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Research Article

Diversity of cicadas (Homoptera: Cicadidae) in former Mamut copper mine, Kampung Lohan and Kinabalu Park (Poring substation), Ranau, Sabah, Malaysia

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ABSTRACT. A study on the diversity of cicada was conducted at the former Mamut copper mine, Lohan village and Kinabalu Park (Poring substation) at the Ranau district in Sabah, Malaysia. The objectives were to study and compare the diversity of cicadas at the former Mamut copper mine, Lohan village and Kinabalu Park (Poring substation). Samplings were conducted twice; first in November and December of 2009, and the second one carried out in February of 2010 using light traps. A total of 54 specimens made up of two families, nine genera and 18 species were recorded. Result shows Kinabalu Park (Poring substation) had the highest number of cicadas (29 individuals, 13 species), followed by Lohan village (14 individuals, 7 species) and Mamut copper mine (11 individuals, 4 species). The Shannon-Weiner (H') diversity index showed that the highest H' value was at Kinabalu park (Poring Substation) (H'=2.15), followed by Lohan village (H'=1.73) and Mamut copper mine (H'=1.03). This study is the first of its kind in the area and contributes to a new record of cicadas. This suggests that after years of termination of copper mining activities, in Mamut, cicada communities at the former Mamut mine have not recovered to the same level as its surrounding areas.

Keywords: Cicadas, Kinabalu Park, Poring Hotspring, Mamut copper mine, Sabah.

INTRODUCTION

All over the world, the order Hemiptera is well distributed. They reside in many habitats ranging from mountainous zones to lowland areas. Cicadas or "riang-riang" in the Malay language is classified under the suborder Homoptera. In Greek, Homoptera means similar or uniform (homo) and wing (pteron). This is due to the similar and uniformed texture and shape of the wing. Homoptera is then divided into Auchenorrhyncha and Stenorrhyncha and cicadas are classified under the Auchenorrhyncha. Cicadas vary in length ranging between 10 – 100 mm from its head to the tip of its wing. Most have big and wide heads, and transparent wings. Its body is wide and flat with a pair of transparent and clearly venated wings, a characteristic of cicadas. Some species of cicadas are among the largest in the insect group. *Megapomponia imperatoria* for example has a wingspan of 210mm (Moulton, 1923; Maurice & Bourton, 1975; Moulds, 1990). Cicadas also produce sound, generated by tymbal membrane located in-front of the first abdominal tergite (Maurice & Bourton, 1975).

Cicadas spend time on trees making differential calls during the day or at dawn and dusk to find mates (Moulds, 1990). Males are

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able to make calls that can be heard as far as 400 m (Maurice & Bourton, 1975). Adult and juvenile cicadas feed on the sap of shrubs. Nymphs on the other hand feed mainly on juices from tree roots. Soon after copulation, female cicadas place their eggs through ovipositors stacked on one other under the bark of twigs and branches. Depending on species, these eggs usually hatch instantly right after rain which usually takes 70 to 120 days. Hatched transparent pronymphs that last for only several minutes leave the eggs and soon molt into nymphs. The nymphs then drop by themselves and burrow into the ground. The nymphs then feed on tree roots and further develop into adults through molting for nine months to several years (Moulds, 1990). Cicada nymphs undergo four and one moltings during the nymph and adult stages, respectively.

Mining activities result in various impacts on biodiversity due to the discharge of mining waste, clearing of the area, and the cleaning process after the end of mining (Knight, 1998). Previous research shows that invertebrates are affected by heavy metals eventhough the effects can be different on different taxonomic groups. Cicada nymphs face high chances of being exposed to heavy metals or other contaminants as they spend time in the soil (Robinson, *et al.* 2007). Commercial mining operations in Mamut started in 1975. When the operation stopped in 1999, Mamut had produced 133.9 million tonnes of copper. Waste discharge from the operation forced the termination of the mine in 1999 after 24 years of operations (Dasar Mineral Negara ke-2, 2009). Copper mining in Mamut has left the area, particulary Lohan village and forest along Mamut river contaminated with arsenic and other heavy metals.

