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Mindanao broken stick insect: a new species and first country record of the genus *Baculofractum* Zompro, 1995 (Phasmatodea: Lonchodidae: Lonchodinae: Lonchodini) from the Philippines

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Abstract

Baculofractum Zompro 1995 is a genus of stick insects in the family Lonchodidae, subfamily Lonchodinae represented by three species: *B. insigne*, *B. shelfordi*, and *B. williemsei,* distributed in Indonesia and Malaysia. This paper reports the discovery of a new species of *Baculofractum* from Mt. Malimumu, Pantaron Range, Bukidnon which also represents the first record of the genus in the Philippines. The new species can be distinguished by the absence of four tubercles at the back of the head's median ridges and its distinctly elongated operculum exceeding the end of the abdomen.

Keywords: *Baculofractum junliti*, Bukidnon, Mt. Malimumu, new record, phasmids

Introduction

The Philippines is the second most important biodiversity hotspot on earth and is considered a hotspot of Phasmatodean biodiversity representing 5.7% of the world phasmids with 190 representative species (Myers et al., 2000, Brock et al., 2023). Ninety-five percent (95%) of these are Philippine endemics. Family Lonchodidae has the most number of representative species in the country followed by family Heteropterygidae (Brock et al., 2023).

The genus *Baculofractum* Zompro 1995 belongs to a group of elongate and mostly wingless anareolate stick insects in the Lonchodidae, subfamily Lonchodinae (Bradler et al., 2014). After examining *Carausius insignis* Brunner von Wattenwyl, Zompro (1995) erected the new genus *Baculofractum* on the basis of the female having developed flap-like dilations on the dorsal portion of the forefemora and tibiae, presence of wings in the male, and an egg capsule lacking a capitulum. At present, the genus is represented by three species: *B. insigne* (Brunner von Wattenwyl), *B. williemsei* Seow-Choen and *B. shelfordi* Bragg which are geographically restricted to Malaysia and Indonesia (Fig. 1) (Brock et al., 2023).

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A recent survey in Mindanao resulted in the discovery of a species new to science representing the first Philippine member of *Baculofractum* and the fourth member within this genus. The description is based on a single adult female. The male and the egg are still unknown. A checklist of the genus *Baculofractum* is provided.

This new species was collected in Mt. Malimumu, Pantaron Range, Bukidnon in lower montane forests at an elevation of 1,200 m.a.s.l. Major vegetation includes lawaan trees [*Shorea astylosa* Foxw.], bangkal trees [*Nauclea orientalis* (L.) L.] and tree ferns [*Sphaeropteris glauca* (Bl.) R.M. Tryon].

Materials and Methods

A specimen was collected from Mt. Malimumu, Brgy.

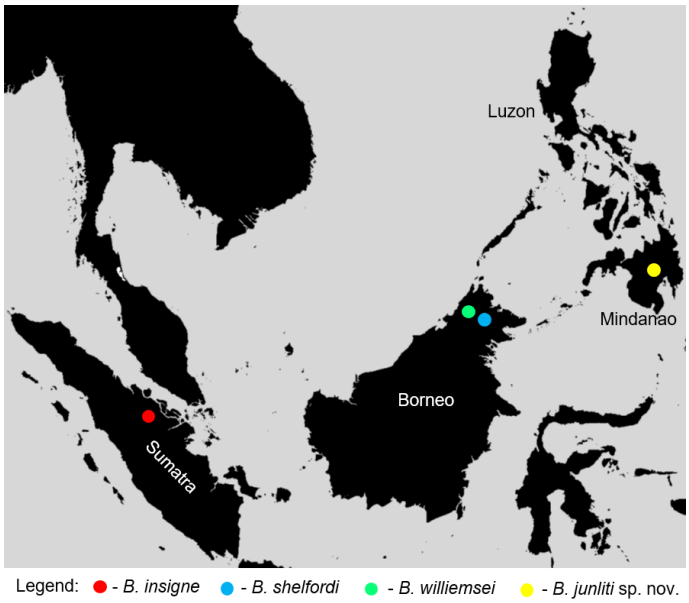

Figure 1. Map showing the geographical distribution records of genus *Baculofractum* Zompro, 1995 in South East Asia. Map image downloaded from: https://freevectormaps.com/world-maps/southeast-asia/WRLD-SEA-01-0001

