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Possible New Species of *Araecerus* (Coleoptera: Anthribidae) Associated with *Mastixiodendron pachyclados* (Garo garo), Rubiaceae

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Abstract

Araecerus is a genus of beetles belonging to the family Anthribidae. They are very important economic pests of coffee, cocoa and other agricultural crops. The species that commonly attack coffee (Rubiaceae) beans is *Araecerus fasciculatus* (Degeer) commonly known as coffee bean weevil. However, five (5) undescribed species of genus *Araecerus* were reared predominantly from the seeds of *Mastixiodendron pachyclados* (Rubiceae) commonly known as Garo garo and it is a native tree of Papua New Guinea. Fruits of *M. pachyclados* were regularly sampled and insects attacking them were reared, preserved and identified. Fruits were hand collected, photographed, weighed and reared. Insects emerging from the fruits were captured and preserved in 99% ethanol. All the specimens were identified into morphospecies at the laboratory. The five new species of genus *Araecerus* (Anthribidae) were designated as *Araecerus* sp.1, *Araecerus* sp.2, *Araecerus* sp.3, *Araecerus* sp.4 and *Araecerus* sp.5 according to their differences in body length; scutellum color, size, hair-scales and visibility; length of first and second segments of fore tarsus; apical and subapical teeth-size (mandible and maxillary palpi); declivity of dorsal abdomen; basal-anterior eye markings; lateral eye markings; absence of eye markings; and shape of pygidium. *Araecerus* sp.1 was described as having yellowish gold marking inside the base of eye, *Araecerus* sp.2 with pygidium almost vertically-flat at abdominal apex, *Araecerus* sp.3 have eyes without yellowish gold marking and generally dark in colour, *Araecerus* sp.4 with distinct yellowish gold interior-lateral marking in its eye, and *Araecerus* sp.5 with pygidium pointed at abdominal apex. Proper identification of these five species is beneficial for effective application of control measures. Since they are major pests of cash crops such as coffee and cocoa, identification of their species and quantification of their abundance will foster economic returns and crop protection aspects as their abundance is closely related to crop damage.

Keywords: Araecerus; scutellum; declivity; pygidium.

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1. Introduction

Araecerus is a genus of **beetles** belonging to the family **Anthribidae**. They are important storage pests of cash crops such as coffee (Rubiaceae) and cocoa (Malvaceae). The species *Araecerus fasciculatus* (DeGeer) is a common storage pests of coffee beans stored in warehouse, coffee mills and other storage areas [1]. *A. fasciculatus* is also a common pest infesting cocoa beans in storage [2]. Duke [3] mentioned that *A. fasciculatus* was one of the pest of nutmeg. *A. fasciculatus* was reported by Abo and Ja [4] as major pests of yam and cassava flour. *Araecerus levipennis* Jordan is a pest of leguminous plant *Leucaena glauca* (L.) that has high protein content that is mainly used as a valuable foraging crop in ranches.

Early entomologists like Pascoe [5], Jordan [6] and Wolfrum [7] extensively described about one hundred genera and one thousand species under Anthribidae family in which *Araecerus* Schönherr [8] was categorized under Subfamily **Choraginae** and Tribe *Araecerini*. Choraginae subfamily consisted of 3 species in South America in comparison with 14 species in Central America. Jordan [9] described ten species while Valentine [10, 11] contributed to the revision of the species. At least 98 species of Choraginae existed in the Old World [12]. The first species of the tribe Araecerini is *Araecerus fasciculatus* (DeGeer, 1775), a pluralistic species of the genus *Araecerus* Schoenherr, 1823 that comprises of about 70 described species in Indo Pacific [13].

Five possibly new species of genus *Araecerus* were discovered during this research in Wanang Conservation Area, Madang, Papua New Guinea. Ctvrtecka *et al.* [14] obtained 1200 specimens of Anthribidae as a part of Curculionoidea in the same location, but they could not be reliably identified to species. Seven species were found but had to be excluded also because most of the specimens remain unsorted [14]. Morimoto [15] described *Araecerus* Schoenherr as having tarsal segment 3 bilobed, nearly as broad as segment 2; tarsi slender, segments 1 and 2 much longer than wide; front tibiae simple at least in female; front tarsi normal; lateral prothoracic carinae reaching the middle; front tarsal segment 1 longer than the remaining segments added together; and eyes oval, less prominent. All of the five species of *Araecerus* were host specific to *Mastixiodendron pachyclados* (common name: Garo garo) which is a native tree to Papua New Guinea (PNG) north-western lowland rainforests. *M. pachyclados* (Rubiaceae) grows to over 10 meters in height, dbh 7.4 cm, trunk height to foliage 5.3 m, crown height 4.97 m, crown width 3.15 m, outer bark with lenticels; flower buds green, and fruits light green when immature, turning pale yellow to mature, inner flesh white [16]. Identification of the five species of *Araecerus* is based on their morphology.