There are 87 species (24 genera and 2 families) of cicadas recorded in Sabah (Zaidi & Azman, 2003; Duffels, 2004; Yaakop *et al.*, 2005; Duffels *et al.*, 2007; Nurulaida & Azman, 2007). Of these total, 48 species under 20 genera and two families have been recorded for Kinabalu Park (Nurulaida & Azman, 2007), but none of it reported from former Mamut copper mine and Lohan Village. This study is conducted to assess the diversity of cicadas in the former Mamut copper mine and its surrounding areas which include a village and a conservation area.

MATERIALS AND METHODS

The district of Ranau is located on the north of west coast of Sabah State, Malaysia (between the latitude N5°30' and N6°25', and longitude E116°30' and E117°5'). This study was conducted at the former Mamut copper mine (Mamut), Lohan village (Lohan) and Kinabalu Park, Poring substation (Poring) (Figure 1).

Sampling occasions were conducted twice for each study site, in November to December 2009 and February 2010. Five-days collection period were done in each study site per sampling occasion. Night-time collections of cicada specimens were conducted using light traps from 1900 to 0600 hours of the following day. A 160W mercury vapour bulb powered by a 500W mini electric generator was used.

The attracted cicadas were collected manually by hand or net. Cicada specimens were preserved in killing jars emersed with ethyl acetate. At ITBC-UMS, the specimens were oven-dried, pinned, labelled, identified and classified.

Identification and species naming of the cicada specimens were based on Moulton (1923), Overmeer & Duffels (1967), Duffels (1976, 2004), Beuk (1999), Duffels & Zaidi (1999), Zaidi *et al.* (1999), Yaakob *et al.* (2005) and Duffels *et al.* (2007). Classification is in accordance to that of Metcalf (1963) and Duffels & Van der Laan (1985). All specimens were deposited in the BORNEENSIS collection, Institute for Tropical Biology and Conservation (ITBC), Universiti Malaysia Sabah (UMS).

Data analysis

Species diversity was measured using the Shannon-Weiner diversity index (H) as shown below.

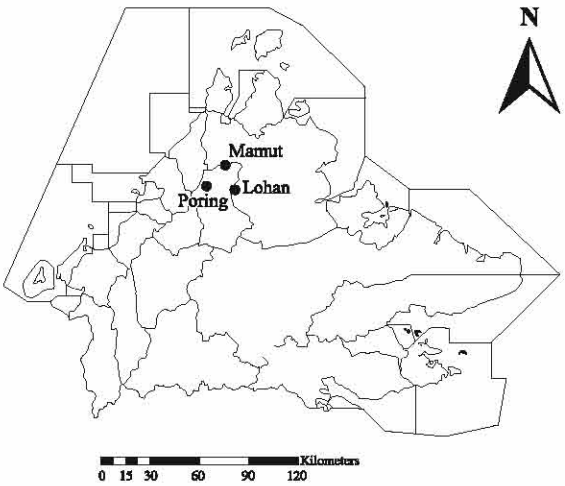

Figure 1. Location of the sampling sites (former Mamut copper mine; Lohan village, and Kinabalu Park (substation Poring).

Shannon Weiner diversity index (H') (Magurran, 1988)

$$H = \sum_{i=1}^{S} -(Pi * \ln pi)$$

H = Shannon Weiner diversity index
pi = relative abundance of each species
S = total number of species
$\sum$ = total for species 1 to species s
ln = normal logarithm

RESULTS AND DISCUSSION

A total of 54 specimens (35 males, 19 females) comprising 18 cicada species were recorded in this study. These specimens consist of nine genera of two families of cicadas (Appendix 1). The two families were Cicadidae (16 species) and Tibicinidae (2 species).