Magkalungay, San Fernando, Bukidnon Province under the Department of Environment and Natural Resources Wildlife Gratuitous Permit (DENR X WGP): 2021-16. The specimen is deposited in the Entomological Collections of the Central Mindanao University Museum, Center for Biodiversity Research and Extension in Mindanao. Specimen measurements provided are in millimeters (mm). Terminology for the general morphology of phasmids used here follows Nichols et al. (2009) and Bragg (1997).

Taxonomy

Genus ***Baculofractum*** Zompro, 1995
Type-species. *Carausius insignis* Brunner von Wattenwyl, 1907: by original designation
Baculofractum Zompro 1995: 488
Seow-Choen 2000: 15, Zompro 2004: 306, Bragg 2005: 31, Bradler et al. 2014: 205, Seow-Choen 2017: 133, 2018: 455, 2020: 4, 2021: 16.

Genus ***Baculofractum***

The body of ♀♂ is distinctly long and slender, body surfaces covered with small tubercles except on the head and pronotum, dorsal thoracic region and abdominal tergites show considerable congeneric variability concerning the form, size and the location of the outgrowths. Wings are present on ♂♂ whereas ♀♀ are apterous. ♂♂ tegmina is vestigial and generally covers the base of alae. Alae appeared minuscule while in other species become longer posteriorly and reach the II abdominal tergite region. ♀♂ head longer than wide and between eyes of ♀♀ with two transverse lobes or with four tubercles at the back of respective structures. ♂♂ with two practically vertical conical spines. The length of the antennae if straightened anteriorly often not surpassing the front legs. ♀♂ pronotum slightly more or less equal length of the head. ♀♂ mesonotum is about 7.5 to 8 times as long as pronotum. ♀♂ mesosternal with distinct thin elevated longitudinal medio carina. ♀ metanotum is about half of the length of the mesonotum while ♂ is variable ranging from 1.4 to 3 times as long as of mesonotum. ♀♂ median segment to VI abdominal tergites laterally parallel-sided, VII and VIII abdominal tergites diverging laterally, ♀ IX lateral margins anterior half is diverging while posterior half converging but ♀ *B. insigne* characterization on VII to anal segment is almost parallel-sided., ♂ IX abdominal tergite dorsally sub-rectangular, wider than long. ♀ anal segment slightly expanding laterally, and the posterior marginal end is widely round. ♂ anal segment with anterior margins slightly retracted distally and outwardly extending medially towards IX medial posterior margin or posterior marginal end with bilobed indented posteromedially. ♂ lamina supraanalis protrudes posteriorly but not surpassing the length of cerci. ♀ lamina supraanalis very small, wider than long, length is about 4 to 6 times as long as the anal segment or a long and slender, elongated, narrow strip projecting posteriorly. ♀♂ cerci flattened, apex blunt. The ♀♀ operculum conceivably twice or 2.5 times as long as wide, varies from broad, deep, compressed, and armed posteriorly, or with the broad longitudinal keel on the basal half or basal three-fourth length of the operculum but laterals are expanded and laterocaudad margin flattened. The length of the operculum ranges from not exceeding the end of the abdomen to projecting beyond over the end of the abdomen at about 3.5 times the length of lamina supraanalis, apex acute. Forefemur-tibia are laterally compressed on both sexes however this structure is more discernible in ♀♀ and develops flaps-like dilations or lamina. ♀♀ foretibia dorsal lamina is immensely broad comparable to the forefemur; the dorsal lamina is likely plain or with a large dorsal lobe situated more or less in the middle portion. ♀♂ forebasitarsus lobed. Egg capsule shape near ovoid but laterally compressed, opercular angle practically flat, operculum with oval outline, posterior polar end range from simple round to slightly pointed polar mound. The external micropylar plate is elongated, wider area on the anterior half or middle portion along with the micropyle, internal plate is closed.

