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A new species of the genus *Rhaphidophora* from Seram island (Moluccas, Indonesia) with notes on the geographic distribution of the subfamily Rhaphidophorinae (Orthoptera, Rhaphidphoridae)

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Abstract
A new species of *Rhaphidophora* (*R. barociniturricchiae* n.sp.) is described from a cave of Seram Island (Moluccas, Indonesia). The new species shows affinities with *R. wasile* and *R. amboinensis* from Halmaera and Amboina Islands respectively. The geographic distribution of the genus *Rhaphidophora* and the close genus *Stonycophora* is discussed in relation to the Wallace and Liddeker lines.

Keywords: *Rhaphidophora*, *Stonycophora*, Seram, Moluccas, Wallace line, Liddeker line

1. Introduction
The subfamily Rhaphidophorinae togheter with the Aemodogryllinae are the more representative groups of the Orthoptera Rhaphidophoridae living in the South East Asia and Oceania. In particular they encompass many regions of these two continents including about 332 species widespread from the Himalaya to Japanese archipelagous [1]. Among the numerous members of the Rhaphidophorinae, presently grouped in 7 genera, only two genera *Rhaphidophora* and *Stonycophora* hold species occurring in the Wallacea region up to New Guinea and some Oceanic islands. These two genera are considered morphologically very similar differing only in some characters of the genitalia and of the abdominal segments, furthermore they overlap most of the territories of their geographic range. The opportunity to study a new sample collected in a cave from Seram Island in the Moluccas archipelagous gave us the opportunity to describe a new species of *Rhaphidophora* and to rewiev the geographic distribution of the this genus in the South East Asia in comparison to that of the near genus *Stonycophora.*

1.1 Taxonomic background
The generic classification of the Rhaphidophorinae is formal to some extent, since the morphology of the members of this subfamily is rather uniform: the wings and sound organs are undeveloped, and the genitalia are entirely membranous without complex structures. Affinities in groups with such a scanty set of characters can hardly be found based on morphological examination. However as outlined in the introduction two main groups can be distinguished on the basis of the presence/absence of a large copulatory process on the male abdomen: 1- the genus *Stonychophora* Karny, 1934 with a large process on tergite VII. The presence of such a process is considered as a primitive character [2]. 2-the genus *Rhaphidophora* Serville, 1838 whose species have not any large copulatory processes on the abdomen. Furthemore Gorochov [2] distinguishes two main groups inside this genus. The first group characterized by the occurrence of two ventral spines on the fore tibia and a male epiproct of different shape; the second one with 3-4 ventral spines on the fore tibia and a simple (oval) epiproct.

2. Materials and methods

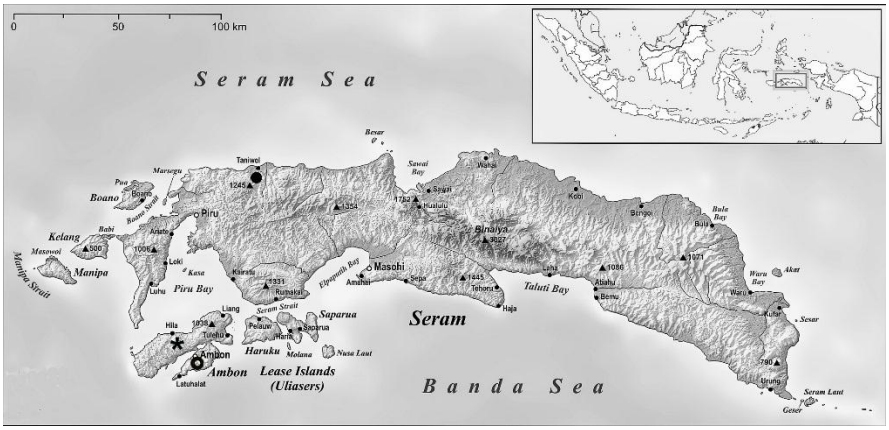

Fig 1: Map of Seram Island with site collection of *Rhaphidophora baronciniturricchiae* n.sp. (filled circle); *Rhaphidophora amboinensis* (asterisk), *Stonycophora nigerrima* (black ring).

All the studied specimens were collected during the expedition to Sepalewa River in Seram Island conducted by A. Benassi and G. Baroncini Turricchia in 2012 [3] (Figure 1).
Specimens were preserved in 70% alcohol and deposited in the collection of the Museum of Zoology of the University of Rome "La Sapienza" (MZUR). The specimens were studied by a Leica MZ 12.5 stereomicroscope. All measurements are in mm. Photographs were taken by means a Samsung NX mini digital camera. The photographs and distribution maps were processed using ACDSee Pro 8. In the morphological analysis the following characters are considered: the shape of rostral tubercles, X tergite, subgenital plate and relative styles, amount of spinulation of the legs, shape and spinulation of the hind tarsum. Data on the geographic distribution of the two genera *Rhaphidophora* and *Stonycophora* were obtained from the updated list published in Orthoptera Species files [1].