Species of the Family Cicadidae were *Dundubia rufivena* (Walker) (Plate 1a), *D. vaginata* (Fabricius) (Plate 1b), *Maua albigutta* (Walker) (Plate 1c), *Nabalua borneensis* Duffels (Plate 1d), *Orientopsaltria alticola* (Distant) (Plate 2a), *O. kinabaluana* Duffels & Zaidi (Plate 2b), *O. montivaga* (Distant) (Plate 2c), *O. padda* (Distant) (Plate 2d), *Pomponia decem* (Walker) (Plate 3a), *Pomponia* sp.10 (Plate 3b), *Platylomia viridimaculata* (Distant) (Plate 3c), *P. spinosa* (Fabricius) (Plate 3d), *Nabalua mascula* (Distant) (Plate 4a), *Purana ubina* Moulton (Plate 4b), *P. guttularis* (Walker) (Plate 4c), and *Purana* sp.4 (Plate 4d). Species of the family Tibicinidae were *Abroma maculicollis* (Guerin) (Plate 5a) and *Muda obtusa* (Walker) (Plate 5b).

Poring recorded the highest number of individuals (29), followed by Lohan village (14) and the former Mamut copper mine (11) (Appendix 1). The high species richness of cicadas at Poring coincides with a suitable environment of the area. Poring is primarily a lowland tropical rainforest with low level of disturbance compared to the former Mamut copper mine and Lohan village. This favourable environment is suitable for cicadas in completing their life cycle. However, rocky and compacted soil surface at the former Mamut copper mine is not suitable for cicadas. Cicadas find it difficult to reproduce in this kind of environment as their nymphs need space under the ground for their development

and maturation (Maurice & Bourton, 1975). Furthermore, the acidic environmental of the area (Jopony & Tongkul, 2009) also contributes to the low richness of cicadas.

The former Mamut copper mine area also has very few trees (Jopony & Tongkul, 2009). Cicadas need trees and shrubs in their life cycle to deposit eggs, for molting, to serve as a feeding site, and a place for mating (Maurice & Bourton, 1975). This clearly shows that habitat suitability is essential in determining the distribution and survival of many species. This place is an open area with few trees. This gives no space for cicadas to cling on to. At Lohan village, cicadas were not only attracted to the light trap, but also to lights at nearby houses. This was not seen in Poring.

Orientopsaltria alticola recorded the highest number of individuals (11) followed by *O. kinabaluana* (8), *Nabalua mascula* and *Dundubia rufivena* (5 each), *D. vaginata* (4), *O. montivaga* and *Pomponia decem* (3 each), *Platylomia spinosa, Purana ubina, P. guttularis, Pomponia* sp.10 (2 each); and *Maua albigutta, Nabalua borneensis, O. padda, Platylomia viridimaculata, Purana* sp.4, *Abroma maculicollis* and *Muda obtusa* each represented by only one individual (Appendix 1).

Nabalua mascula appeared as the most common species in this study, collected from all three sites. *Dundubia vaginata, O. kinabaluana, Pomponia* sp.10 and *Platylomia spinosa* were collected from two sites. The discovery of *Pomponia* sp.10, a possible new species, has increased the record of cicada fauna for Kinabalu Park from 48 to 49 species. The identity of *Purana* sp.4 needs further confirmation.

Male cicadas recorded the highest number of individuals (36 out of 54 individuals) collected. *Dundubia vaginata, Maua albigutta, Nabalua borneensis, Orientopsaltria alticola, O. kinabaluana, O. montivaga, O. padda, Platylomia spinosa, P. viridimaculata, Pomponia decem, Pomponia* sp.10, *Nabalua mascula, Purana ubina, P. guttularis, Purana* sp.4 and *Muda obtusa* were represented by male specimens. Zaidi (1996) reported that male cicadas are more attracted to light and that was the reason more males were collected than females (Figure 2).