2. Materials and Methods

2.1. Field sampling

The study was conducted in primary forest at Wanang Conservation Area (5°13 'S, 145°04 'E, 100 masl), Madang, Papua New Guinea from 15th January to 31st May, 2015. Vegetation as described by Laidlaw *et al.* [17], Paijmans [18] & Whitfeld *et al.* [19] as mixed evergreen rain forest on Latosol with a humid climate, mean annual rainfall of 3600 mm, a mild dry season from July to September, and mean annual temperature of 26 °C [20].

Fruits were sampled (collected) systematically following rows from the existing 50-ha forest dynamics plant plot in the Wanang Conservation Area (Papua New Guinea) and few were sampled outside the plot. *Mastixiodendron pachyclados* (Rubiaceae) is a locally abundant fruiting-tree species therefore it was selected for the study. The sampling took place in different areas of the forest including both low and high abundance of the host tree species. The densities of fruits on the ground were measured and the sampling covered areas of both high and low density of fruits. Fruits of each tree species were separately placed into plastic bags, given a unique tree number code and brought to the bush laboratory at Wanang station. A fruit from each tree was sliced in half and photographed together with unsliced fruits along with their respective tree number code.

The fruits were then separated into plastic rearing containers (plastic lunch boxes) and weighed on an electronic balance. Fruits from each tree represented by 3 fruits were sliced and measured (fruit length, fruit width, fruit height, seed length, seed width and seed height). The rearing containers were closely monitored on a daily basis for emerged insects. Once insects emerged, they were collected by opening the side of the plastic lead and collected with a medium sized plastic test tube and preserved in 99% ethanol.

2.2. Laboratory insect sorting and identification

All wet specimens were then taken to the main research center of New Guinea Binatang Research Center (NGBRC) in Madang, Papua New Guinea for identification purposes. Identification was aided with reference text books, online insect databases (**www.buglife.com**), NGBRC insect database and reference collections of NGBRC. Insect specimens were initially sorted into morpho-species and given codes based on their distinct morphological features. Identification was done to genus level for *Araecerus* and species were divided into *Araecerus* sp.1, *Araecerus* sp.2, *Araecerus* sp.3, *Araecerus* sp.4 and *Araecerus* sp.5 according to their differences in morphology. The resulting morphological descriptions were analyzed using Dichotomous Key system which serves as Identification Keys.

3. Results

Identification of the five new species of *Araecerus* (Anthribidae); *Araecerus* sp.1, *Araecerus* sp.2, *Araecerus* sp.3, *Araecerus* sp.4 and *Araecerus* sp.5 were mainly based on the length of body, tarsal segment, eye markings, apical teeth, scutellum and pygidium. Dichotomous key was utilized to describe each species. The identification keys of each species and pictures of their specific body parts are stated as follows:

1. Length of body equal or more than 4mm (Fig. 1) 2
   Length of body equal or less than 4mm (Fig. 2) 2

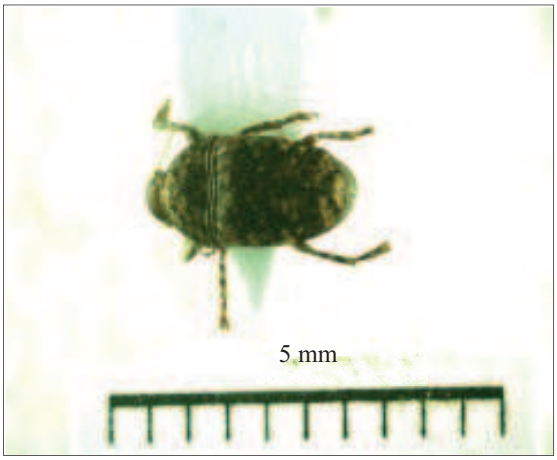

Figure 1: Body length > 4mm.