3. Results & Discussion

3.1 Systematics

Family : Rhaphidophoridae Walker, 1869
Subfamily : Rhaphidophorinae Walker, 1869
Genus : *Rhaphidophora* Serville, 1838,
Type species : *Rhaphidophora loricata* (Burmeister, 1838)

3.1.2 *Rhaphidophora baronciniturricchiae* sp. nov.

Description

Male (Holotype). Measures (mm): Length of body 17.0; pronotum length 5.4; fore femur 9.4; mid femur 10.0; hind femur 17.8; fore tibia 10.0; mid tibia 9.6; hind tibia 18.3; hind tarsum 7.3; 1° segment of the hind tarsum 3.5. Body size relatively big (Figure 2a). Color brown-yellowish, darker on the head; pronotum and appendeages paler on the lateral sides. The head holds two emerging rostral turbecles, dark and deeply sulcated (Figure 2b); the eyes are well developed. Front widened testaceous, upper labrum rounded and mandibles very developed. Torax with the first segment (protorax) more developed than the meso and meta torax. Legs: fore femur with only 1 spine on the inner side; fore tibia with both the dorsal edges unarmed while the ventral edges hold 3 spines. Mid femur with 2 spines on both sides of the upper edge; mid tibia dorsally unarmed and 2 spines on both sides of ventral edge. Hind tibia with 22 short spines on both sides of the upper margin, the ventral margin unarmed; tibia apex armed with 1/3 spurs. The first segement of the hind tarsum has one apical spine and two strong dorsal spines (Figure 2c). Abdomen: dorsally all the abdominal segments are simple without any particular structure or ornaments. The X tergite short with a concave posterior margin; epiproct triangular, elongated and deeply graven in the middle. Genitalia membranous without any sclerificated structure. Sub genital plate trapezoidal with two pronounced conycal styles (Figure 2d).
Female. Due to absence of adult specimens we could not describe any morphological characters for the female of this species. Only the shape of the subgenital plate was detectable resulting wide, triangular and acuminated at the apex as found in most of the *Rhaphidophora* species.

Ethymology

The name of the new species refers to our friends Guido Baroncini Turricchia of Circolo Speleologico Romano (CSR-Roma Italy) collecting the specimens during the speleological survey in the Seram Island.

Specimens examined

Holotype male, Indonesia, Moluccas, Seram Isl., Taniwel, Gua Sapalewa, Sapalewa underground River, 2°55'25''S, 128°28'17''E, 235 m, 11.06.2012, G. Barroncini Turricchia leg. Paratypes: 1 male and 1 female nymphes, same data and collector as holotype.

Fig 2: 2a) Male habitus of *Rhaphidophora barronciniturricchiae* sp. nov;

Fig 2: 2b) Head with the particular of the rostral tubercles;

Fig 2: 2c) Hind tarsum, with the particular of the first segment holding dorsal spines;

Fig 2: 2d) X tergite, epiproct and styles on the subgenital plate (dorsal view).

3.2 Affinities

Only other two species of *Rhaphidophora* occur in the Moluccas archipelagous: *R. wasile* Gorochov, 2013 from Halmaera and *R. amboinensis* Karny, 1930 from Amboina islands respectively. The new species *R. barociniturricchiae* sp. n. although very similar to both these two species, differs for the shape of the epiproct, the apical spine on the hind tarsum, absent in *R. wasile*, the absence of the carena on the VII tergite and absence of the spines on the ventral edge of the hind femur (both these two latter characters occur in *R. amboinensis*).

3.3 Geographic distribution of the genera Rhaphidophora and Stonycophora.

On the whole we have listed and checked 90 species belonging to the genus *Rhaphidophora* and 37 species belonging to the genus *Stonycophora*. For a better comprhension of their geographical distribution, these data are plotted in a map where the species abundance (number of species) for each genus are indicated to the relative areas (Figure 3).

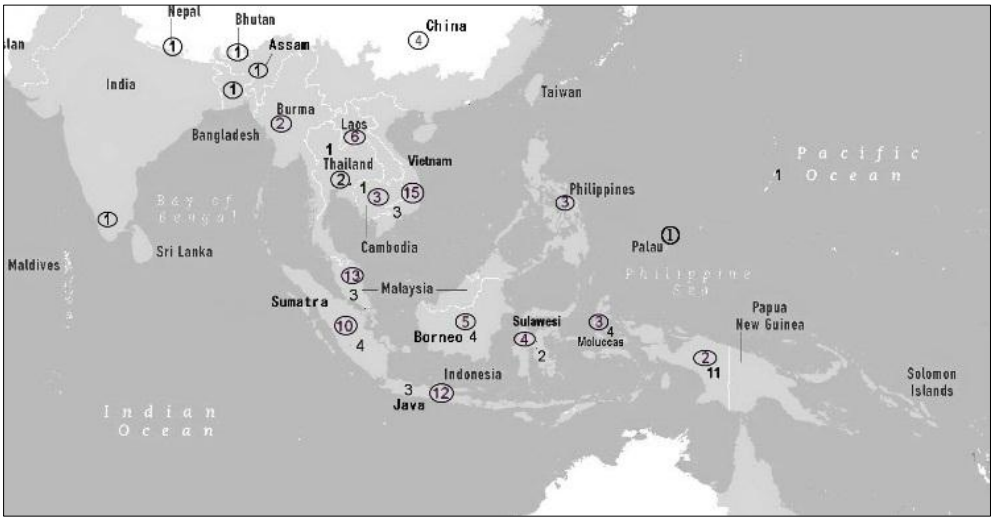

Fig 3: Species abundances (number of species) reported for the relative areas of the South Eeast Asia and Oceania. Numbers in the circle: genus *Rhaphidophora*; black numbers: genus *Stonycophora*.