The Shannon-Weiner species diversity index for Kinabalu Park (Poring) recorded the highest value (H'=2.15) followed by Kg. Lohan (H'=1.73) and the former Mamut copper mine (H'=1.03). Kinabalu Park (Poring) indeed

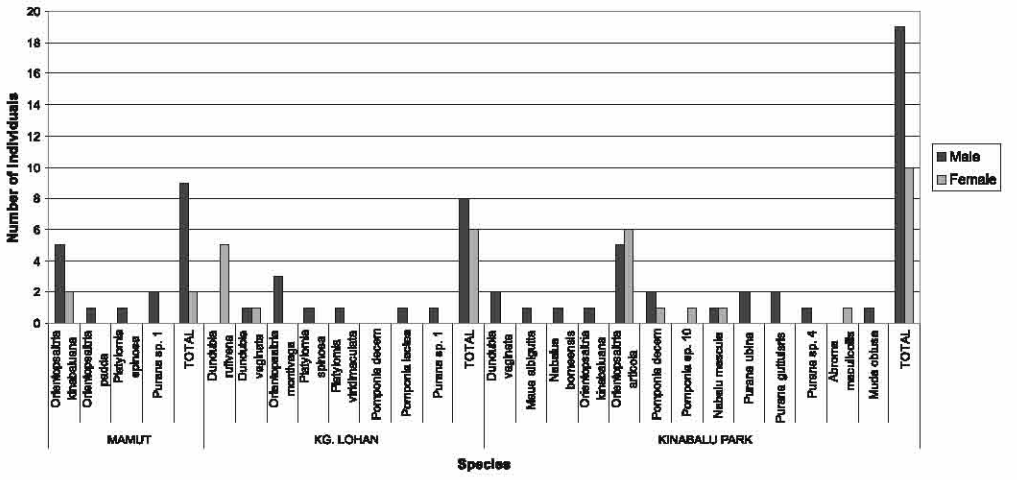

Figure 2. Comparison of number of species (species richness) and abundance (number of individual per species) of cicadas in the three study sites.

offers a favourable environment for many species of cicadas. The pristine jungle of Poring offers a suitable surrounding for cicadas to breed and develop. Development of the area surrounding Poring exerts a certain level of disturbance on the cicada fauna.

CONCLUSION

In conclusion, this study managed to record 54 cicada individuals from the former Mamut copper mine, Kinabalu Park (Poring) and Lohan village, Ranau consisting 18 species of nine genera and two families. Kinabalu Park recorded the highest number of species, followed by Lohan village and the former Mamut copper mine. Data from the former Mamut copper mine is the first of its kind. This study indicates low cicada diversity eventhough many years have passed since the discontinuation of mining. This shows the negative impact of the environment on fauna diversity particularly in the former mining area. Ecological studies on specific species present at the former Mamut copper mine can be interesting for future research. This will unveil survival strategies of these insects and its possible use as biological indicators.

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Appendix 1. List of cicadas species collected from the three study sites; former Mamut Copper Mine (Mamut); Kg. Lohan; and Kinabalu Park, Poring Substation (Poring).

No.	Taxa	Study sites			Total
		Mamut	Kg. Lohan	Poring	
	Cicadidae				
1.	*Dundubia rufivena* (Walker)		5		5
2.	*Dundubia vaginata* (Fabricius)		2	2	4
3.	*Maua albigutta* (Walker)			1	1
4.	*Nabalua borneensis* Duffels			1	1
5.	*Orientopsaltria alticola* (Distant)			11	11
6.	*Orientopsaltria kinabaluana* Duffels & Zaidi	7		1	8
7.	*Orientopsaltria montivaga* (Distant)		3		3
8.	*Orientopsaltria padda* (Distant)	1			1
9.	*Pomponia decem* (Walker)			3	3
10.	*Pomponia* sp.10		1	1	2
11.	*Platylomia viridimaculata* (Distant)		1		1
12.	*Platylomia spinosa* (Fabricus)	1	1		2
13.	*Nabalua mascula* (Distant)	2	1	2	5
14.	*Purana ubina* Moulton			2	2
15.	*Purana guttularis* (Walker)			2	2
16.	*Purana* sp.4			1	1
	Tibicinidae				
17.	*Abroma maculicollis* (Guerin)			1	1
18.	*Muda obtusa* (Walker)			1	1
	Total	11	14	29	54