Checklist of Genus *Baculofractum* Zompro, 1995

1. *B. insigne* (Brunner von Wattenwyl, 1907) (Distribution: Sumatra, Peninsular Malaysia, Singapore)
2. *B. shelfordi* Bragg, 2005 (Distribution: Malaysia, Borneo Isl., Sabah, Imbak Valley)
3. *B. williemsei* Seow-Choen, 2017 (Distribution: Malaysia, Borneo Isl., Sabah, Mt. Trusmadi, BJGC.)
4. *B. junliti* sp. nov. (Distribution: Philippines, Mindanao Isl., Mt. Malimumu, Brgy. Magkalungay, San Fernando, Bukidnon)

Keys to Species of *Baculofractum* Zompro, 1995

Female

1. Operculum broad, deep, compressed, and armed posteriorly (Indonesia, Sumatra Isl.)..... .....***B. insigne*** **(Brunner von Wattenwyl, 1907)**
– Operculum longitudinal keel is broad on the basal half or basal two-third length of the operculum and laterocaudad margin flattened.....2
2. Head with two transverse ridges between eyes and with four tubercles at the back of the ridges; operculum twice as long as wide, basal half of operculum with broad longitudinal keel, projecting posteriorly but not exceeding the end of the abdomen (Malaysia, Borneo Isl.)..... .....***B. shelfordi*** **Bragg, 2005**
– Head with two transverse ridges between eyes and lack of tubercles at the back of the ridges; operculum 2.5 as long as wide, two-third length of operculum with broad longitudinal keel, projecting posteriorly and exceeding end of the abdomen (Philippines, Mindanao Isl.)..... ..... ***B. junliti*** **sp. nov.**

***** *B. williemsei* Seow-Choen, 2017 female is still unknown

Male

1. Hindwings vestigial (Malaysia, Borneo Isl.)..... .....***B. williemsei*** **Seow-Choen, 2017**
– Hindwings reaching II abdominal tergal region.....2
2. Between eyes with divided median ridge, abdominal tergite VI lobe-like structures (Indonesia, Sumatra Isl.).....***B. insigne*** **(Brunner von Wattenwyl, 1907)**
– Between eyes with pair of spines, abdominal tergite VI simple (Malaysia, Borneo Isl.)..... .....***B. shelfordi*** **Bragg, 2005**

