

Discussion

Our survey revealed different species richness among sites. The hand collection is the most efficient method of collecting ground beetles in Gaomei Wetlands Wildlife Refuge; however, most species were collected by the single method in a single site (Table 1). No ground beetle was obtained in the Gaomei number 2 sea wall site from our survey (Table 1), in spite of the fact that there was a record of *Tachys fumicatus* from the same place (Terada et al., 2013). This site was frequently flooded by tide, hence this habitat is perhaps no longer suitable for carabid beetles. However, the Huan-á-liâu sea wall site is also a swampland and frequently flooded by tide but had ground beetles have occurred. We suggest the high grass vegetation of *Phragmites australis* in Huan-á-liâu sea wall site provides refuges for the full wings ground beetles, such as *Stenolophus (Egadroma) quinquepustulatus* (Wiedemann, 1823) and *Stenolophus (Egadroma) smaragdulus* (Fabricius, 1798). Although both sides of the Dajia River estuary have similar habitats in vegetation and landscape, the ground beetle compositions, species richness and abundance were different between the two sites (Table 1). For example, the highest species abundance which belongs to *Bembidion* group and *Chlaenius* group occurred only on northern side of the Dajia River estuary. It is not clear why these two sides had different species compositions;

however, the frequent flooding, erosion, and sedimentation in raining season which caused frequent habitat changing and microenvironmental difference perhaps one of the reasons. It should have further study to confirm what caused the different species compositions. Overall, our survey indicated that the ground beetle richness and compositions among sites likely associated with the habitat heterogeneity in Gaomei Wetlands Wildlife Refuge.

We provide an ecological note and discussions of the two most abundant species, *B. (D.) foochowense* and *Mastax brittoni* Quentin, 1952. *B. (D.) foochowense* is a littoral (seashore-dwelling) ground beetle (Fig. 2D) which lives in intertidal habitat and distributed in China, Hong Kong and Taiwan (Marggi et al., 2017). The first collection record of this species in Taiwan was from Fulong, northern Taiwan in 2008 (Toledano, 2009). Our finding is the first record in central Taiwan and the second record after a decade of the first record in Taiwan. This result implies the insufficient investigation of Taiwan carabid fauna and a much wider potential distribution of *B. foochowense* in river estuaries of Taiwan.

Mastax brittoni has three different elytral color patterns (Terada & Wu, 2018). The Gaomei population consists of only one pattern, which has two dull-orange anterior spots and a whitish posterior spot on each elytron (Fig. 2R). It is interesting that the elytral pattern of *M. brittoni* is almost constant of all specimens from Gaomei Wetlands Wildlife Refuge because it was not clear that these three elytral patterns are inter- or intrapopulation variations. Our finding is perhaps an evidence that these three elytral patterns are interpopulation variations; however, it still needs more investigation survey of other geological populations to confirm our inference. In our result, thirty individuals of *M. brittoni* were all collected from the southern side of Dajia River estuary (Fig. 1B), and no individuals from the other three collection sites (Table 1). Those specimens were found in a dry-out puddle with moist sandy substrate covered with some gravel, where we also observed a certain ant species (*Paratrechina* sp.) was sympatric with them. Although these two species appeared in the same habitat, no interaction was observed between them.

Species list of Gaomei Wetlands Wildlife Refuge

(Based on our collection in 2020)

Cicindelinae Latreille, 1802

Cicindelini Latreille, 1802

1. *Callytron inspeculare inspeculare* Horn, 1904 暗色白緣虎甲蟲 (Fig. 2A)

Material examined. TAIWAN: 1♀1♂, Taichung City, southern side of Dajia estuary, 24.327003N 120.553611E, hand collection, 03. VI. 2020, L.-W. Yeh leg.; 1♀, Taichung City, Huan-á-liâu sea wall, 24.324441N 120.553119E, hand collection, 03. VI. 2020, L.-W. Yeh leg.; 2♂, Taichung City, Huan-á-liâu sea wall, 24.318281N 120.550611E, hand collection, 22. IX. 2020, L.-W. Yeh leg.

2. *Calomera angulata* Fabricius, 1798 白紋虎甲蟲 (Fig. 2B)

Material examined. TAIWAN: 4♀♀1♂, Taichung City, northern side of Dajia estuary, 24.334310N 120.558642E, hand collection, 29. IV. 2020, L.-W. Yeh leg.; 1♂, Taichung City, northern side of Dajia estuary, 24.333499N 120.558756E, hand collection, 03. VI. 2020, L.-W. Yeh leg.; 1♂, Taichung City, northern side of Dajia estuary, 24.333499N 120.558756E, hand collection, 05. VI. 2020, L.-W. Yeh leg.; 2♂♂, Taichung City, northern side of Dajia estuary, 24.333499N 120.558756E, hand collection, 23. IX. 2020, L.-W. Yeh leg.; 3♀♀5♂♂, Taichung City, northern side of Dajia estuary, 24.334475N 120.557875E, light trap, 23. IX. 2020, L.-W. Yeh leg.