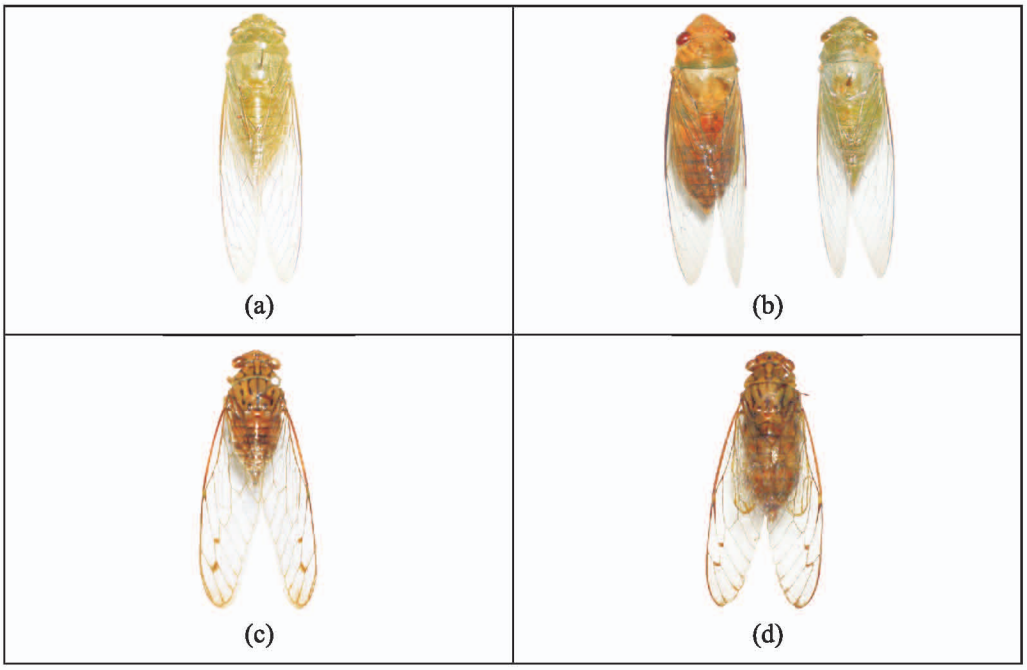

Plate 1. (a) *Dundubia rufivena,* female; (b) *Dundubia vaginata,* male and female; (c) *Maua albigutta,* female; and (d) *Nabalua borneensis,* male.