The genus *Rhaphidophora* shows a peak of species abundance in the area including the Southeastern Asia (21 in Vietnam-Laos and 13 in the Malaysia Peninsula) and the Eastern Indonesia (10 in Sumatra and 12 in Java). 9 species inhabit forested area of Borneo and Sulawesi, 3 the Phylippines arcipelagous and only few species (5) extend eastward to the Moluccas and Papua-N. Guinea regions. The remaining species (11) inhabit the western area of the Indocina reaching India and Nepal with 2 species and southern China with 4 species. On the contrary the genus *Stonycophora* shows the highest peak of species in the Papua-N. Guinea region including some Oceanic islands (11). It is present also in some islands of the Moluccas (4), Borneo (4), Sulawesi (2), Java (3), Sumatra (4) and in the Malaysia Peninsula (3), reaching in the West, with only 5 species, Indocina until Myanmar. Ecologically these two genera don't show any particular differences both inhabiting forest habitats largely reperesented in this area. Only the genus *Rhaphidophora* includes species that in different way have colonized caves as the species *R. cavernicola* Chopard, 1916 from Malaysia, *R. drammermani* Karny, 1924 from Java, *R. mulmeniensis* Chopard, 1916 from Myanmar, *R. oophaga* Chopard,1959 from Borneo and *R. rufobrunnea* Chopard, 1921 from Assam [4]. However none of these species show troglobitic features as depigmentation or eyeless, as conversely found in some reperesentants of the Aemodogryllinae subfamily [5-7].

Considering the different lines of separation between the Asian zoogeographical regions and the Australian one, we observe that about the 90% of the species belonging to the genus *Rhaphidophora* is confined to the west of the Wallace line, the 6% is present in the Wallacea region, comprised between the Wallace line and the Liddeker line and only the 4% exceeds the Liddeker line colonizing Papua-N.Guinea and one Oceanic island. On the contrary species of the genus *Stonycophora* appear to be present in a consistent proportion, both at the west of the Wallace line (51%) and at the east of the Liddeker line (33%). In this case the 16%of the species lives in the islands composing the Wallacea region (Figure 4).

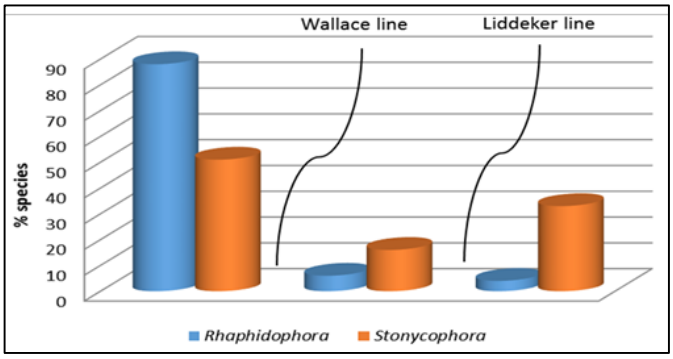

Fig 4: Relative abundance of species (%) of the two genus in relation to the Wallace and Liddeker lines.

This geographic pattern results very intriguing and could reflects both the different center of dispersal of the two genus and the different colonization time of the area by the two lines of the subfamily Rhaphidophorinae. For the *Stonycophora* species, being almost equally widespread both at the west of the Wallace line and at east of the the Liddeker line, to hypothize a centre of dispersal appears very diffcult, but we

can suppose an old colonization of this area starting indefferentially from Sunda or Sahul shelfs, before the present fragmentation of the area. The following dispersion towards east or west probably happened along the migration routes between Asia and Australia through the Wallacean Islands [8], when the major changes in sea level occurred during the Pleistocene glaciations: 70.000 to 40.000 years ago [9]. As outlined in the introduction, the antiquity of the origin of *Stonycophora* is in agree with the supposed primitivity of this genus, due to the presence of process on the VII tergites. On the contrary the center of dispersal for the more recent genus *Rhaphidophora* could be placed in the ancient Sunda shelf that icluded for long time S.E. Asia [9], comprising Borneo, Java, Sumatra and Malaysia Peninsula as well. In fact in this area the 90% of the species of the genus *Raphidophora* occurs, and only few species reach some territories placed at East of the Wallace line. This finding suggests a more recent origin of this line of Rhaphidophorinae probably posterior of the Pleistocenic bridges lands that allowed exchanges of fauna between South East Asia and the Australia regions.

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