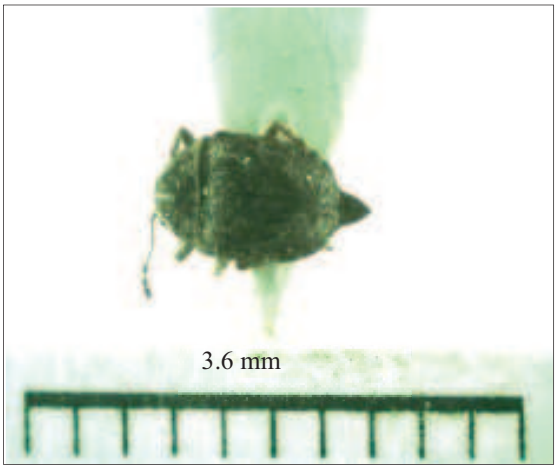

Figure 2: Body length < 4mm.

2. Scutellum very small, poorly visible or dark in colour (Fig. 3) 3
   Scutellum small and densely covered with yellowish brown hair-like scales (fig. 4) 3
3. First segment of fore tarsus longer than second segment (Fig. 5) 4
   First segment of fore tarsus equal or shorter than second segment (Fig. 6) 4

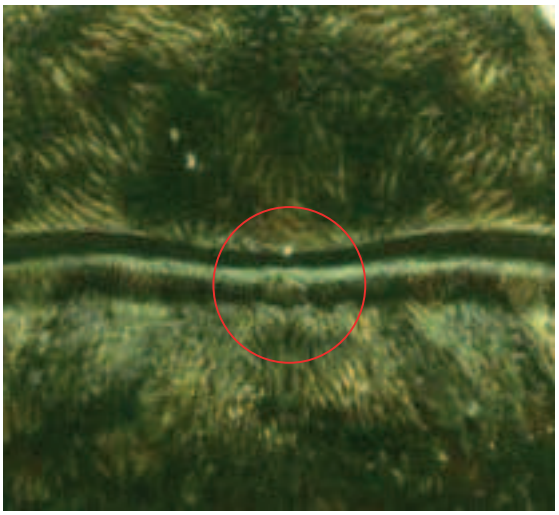

Figure 3: Scutellum poorly visible.

Figure 4: Scutellum yellowish.

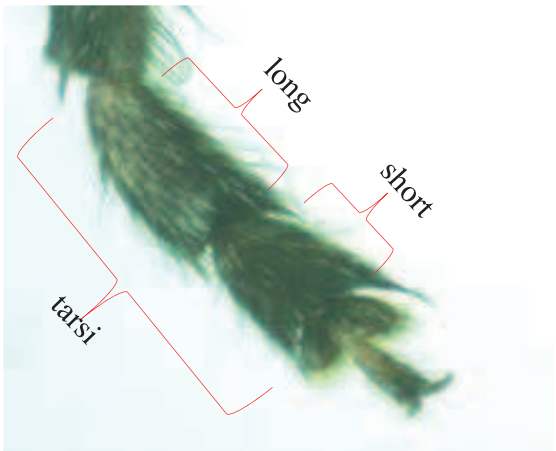

Figure 5: 1st fore-leg tarsal segment longer then 2nd segment.

4. Unequal-sized apical and subapical teeth (mandible and maxillary palpi) (Fig. 7) 5

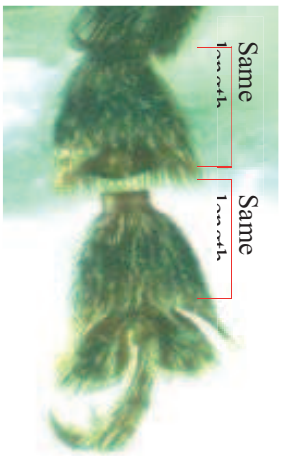

Figure 6: 1st and 2nd fore-leg tarsal segment same in length.

Almost equal-sized apical subapical teeth (mandible and maxillary palpi) (Fig. 8) 5

Figure 7: Unequal-sized mandible.

5. High declivity towards abdominal apex (Fig. 9) 7
   Low declivity towards abdominal apex (Fig. 10) 6

6. Yellowish gold marking inside the base of eye (Fig. 11) . . . . . *Araecerus* sp. 1
   Eyes without yellowish gold marking inside the base of eye (Fig.12) 8

7. Pygidium pointed at abdominal apex (Fig. 13) . . . . . *Araecerus* sp. 5
   Pygidium almost vertically-flat at abdominal apex (Fig. 14) . . . . . *Araecerus* sp. 2

