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CONTENTS

A first look at the biodiversity of praying mantids (Insecta: Mantodea) in Sabah, Borneo	M.E. Helmkampf, C.J. Schwarz & J. Beck	1
Parastheneboea imponens (Brunner, 1907) of Kinabalu Park	B.M. Noramly, B.L. Maklarin & J. Lapidin	15
Gingers in Sabah and their traditional uses	J. Kulip	23
NOTES		
Some notes on *Jatropha curcas* (a potential biodiesel tree for agroforestry plantations) at the nursery stage	F.R. Chia, K.K.N. Pang & A.Y.C. Chung	45
A new record of defoliator on a medicinal herb (*Oxalis corniculata*)	V.K. Chey	57
BOOK REVIEWS		61

Front cover: *Jatropha curcas* seeds, a source of biodiesel (Photo: Kelvin K.N. Pang)

Sepilok Bulletin 7: 1-13 (2007)

A first look at the biodiversity of praying mantids (Insecta: Mantodea) in Sabah, Borneo

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Abstract. Light-trapping was conducted in February and March 2003 near Kinabalu Park and in the Danum Valley Conservation Area in Sabah, Malaysia. During 18 sample nights a total of 106 praying mantids, comprising 28 species, were collected in three different habitat types: a heavily disturbed farmland site, a selectively logged forest and an undisturbed canopy site in a primary dipterocarp forest. Species richness, within-habitat diversity (expressed as Fisher's α) and estimated "true" species richness were highest on the farmland site, followed by the primary forest site and the secondary forest site. The between-habitat diversity indices Jaccard and NESS indicate the highest similarity of the species community between the farmland site and the primary forest site. Similar microclimatic conditions in the open farmland and the upper canopy might be responsible for this effect. The high biodiversity of generalist predators such as mantids on the farmland site could be explained by large abundances of potential prey species that profit from anthropogenic disturbances, such as orthopterans and moths. The value of light-trapping as an effective means to assess the biodiversity of praying mantids is discussed.

Keywords: biodiversity, Borneo, habitat disturbance, Mantodea

INTRODUCTION

Praying mantids (Mantodea Burmeister 1838) form an order of exclusively carnivorous insects. Living solitarily in the vegetation – or, more rarely, on the ground – they ambush insects, spiders and occasionally even small vertebrates (Prete *et al.* 1999). Mantids belong to the top predators of the arthropod community. Some species wear cryptic colours and resemble leaves, flowers, sticks or bark (examples are provided in Plates 1 & 2). Mantids are characterized by their highly specialised raptorial forelegs and a mobile head with powerful compound eyes that allow for binocular sight. An elongated prothorax is also typical. Phylogenetically, they are placed in the vicinity of termites and cockroaches, with which they form the superior taxon Dictyoptera (see also Prete *et al.* 1999). In spite of their close relationship to these long-established groups, mantids themselves do not appear in the fossil record in their modern form before the Cretaceous (Ehrmann 2002). There are approximately 2300 species known worldwide (Ehrmann

2002), the majority of which occur in the tropics and subtropics. African forests and savannahs contain the highest known species richness, followed by the rain forests of South East Asia.

In spite of their size and often spectacular appearance, surprisingly little is known about the ecology of praying mantids. However, numerous studies concerning their physiology, neurology and behaviour do exist – most of them focusing on visual performance, and defensive, courtship and feeding behaviour (e.g. Mittelstaedt 1957, Maldonado 1970, Rossel 1983, Liske *et al.* 1989). Mantids are also used as model organisms in studies on predator's behaviour and strategies (e.g. Inoue & Matsura 1983, Matsura & Nagai 1983, Iwasaki 1998). An overview of mantid ecology and behaviour is given in Prete *et al.* (1999). Comprehensive ecological studies usually concentrate on a single or few species, often from temperate regions (e.g. Rathet & Hurd 1983, Daniels *et al.* 1985). The information about South East Asian species is limited (e.g. Lieftinck 1953). There is almost no literature on mantids from Borneo: Shelford (1903) published descriptive notes on some mantids from Sarawak. So far, 102 species out of 47 genera have been recorded to occur in Borneo (Ehrmann 2002).

The objective of this study is to contribute to the knowledge of the biodiversity of praying mantids in Sabah. To our knowledge, this is attempted for the first time. Mantids are often caught incidentally in studies concerning other insect groups, but they rarely receive full attention in biodiversity studies. Moreover, further information about the impact of anthropogenic disturbance on tropical mantid communities is provided.

To collect specimens, we took advantage of the well-known fact that mantids are attracted to artificial light sources during the night (Ehrmann 2002). Males especially fly during the dusk and the night to find mating partners. In doing so, they avoid their most dangerous diurnal predators (birds and reptiles), but are exposed to bat predation. As other nocturnal insect orders, mantids have evolved auditory organs sensitive to bat echolocation calls, together with active escape behaviours (Yager *et al.* 1990). Females, on the other hand, tend to stay constantly in one area (Ehrmann 1985) and are generally more sedentary than the males. In several species females have reduced wings and are not able to fly over longer distances.