3. *Cylindera (Eugrapha) elisae formosana* Minowa, 1932 臺灣虎甲蟲; 蓬萊虎甲蟲 (Fig. 2C)

Material examined. TAIWAN: 3♀♀4♂♂, Taichung City, northern side of Dajia estuary, 24.334475N 120.557875E, light trap, 23. IX. 2020, L.-W. Yeh leg.

Trechinae Bonelli, 1810

Bembidiini Stephens, 1827

4. *Bembidion (Desarmatocillenus) foochowense* Lindroth, 1980 (Fig. 2D)

Material examined. TAIWAN: 14♀♀19♂♂, Taichung City, northern side of Dajia estuary, 24.334678N 120.556376E, hand collection, 24. IV. 2020, L.-W. Yeh leg.; 6♀♀3♂♂, Taichung City, northern side of Dajia estuary, 24.333499N 120.558756E, hand collection, 23. IX. 2020, L.-W. Yeh leg.; 1♂, Taichung City, northern side of Dajia estuary, 24.334475N 120.557875E, light trap, 23. IX. 2020, L.-W. Yeh leg.; 2♀♀3♂♂, Taichung City, northern side of Dajia estuary, 24.334678N 120.556376E, hand collection, 26. X. 2020, L.-W. Yeh leg.

5. *Bembidion (Notaphocampa) niloticum batesi* Putzeys, 1875 (Fig. 2E)

Material examined. TAIWAN: 2♂♂, Taichung City, northern side of Dajia estuary, 24.334527N 120.556774E, hand collection, 22. VII. 2020, L.-W. Yeh leg.; 2♂♂, Taichung City, northern side of Dajia estuary, 24.333499N 120.558756E, hand collection, 23. IX. 2020, L.-W. Yeh leg.

6. *Bembidion (Odontium) gebieni* Netolitzky, 1928 (Fig. 2F)

Material examined. TAIWAN: 3♀♀1♂, Taichung City, northern side of Dajia estuary, 24.333499N 120.558756E, hand collection, 05. VI. 2020, L.-W. Yeh leg.

7. *Bembidion (Trichoplathaphus) taiwanum* Netolitzky, 1939 (Fig. 2G)

Material examined. TAIWAN: 1♀2♂♂, Taichung City, northern side of Dajia estuary, 24.334238N 120.559111E, hand collection, 21. IX. 2020, L.-W. Yeh leg.; 9♀♀7♂♂, Taichung City, northern side of Dajia estuary, 24.334475N 120.557875E, light trap, 23. IX. 2020, L.-W. Yeh leg.; 7♀♀1♂, Taichung City, northern side of Dajia estuary, 24.333500N 120.561086E, hand collection, 21. X. 2020, L.-W. Yeh leg.

Harpalinae Bonelli, 1810

Chlaeniini Brullé, 1834

8. *Chlaenius (Amblygenius) touzalini* Andrewes, 1920 (Fig. 2H)

Material examined. TAIWAN: 1♀, Taichung City, northern side of Dajia estuary, 24.334529N 120.558082E, drift-fence funnel trap, 29. IV. 2020, L.-W. Yeh leg.; 1♂, Taichung City, northern side of Dajia estuary, 24.334529N 120.558082E, drift-fence funnel trap, 05. VI. 2020, L.-W. Yeh leg.; 2♂♂, Taichung City, northern side of Dajia estuary, 24.334529N 120.558082E, drift-fence funnel trap, 07. VI. 2020, L.-W. Yeh leg.

9. *Chlaenius (Chlaeniellus) inops inops* Chaudoir, 1856 (Fig. 2I)

Material examined. TAIWAN: 2♀♀, Taichung City, northern side of Dajia estuary, 24.334288N 120.558867E, hand collection, 21. IV. 2020, L.-W. Yeh leg.; 4♀♀8♂♂, Taichung City, northern side of Dajia estuary, 24.334288N 120.558867E, hand collection, 21. X. 2020, L.-W. Yeh leg.

10. *Chlaenius (Chlaeniostenus) circumdatus xanthopleurus* (Chaudoir, 1856) (Fig. 2J)

Material examined. TAIWAN: 2♀♀3♂♂, Taichung City, northern side of Dajia estuary, 24.334288N 120.558867E, hand collection, 21. X. 2020, L.-W. Yeh leg.