*****_B. junliti_ sp. nov., male is still unknown.

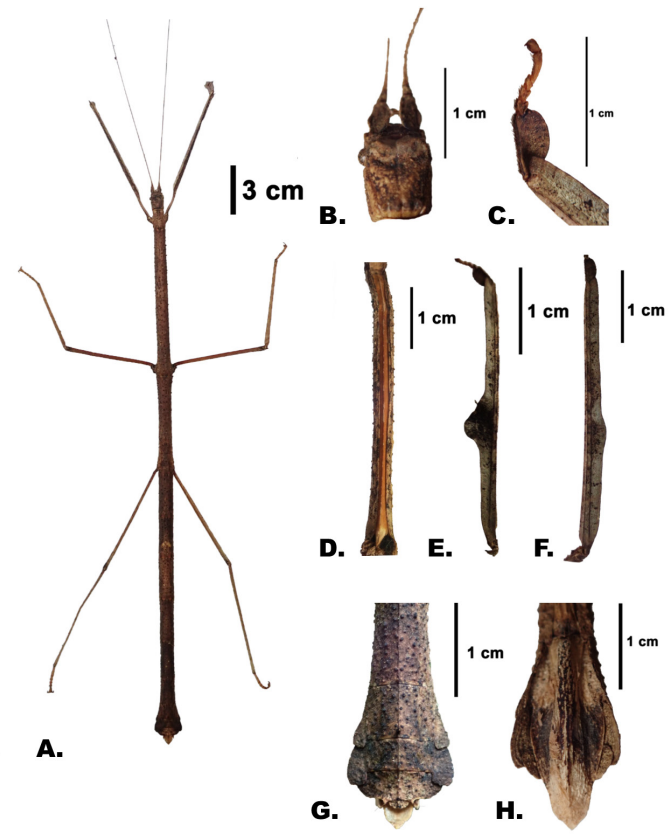

Figure 2. *Baculofractum junliti sp. nov.* (female). (a) Habitus, dorsal view, (b) Head, (c) Fore tarsus, (d) Mesosternum, (e) Left foretibia (f) Right foretibia (g) Apex of abdomen (dorsal view) (h) Apex of abdomen subgenital plate (ventral).

Baculofractum junliti Acola & Eusebio, sp. nov. (Fig. 2)

Diagnosis. Females of *B. junliti sp. nov.* and *B. shelfordi* are closely related in having flat-formed instead of swollen operculum present in *B. insigne*; additionally, the posterior margins of the operculum are generally simple. *B. junliti* can be easily separated from *B. shelfordi* based on the head and the shape of the operculum. The head of *B. shelfordi* has four tubercles at the back of the median ridges while *B. junliti* lacks any tubercles at the back of the median ridges. The operculum of *B. shelfordi* is projecting posteriorly and almost the length end of the abdomen, while in *B. junliti* it is distinctly elongated and considerably surpasses the end of the abdomen. *B. insigne* differs from other congeners for having a broad, deep & compressed operculum, apparently the posterior margin is armed or denticulated. The female of *B. williemsei* is unknown but the male morphological character is closely related to *B. shelfordi,* both develop spines between eyes but *B. williemsei* has only vestigial hind wings while *B. shelfordi* with well-developed hind wings. The egg and male of *B. junliti* are still unknown.

Material examined. 1 adult ♀.

Holotype: Adult ♀**,** Philippines: Mindanao Isl. Mt. Malimumu, Brgy. Magkalungay, San Fernando, Bukidnon. August, 2021, M.S. Acola and A.L. Hongco [CMU-MZ 51005]

♀- Long and slender, general body surface with scattered short and small hair-like form but lightly dense, tubercles scattered more over from mesonotum to the posterior end of the abdomen, light-brown and with scattered dark brown stain-like coloration.

Head. Longer than wide, sub-quadrate; dorsally, lateral margins slightly converge posteriorly. Eyes hemispherical projecting laterally, with median ridges between eyes forming two roughly jagged-like ridges. Distinct medio-longitudinal groove accompanied by another 2 pairs of longitudinal grooves, on laterad to medio-longitudinal groove on the dorsal surface. All longitudinal grooves begin at the posterior margin and run anteriorly, the median and laterals grooves terminate before the eyes. Six hump-like structures across the posterior margin of the head, lying slightly lateral of the medio-longitudinal groove are relatively larger than the rest. Antenna partially missing, right antenna <89, scape dorso-ventrally flat, lateral margins widely convex; pedicel sub-cylindrical more or less one-fourth as long as scape and slender, antennomere 1 slender and almost as long as the pedicel, succeeding antennomeres shorter (Fig. 2b).

Prothorax. Longer than wide, slightly longer than the head. Anterior margin gently convex, posterior margin posteriorly arcuate; anterior half with medio-longitudinal sulcus; medio-transverse sulcus widely inverted V-shaped and reaching lateral margins; posterior half with medio-longitudinal sulcus.

Mesothorax. Distinctly elongated, seven and half times as long as pronotum, general surface with scattered tubercles, moderately dense; thin medio-longitudinal sulcus running from anterior to posterior marginal end, anterior margin concave; generally, both sides of lateral margins are parallel-sided except on anterior fifth slightly converging and posterior third gradually expanding until reaching the posterior marginal end. Sternum with a distinct thin line of medio-longitudinal carina appeared from the anterior margin to the posterior marginal end (Fig. 2d).