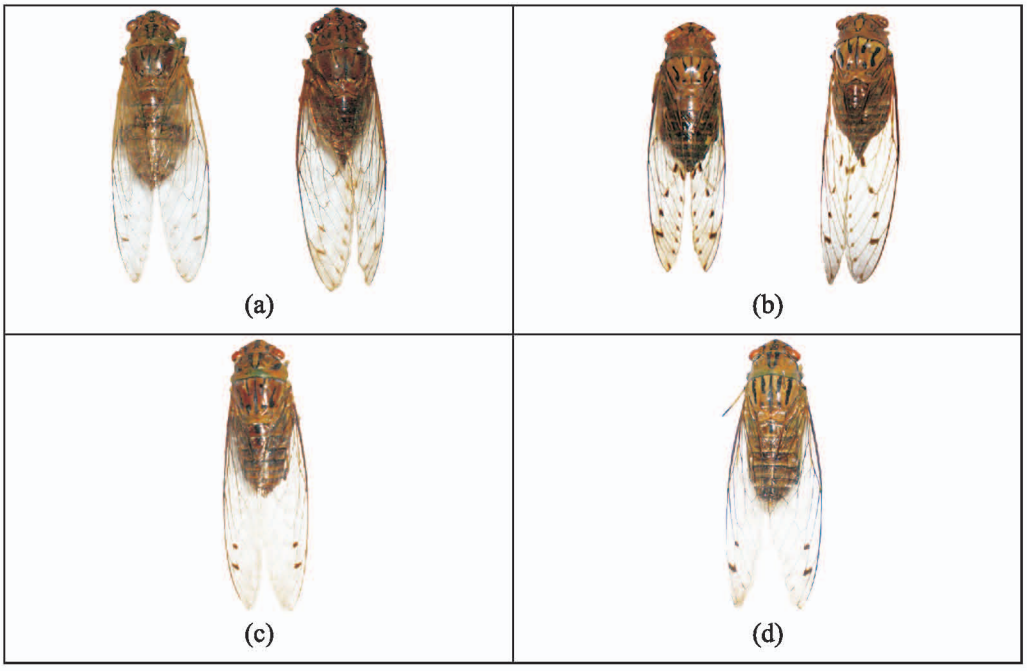

Plate 2. (a) *Orientopsaltria alticola,* male and female; (b) *Orientopsaltria kinabaluana,* male and female; (c) *Orientopsaltria montivaga,* male; and (d) *Orientopsaltria padda,* male.

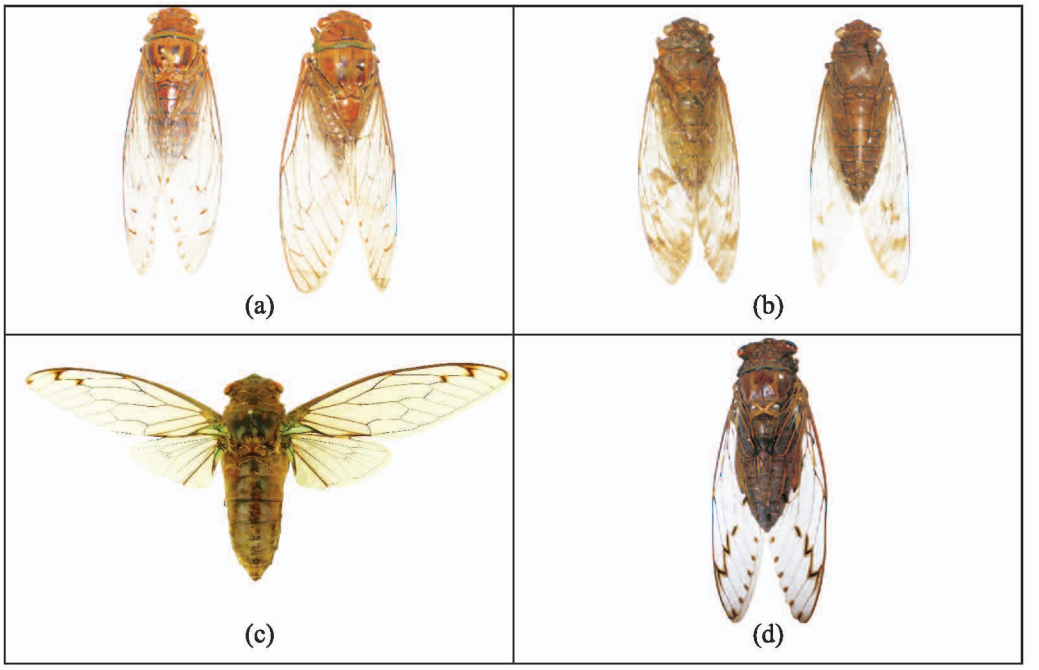

Plate 3. (a) *Pomponia decem,* male & female; (b) *Pomponia* sp.10, males; (c) *Platylomia viridimaculata,* male; and (d) *Platylomia spinosa,* male.