11. *Chlaenius (Lithochlaenius) rambouseki* Lutshnik, 1933 (Fig. 2K)

Material examined. TAIWAN: 1♂, Taichung City, northern side of Dajia estuary, 24.334475N 120.557875E, light trap, 23. IX. 2020, L.-W. Yeh leg.

Galeritini Kirby 1825

12. *Galerita orientalis* Schmidt-Gobel, 1846 (Fig. 2L)

Material examined. TAIWAN: 1♂, Taichung City, southern side of Dajia estuary, 24.327490N 120.559409E, drift-fence funnel trap, 13. III. 2020, L.-W. Yeh leg.; 1♀2♂♂, Taichung City, northern side of Dajia estuary, 24.334529N 120.558082E, drift-fence funnel trap, 13. III. 2020, L.-W. Yeh leg.; 2♀♀1♂, Taichung City, northern side of Dajia estuary, 24.334529N 120.558082E, drift-fence funnel trap, 29. IV. 2020, L.-W. Yeh leg.; 1♂, Taichung City, southern side of Dajia estuary, 24.327490N 120.559409E, drift-fence funnel trap, 05. VI. 2020, L.-W. Yeh leg.; 3♀♀, Taichung City, northern side of Dajia estuary, 24.334529N 120.558082E, drift-fence funnel trap, 07. VI. 2020, L.-W. Yeh leg.; 1♀, Taichung City, southern side of Dajia estuary, 24.327490N 120.559409E, drift-fence funnel trap, 23. IX. 2020, L.-W. Yeh leg.

Harpalini Bonelli, 1810

13. *Acupalpus (Stenolophidius) inornatus* Bates, 1873 (Fig. 2M)

Material examined. TAIWAN: 2♀♀1♂, Taichung City, Huan-á-liâu sea wall, 24.322278N 120.552676E, light trap, 25. IV. 2020, L.-W. Yeh leg.

14. *Stenolophus (Egadroma) quinquepustulatus* (Wiedemann, 1823) (Fig. 2N)

Material examined. TAIWAN: 3♀♀5♂♂, Taichung City, Huan-á-liâu sea wall, 24.322278N 120.552676E, light trap, 25. IV. 2020, L.-W. Yeh leg.

15. *Stenolophus (Egadroma) smaragdulus* (Fabricius, 1798) (Fig. 2O)

Material examined. TAIWAN: 2♂♂, Taichung City, Huan-á-liâu sea wall, 24.322278N 120.552676E, light trap, 25. IV. 2020, L.-W. Yeh leg.

Panagaeni Bonelli, 1810

16. *Craspedophorus mandarinus* (Schaum, 1854) 寬四星步行蟲 (Fig. 2P)

Material examined. TAIWAN: 1♀, Taichung City, northern side of Dajia estuary, 24.334529N 120.558082E, drift-fence funnel trap, 29. IV. 2020, L.-W. Yeh leg.

Platynini Bonelli, 1810

17. *Anchomenus leucopus* (Bates, 1873) (Fig. 2Q)

Material examined. TAIWAN: 1♀, Taichung City, northern side of Dajia estuary, 24.334475N 120.557875E, light trap, 23. IX. 2020, L.-W. Yeh leg.; 1♀1♂, Taichung City, northern side of Dajia estuary, 24.334288N 120.558867E, hand collection, 21. X. 2020, L.-W. Yeh leg.

Brachininae Bonelli, 1810

Brachinini Bonelli, 1810

18. *Mastax brittoni* Quentin, 1952 (Fig. 2R)

Material examined. TAIWAN: 19♀♀11♂♂, Taichung City, southern side of Dajia estuary, 24.328201N 120.558788E, hand collection, 18. XI. 2020, L.-W. Yeh leg.

19. *Pheropsophus (Stenaptinus) javanus* (Dejean, 1825) 黃紋放屁蟲 (Fig. 2S)

Material examined. TAIWAN: 1♀, Taichung City, southern side of Dajia estuary, 24.326734N 120.552198E hand collection, 25. IV. 2020, L.-W. Yeh leg.; 1♀2♂♂, Taichung City, southern side of Dajia estuary, 24.327490N 120.559409E, drift-fence funnel trap, 29. IV. 2020, L.-W. Yeh leg.; 2♂♂, Taichung City, southern side of Dajia estuary, 24.327490N 120.559409E, drift-fence funnel trap, 05. VI. 2020, L.-W. Yeh leg.; 1♂, Taichung City, northern side of Dajia estuary, 24.334529N 120.558082E, drift-fence funnel trap, 07. VI. 2020, L.-W. Yeh leg.; 1♀, Taichung City, southern side of Dajia estuary, 24.327490N 120.559409E, drift-fence funnel trap, 23. IX. 2020, L.-W. Yeh leg.