Metathorax. Elongate, almost half as long as mesonotum, general surface with scattered tubercles, with the medio-longitudinal line as mesonotum; anterior margin widely arcuate-emarginate, weakly emarginate; on the dorsal aspect, lateral margins are parallel-sided except the anterior half converging; posterior marginal end concaved. Sternite carina as is mesosternum.

Abdomen. General surface as in mesonotum. Median segment less than half length of metanotum; margin tectiform dorsally; lateral margins widely concavus; end of posterior margin with transverse suture. II abdominal tergite to lamina supraanalis with distinct medio-longitudinal keel; II abdominal tergite longer than median segment; III slightly shorter than II; IV and V as long as III in respective tergite; VI shorter than former tergite; VII shorter than VI; VIII more than half length of VII, lateral margins diverging, latero-posterior marginal end angles with very small scale-like dilations projecting posteriorly and slightly surpassing the succeeding tergite; IX wider than long, more or less half-length of VIII, anterior margin widely convex, posterior margin generally widely concave, lateral margins anterior half diverging but posterior half converging, posterior marginal end angles as in VIII but scale-like dilations appeared twice larger than former structures, projecting posteriorly and occupying anterior half

of X within the anterolateral region, anterior margin roundly arcuate, laterals gently converging, end of posterior margin with two widely spaced dentations projecting posteriorly, in between the two dentation appeared a transverse posterior marginal end. Lamina supra-analis more or less one-fourth as long as X, wider than long, posterior marginal end roughly rounded and projecting posteriorly. VII sternites with distinct praeopercular organ, formed by a spine-like posteromedian process, projecting posteriorly and slightly surpassing posterior margin; operculum with longitudinal keel, broad but gently recede at posterior third, median carina distinctly appeared at anterior fourth to posterior fifth, laterals and toward apex flattened, apex tapered and oblanceolate-like, operculum on dorsal aspect extends 3.8 mm beyond the end of the abdomen (Figs. 2g, h). Cerci on the dorsal view distinctly protrude from beneath the anal segment, flattened, projecting beyond the anal segment but not exceeding the end of the abdomen, apex obtuse.

Legs. Forefemora shorter than the mesonotum, dorsal carina expanded into a slightly serrated lamina at 4.3 mm from posterior. Dorso-anterior lamina extended into a spine projecting over the femoral-tibial joint. Foretibiae slightly longer than forefemora. The left foretibiae with dorsal carina expanded into a less distinct lamina with a smaller lobe just before the midpoint (Fig. 2e). The dorsal carina of the right foretibiae expanded into an entire lamina forming a distinct lobe at midpoint (Fig. 2f). Both anterior lamina arcuate. Forebasitarsus lobed, longer than t2-t4 combined, t2-t4 of equal sizes, t5 as long as t3-t4 (Fig. 2c).

Midfemora shorter than forefemora, ventro-posterior carina with minute 2-3 spines projecting towards the posterior. Midtibiae as long as midfemora, carinated. Midbasitarsus almost as long as t2-t4 combined, t2-t4 of equal sizes, as long as t3-t4.

Hindfemora is longer than midfemora but comparably shorter than forefemora, reaching the 4th abdominal segment, ventro-posterior carina with 2-3 minute spines. Hindtibiae as long as hindfemora. Hindbasitarsus slightly longer than t2-t4 combined, t2-t3 of equal sizes, t4 slightly shorter than t3, t5 as long as t3-t4. All tarsomeres with minute hairs on the ventral portion.

Measurements (mm). Holotype: Total length: 161.7; head: 5.3; prothorax: 5.53; mesothorax: 41.53; metathorax: 20.37; median segment: 9.67; forelegs: femur: 38.1.00; tibia: 39.3; midlegs: femur: 28.4; tibia: 29.00; hindlegs: femur: 32.9; tibia: 38.6. Cerci 0.7 mm long.