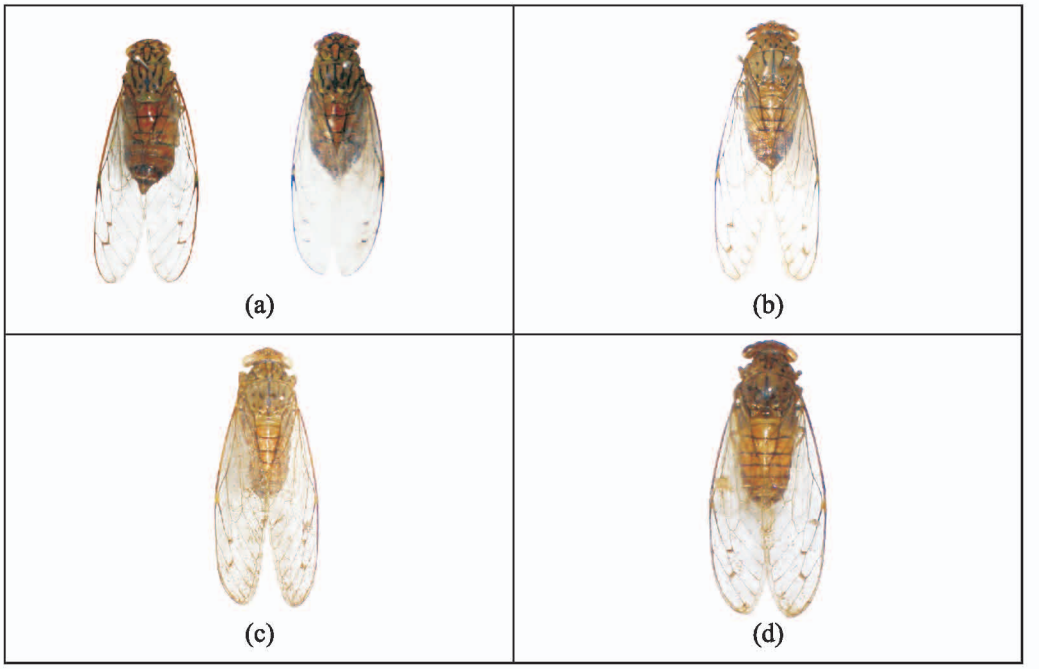

Plate 4. (a) *Nabalua mascula,* males; (b) *Purana ubina,* male; (c) *Purana guttularis*, male; and (d) *Purana* sp.4, male.

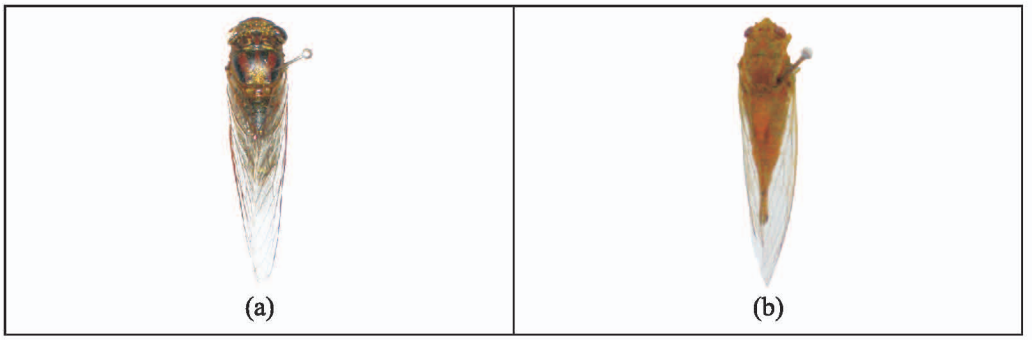

Plate 5. (a) *Abroma maculicollis,* male; and (b) *Muda obtusa,* female.