Table 1. Species composition of Carabidae and collection methods in four sites of Gaomei Wetlands Wildlife Refuge. The abbreviations of H, L and D were hand collection, light trapping and drift-fence funnel trapping, respectively. The number in the parentheses represents the individuals of collection method.

Species	Number of individuals	Northern side of Dajia estuary	Southern side of Dajia estuary	Huan-á-liâu sea wall	Gaomei number 2 sea wall
1. <i>Callytron inspeculare inspeculare</i>	5		H (2)	H (3)	
2. <i>Calomera angulata</i>	17	H (9), L (8)			
3. <i>Cylindera (Eugrapha) elisae formosana</i>	7	L (7)			
4. <i>Bembidion (Desarmatocillenus) foochowense</i>	48	H (47), L (1)			
5. <i>B. (Notaphocampa) niloticum batesi</i>	4	H (4)			
6. <i>B. (Odontium) gebieni</i>	4	H (4)			
7. <i>B. (Trichoplataphus) taiwanum</i>	27	H (11), L (16)			
8. <i>Chlaenius (Amblygenius) touzalini</i>	4	D (4)			
9. <i>C. (Chlaeniellus) inops inops</i>	14	H (14)			
10. <i>C. (Chlaenostenus) circumdatus xanthopleurus</i>	5	H (5)			
11. <i>C. (Lithochlaenius) rambouseki</i>	1	L (1)			
12. <i>Galerita orientalis</i>	12	D (9)	D (3)		
13. <i>Acupalpus (Stenolophidius) inornatus</i>	3			L (3)	
14. <i>Stenolophus (Egadroma) quinquepustulatus</i>	8			L (8)	
15. <i>S. (Egadroma) smaragdulus</i>	2			L (2)	
16. <i>Craspedophorus mandarinus</i>	1	D (1)			
17. <i>Anchomenus leucopus</i>	3	H (2), L (1)			
18. <i>Mastax brittoni</i>	30		H (30)		
19. <i>Pheropsophus (Stenaptinus) javanus</i>	8	D (1)	D (6), H (1)		
Total of species		14	4	4	0