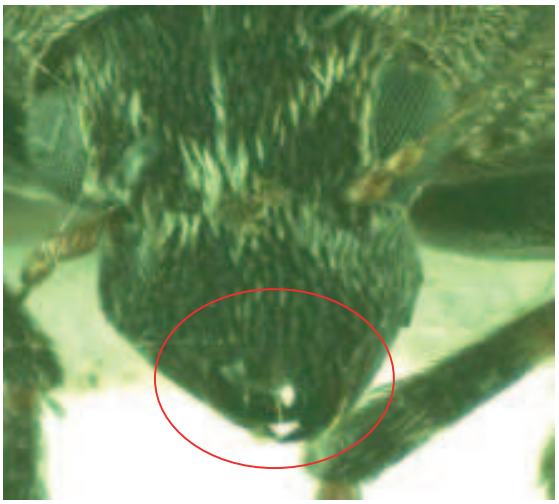

Figure 8: Equal-sized mandible.

Figure 9: Steep sloping of elytra towards abdominal apex.

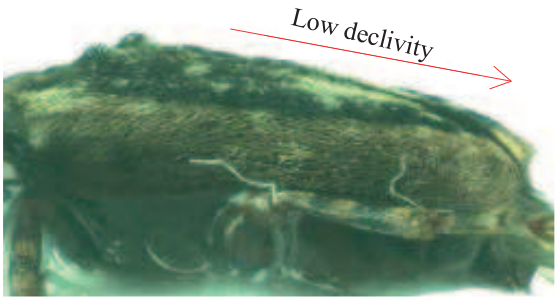

Figure 10: Gently sloping of elytra towards abdominal apex.

8. Eye with yellowish gold interior-lateral marking (Fig. 15) . . . . . *Araecerus* sp. 4
   Eye without marking and generally dark in colour (Fig. 16) . . . . . *Araecerus* sp. 3

The five species of *Araecerus* are considered as seed predators since they were found predominantly in seeds of *M. pachyclados*. The total abundance of each specie varies with fruit weight. The low abundance of each specie shows their rarity thus the possibility of being new species. Table 1 outlines this information.

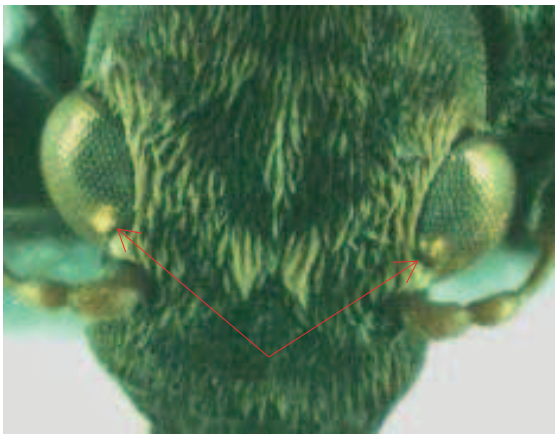

Figure 11: Basal eye yellow markings.

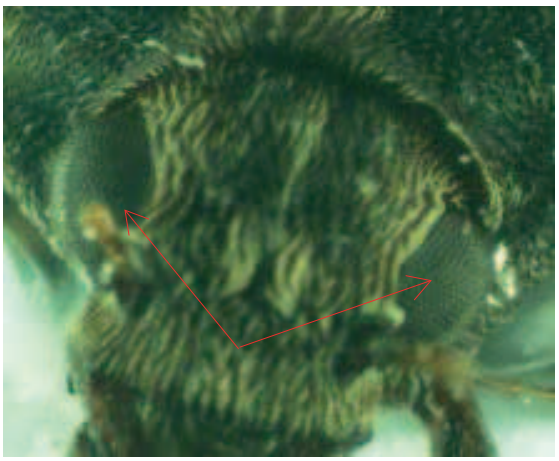

Figure 12: Basal eye markings absent.

Figure 13: Pygidium pointed.

All the five species have body length range of 3.5-5 mm. Figure 17a, b, c, d, and e shows the dorsal view of the 5 species with their scales in millimetre.

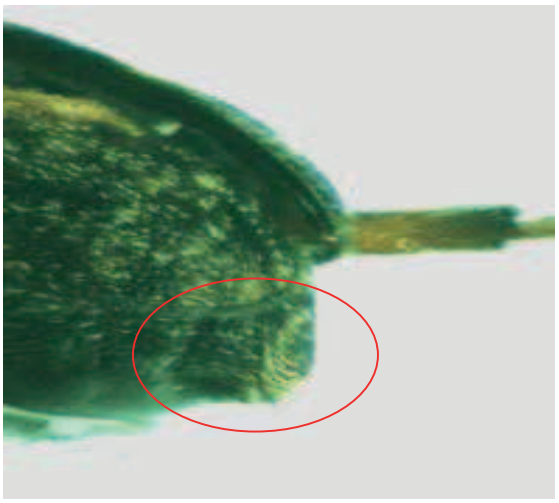

Figure 14: Pygidium not pointed.