Etymology. In recognition of his selfless enthusiasm in mentoring students and colleagues and in sharing his bountiful knowledge, this new species is named after Dr. Ireneo L. Lit, Jr., an esteemed researcher and professor of entomology at the University of the Philippines Los Baños, and a curator for scale insects and other terrestrial arthropods at the university's Museum of Natural History.

Conclusion and Biogeographical Notes

The Philippines is an archipelago that is postulated to be a part of the Pleistocene Aggregated Island Complexes (PAIC's). One of the major regions in the Philippines among the PAIC's is the Greater Mindanao which includes Mindanao island as well as Samar, Leyte, Dinagat and Basilan islands (Vallejo 2011; Heaney et al. 2005). Traditional dispersal theory suggests that the center of origin of plants and animals in the Philippines are Borneo, Sulawesi and Taiwan. The biotic elements from these regions are then dispersed to the Philippine Islands through Palawan and Sulu Islands (Wallace, 1876). Heads (2013) also presented several Philippine endemic clades that have sister-clades in neighboring regions including the Sundaland- former land in what is now the area of the sea separating Peninsular Malaysia, Sumatra, Borneo and Java. The past connections among these regions were evidenced by the presence of shared biotic elements.

The majority of Phasmatodean species are distributed and shared among the regions connected by Sundaland and new species and generic records have been discovered from the Philippines in recent years (Gottardo 2007, Bressee, 2012, Bresseel and Constant 2017). Furthermore, the discovery of new species and even new genera from the Philippines is also growing. Examples include Lit (2010), Hennemann & Conle (2007), Cumming et al. (2017, 2020). More species are expected to be discovered as the group gains interest among researchers and hobbyists. With the wide distribution of stick insects in the Philippines, other Bornean phasmid species are expected to be discovered in the Philippines in the next years. *Baculofractum* Zompro, 1995 is also expected to be present in other areas in the Philippines, particularly in the Greater Mindanao region.

With over 3,500 extant species of Phasmatodea worldwide, it is still one of the remaining insect orders where a robust, higher-level phylogenetic-based classification is lacking (Simon et al. 2019). Recent phylogenetic analyses based on both morphological and molecular data suggest that morphology-based classification alone is not efficient in reflecting the evolutionary history of the group (Tilgner 2002, Whiting et al. 2003, Bradler 2009, Buckley et al. 2009, Bradler et al. 2014, 2015, Büscher et al. 2018). *Baculofractum* was previously placed within the subfamily Necrosciinae but recent studies based on morphological and molecular data placed it under subfamily Lonchodidae (Bradler et al. 2014).

Furthermore, the diversity of oviposition techniques and egg morphology in phasmids are also considered to be evolutionarily significant. Phasmids are the only group with species-specific egg morphology having specialized forms adapted to their oviposition technique (Roberson et al. 2018). Recent study signifies that molecular data along with the oviposition technique and egg morphology is one of the most effective ways to investigate the temporal, biogeographic and phylogenetic patterns to identify the evolutionary history of the group (Robertson et al. 2018).

The Philippines is one of the hotspots of Phasmatodean diversity yet the phylogenetic history of Philippine phasmids remains unresolved due to the lack of phylogenetic studies in the country. Taxonomic studies of Philippine Phasmatodea solely focused on limited groups and mostly based on morphological characteristics only (Hennemann & Conle 2007, Cumming et al. 2017, Rehn & Rehn 1938). Being one of the species-rich country for Phasmatodea with a high degree of endemism, phylogenetic studies of Philippine stick insect using morphology, molecular approach, oviposition techniques and egg morphology are important in understanding its

evolutionary history. Also, with the rapid and irreversible loss of terrestrial ecosystems in the Philippines, further studies of Philippine Phasmatodea are therefore urgently needed (Gottardo 2011, Myers et al. 2000).

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