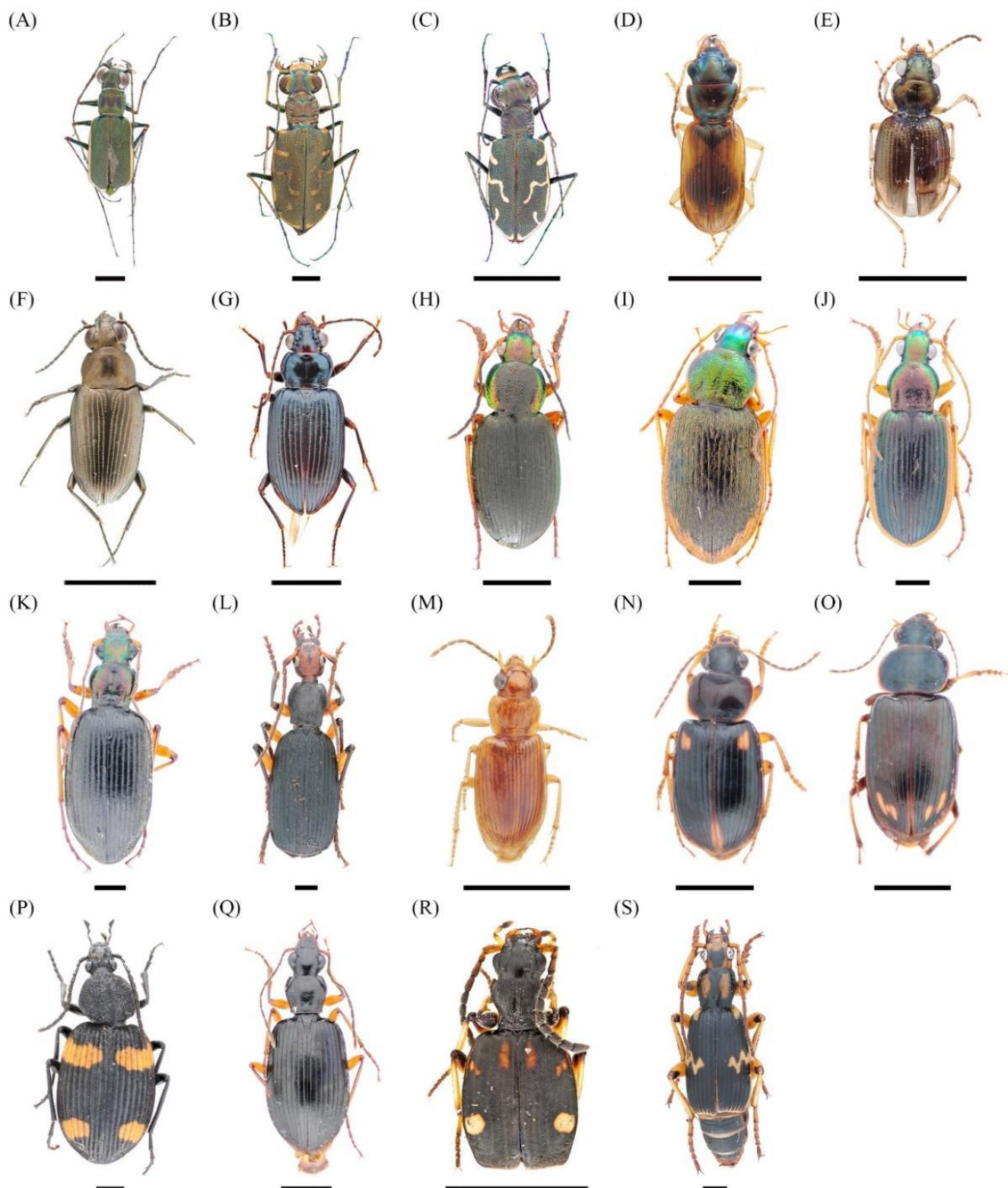


Figure 2. Habitus of (A) *Callytron inspeculare inspeculare* Horn, 1904; (B) *Calomera angulata* Fabricius, 1798; (C) *Cylindera (Eugrapha) elisae formosana* Minowa, 1932; (D) *Bembidion (Desarmatocillenus) foochowense* Lindroth, 1980; (E) *Bembidion (Notaphocampa) niloticum batesi* Putzeys, 1875; (F) *Bembidion (Odontium) gebieni* Netolitzky, 1928; (G) *Bembidion (Trichoplataphus) taiwanum* Netolitzky, 1939; (H) *Chlaenius (Amblygenius) touzalini* Andrewes, 1920; (I) *Chlaenius (Chlaeniellus) inops inops* Chaudoir, 1856; (J) *Chlaenius (Chlaeniostenus) circumdatus xanthopleurus* (Chaudoir, 1856); (K) *Chlaenius (Lithochlaenius) rambouseki* Lutshnik, 1933; (L) *Galerita orientalis* Schmidt-Gobel, 1846; (M) *Acupalpus (Stenolophidius) inornatus* Bates, 1873; (N) *Stenolophus (Egadroma) quinquepustulatus* (Wiedemann, 1823); (O) *Stenolophus (Egadroma) smaragdulus* (Fabricius, 1798); (P) *Craspedophorus mandarinus* (Schaum, 1854); (Q) *Anchomenus leucopus* (Bates, 1873); (R) *Mastax brittoni* Quentin, 1952; and (S) *Pheropsophus (Stenaptinus) javanus* (Dejean, 1825) on Gaomei Wetlands Wildlife Refuge. The scale bars are 2 mm.

Acknowledgments

The work was supported by Forestry Bureau, Council of Agriculture, Executive Yuan, Taiwan and Taichung City Government grants (109 林發-08.1-保-38(1)) to Department of Life Science, Tunghai University. We thank Prof. Hui-Chen Lin for field work support.

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台中市高美野生動物保護區步行蟲科（鞘翅目）調查初探

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摘要: 我們在 2020 年針對台中高美野生動物保護區進行系統性的步行蟲調查，在 4 個不同類型的棲地共記錄 19 種步行蟲。大甲溪北岸的樣點多樣性最高，共記錄 14 種步行蟲。本文提供兩種最優勢的步行蟲的相關生態資訊。*Bembidion fochowense* Lindroth, 1980 為臺灣的第二筆紀錄，也是首次於臺灣中部發現的潮間帶步行蟲。*Mastax brittoni* Quentin, 1952 曾記錄三種不同的翅鞘斑紋，但於高美野生動物保護區的族群顯示相同的翅鞘斑紋，並且觀察到與螞蟻共域的現象。我們的調查結果不僅記錄台中大甲溪口步行蟲的組成，也暗示著臺灣對於沿海地區昆蟲相的調查不足。

關鍵詞: 海濱步行蟲、*Desarmatocillen*、大甲溪口