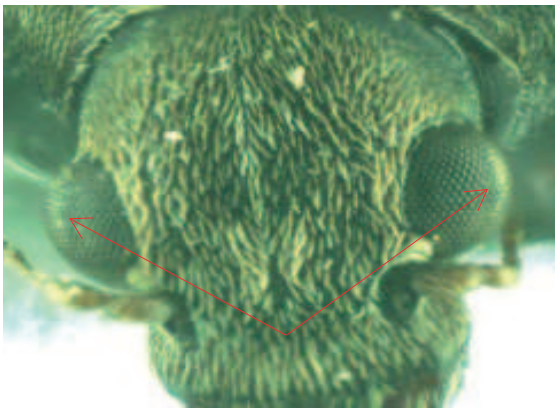

Figure 15: Eyes with lateral yellow markings.

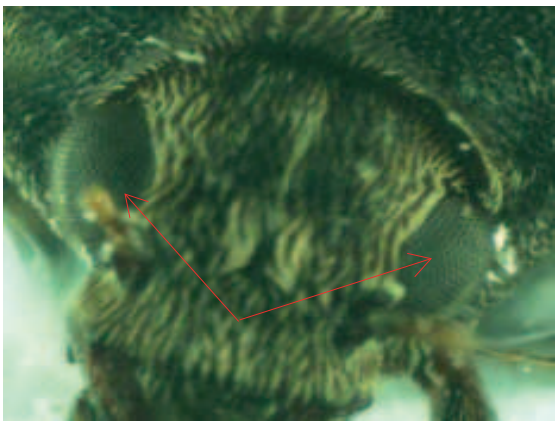

Figure 16: Eyes without lateral yellow markings.

4. Discussion

These five species of *Araecerus* belongs to Anthribidae family that has the prominent club shaped antenna; adults are elongate and slightly oval; they have a short beak and straight antennae; elytra with distinct rows of striae absent; and pronotum with a

TABLE 1: The five species of genus *Araecerus* were only reared from fruits of *M. pachyclados*. Low abundance suggested that they are rear as corresponding to total fruit weight (kg).

Host tree	Species	Feeding Guild	Total abundance	Total No. of Fruits	Total Fruit wt. (kg)
Mastixiodendron pachyclados	*Araecerus* sp.1	Seed Predator	10	543	0.705
	Araecerus sp.2	Seed Predator	9	389	0.531
	Araecerus sp.3	Seed Predator	3	252	0.351
	Araecerus sp.4	Seed Predator	1	148	0.177
	Araecerus sp.5	Seed Predator	2	282	0.365

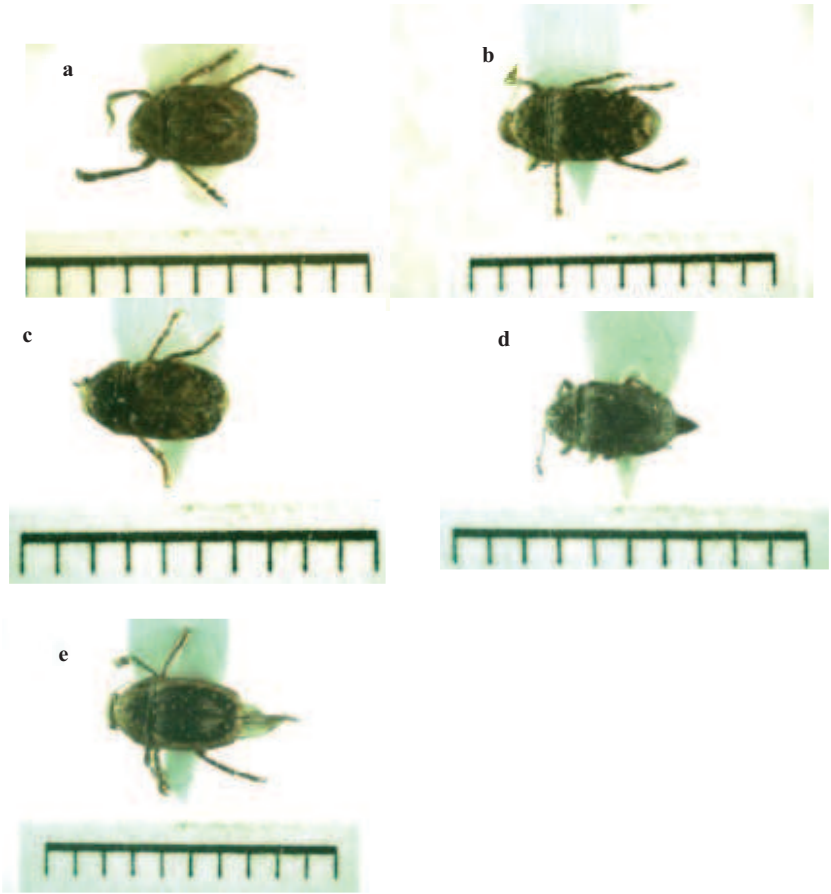

Figure 17: *Araecerus* Sp.1 (a), *Araecerus* Sp.2 (b), *Araecerus* Sp.3 (c), *Araecerus* Sp.4 (d), and *Araecerus* Sp.5 (e). All species were reared from *Mastixiodendron pachyclados*.

transverse ridge towards the base. Genus *Araecerus* as described by Holloway [21] with second segment of tarsi forming lobes around the third segment; elytra with areas of differently coloured scale-like hairs; antenna attached on the top of the head; base of antennal segment and groove is visible from above; first segment of the tarsi is three times longer than wide; pronotum without a transverse ridge but with the base

itself slightly raised; base of pronotum gently curved with mid part converging towards scutellum.

The five species identified differs from their close relative *A. fasciculatus* by certain morphological features. *A. fasciculatus* possess antennal club, the entire eye and the elytra without distinct striation which can be distinguished from related bruchid insects [22]. Body length of the adult beetles is about 3–5 mm [22–24]. All the five species identified falls in the same body length range; *Araecerus* sp.1 (5mm), *Araecerus* sp.2 (3.8 mm), *Araecerus* sp.3 (4mm), *Araecerus* sp.4 (4.5mm) and *Araecerus* sp.5 (3.6mm). *A. fasciculatus* differs generally from the five species by having paler elytra with hairs denser and irregular so that there are darker and lighter areas and first segment of the front tarsi as long as the rest of the segments combined (including the claws). The five species can be readily distinguished from *A. fasciculatus* by presence of dense hairs, regular markings on the elytra and first segment of the front tarsi shorter than the rest of the segments combined (including the claws).

All of the species were host specific to *Mastixiodendron pachyclados* (Garo garo) and were predominantly reared from seeds rather than mesocarp. Both coffee (*Coffea Arabica & Robusta*) and *M. pachyclados* are from the same family, Rubiaceae. This unique feeding guild thus categorized them as seed feeders or alternatively seed predators. Species under this genus such as *Araecerus fasciculatus* was mostly recorded feeding on seeds of crops like coffee [1], cocoa [2], nutmeg [3], leguminous plant *Leucaena glauca* (L.) [25] and on pesticide plant, *Melia azedarach* L. [26]. Further analysis using DNA barcoding technologies can confirm these species. Although Ctvrtecka *et al.* [14] reared some Anthribid beetles also in Wanang Area, these remain unsorted therefore comparison cannot be done at the moment.

The attempt of morphologically describing the five *Araecerus* species corresponds to their possibility as new species. Even though, the closely related species *Araecerus fasciculatus* (coffee bean weevil)*i*s widely described, the identification of the five new species may be an addition to genus *Araecerus*. The fact that they were reared from *Mastixiodendron pachyclados* in tropical rainforest habitat demonstrates the wide host range of *Araecerus* beetles. Some of these species might utilize alternative hosts such as forest trees for breeding, oviposition, migration and food resources. Identification of these five species is beneficial for effective application of control measures.

5. Conclusion

Since genus *Araecerus* is a major pest of cash crops such as coffee and cocoa, identification of their species and quantification of their abundance is a prerequisite to maximize economic returns and crop protection aspects since their abundance is closely related to crop damage. As mentioned by Ardakani & Nasserzadeh, (2014), *A. fasciculatus* was

found feeding on pesticide plant *Melia azedarach* L., which may support their ability to tolerate application of botanical pesticides. In such case, more suitable and effective control measures should be used to overcome such problems. Since these five species have not been described, it is presumed that they are possibly new species. Their morphological descriptions can be used for nomenclatural system and thus contributes to overall insect taxonomy.

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