MATERIALS & METHODS

Light-trapping was carried out in February and March 2003 near Kinabalu Park and in the Danum Valley Conservation Area in Sabah, Malaysian Borneo. The light-trap consisted of a 125 W ultraviolet mercury vapour bulb powered by a portable petrol generator and surrounded by a white gauze cylinder 1.6 m in height and 0.8 m in diameter. Trapping was conducted between sunset and sunrise, i.e. 18:30 pm to 06:00 am. All specimens of mantids found on the gauze tower or within a 5 m radius in the surrounding vegetation were collected by hand. Vegetation was checked thoroughly approximately every 30 minutes. Specimens were stored in silica gel or 70% ethanol and, when possible, identified to at least genus level by a key published online by Oliveira (1996) and by Ehrmann's (2002) comprehensive catalogue of the mantids of the world. Unfortunately, actualised general identification keys to species level exist only for some groups, so most of the further sorting had to be carried out using the morphospecies concept (Beattie &

Oliver 1994). About half of the specimens were brought to Würzburg University for preparation and more precise identification, a task that is still ongoing – for three species even the genus affiliation is yet unclear. Voucher specimens were deposited in the collection of Sabah Parks headquarters.

Three sampling sites with different degrees of human habitat disturbance were chosen: (1) The first site (N06°01'33", E116°46'13") was situated in an extensively cultivated area ca. 7 km outside of the Kinabalu Park at Poring Hot Springs, at an altitude of 350 m a.s.l. The site was covered by banana plants, palms and grass and framed by bushes. This site is subsequently referred to as PorC. (2) The second site (DanS: N04°58'07", E117°50'17") lied along a logging road near the Danum Valley Field Centre in a secondary forest (selectively logged in 1988 and 1989), overlooking a small valley from an altitude of 340 m a.s.l. (3) The third site (DanP: N04°57'53", E117°47'47") was situated on a canopy platform 40 m high in the lowland dipterocarp primary forest of the Danum Valley Conservation Area, 220 m a.s.l. More information about the forest types in Danum Valley and the surrounding areas is provided by Marsh & Greer (1992). Seven consecutive sample nights were carried out at site PorC, six nights at site DanS, and five nights at site DanP.

In order to evaluate the efficiency of light-trapping, 10 transects of 100 m length each were searched systematically for mantids in the primary forest understorey of Danum Valley (using the established "West Grid" system). One daylight hour was spent per transect. Mantids discovered accidentally apart from these transects, or at light sources other than the light-trap described above, were also collected, but not included in any analysis.

To measure within-habitat diversity, the α-value of the log-series distribution (Fisher's α), and its standard deviation were calculated using the "Programs for Ecological Methodology 2nd ed." (Exeter Software 2002, v. 6.1) from Krebs (1999). To ascertain whether the data fitted the log-series distribution, the observed species frequencies were compiled in octaves and compared to expected values by chi-square tests using Statistica 6.0 (StatSoft 2001).

The "true" species richness within the three habitats was estimated with the non-parametric estimators Chao1, ACE (Chazdon *et al.* 1998) and Jack-knife1 (Colwell 1997) using the programme EstimateS v. 5 (Colwell 1997). Chao1 and ACE are abundance-based estimators, whereas Jack-knife1 is incidence-based. The ACE (Abundance-based Coverage Estimator) may be especially well suited for data sets with a large proportion of rare species (Chazdon *et al.* 1998).

For the measurement of between-habitat diversity the indices of Jaccard (see e.g. Southwood & Henderson 2000) and NESS (Grassle & Smith 1976) were calculated. The Jaccard index determines the relative similarity of the species inventory between two communities using presence–absence data only. It is therefore especially sensitive to rare species. In contrast, NESS values point out the normalized estimates of shared species if random samples of size m were drawn from two communities. The sensitivity of the NESS index can be adjusted by means of this parameter m. For $m = 1$ the NESS index is most sensitive to common species. With rising m, it grows more susceptible to rare species. Here, NESS values for $m = 10$ are presented (results did not change essentially for different values of m). For both β-diversity calculations the programme Biodiv97 (see above) was used.

RESULTS

A total of 106 individuals, representing 28 mantid species, were collected during the course of 18 sample nights. This is equivalent to almost a third of the 102 species reported to occur in Borneo (Ehrmann 2002). Three of these species have never been reported from Borneo before, and two of them seem to be altogether undescribed taxa and are subject of subsequent work. One additional specimen so far could not be identified at all. On average between five and eight individuals were caught per night, depending on the sampling site (see Table 1). The highest number of species was found in the cultivated area, totalling 16 – in contrast to 14 collected in the primary forest and 11 in the secondary forest.

Table 1. Numbers of collected species and individuals, sample nights, mean catches per night and values of the within-habitat diversity index Fisher's $\alpha \pm$ SD. Observed species richness and within-habitat diversity is highest in the cultivated area, followed by the primary forest. For sampling site designations see Materials & Methods.

Sampling site	Collected species	Individuals	Sample nights	Mean catch per night	Fisher's α ± SD
PorC	16	40	7	5.7	9.9 ± 6.6
DanS	11	28	6	4.7	6.7 ± 5.0
DanP	14	38	5	7.6	8.0 ± 4.2
Total	28	106	18	5.9	–

Within-habitat diversity expressed as Fisher's α (± standard deviation) was highest in the cultivated area (9.9 ± 6.6), followed by the primary forest site (8.0 ± 4.2) and the secondary forest site (6.7 ± 5.0) as shown in Table 1. All three samples fitted the log-series distribution with $P > 0.95$.

Table 2 specifies all the specimens collected by light-trapping. Along the transects six specimens of probably four species were discovered. None of them could be identified, as all of them were nymphs. Mantids caught accidentally are listed in Table 3. Although they are not included in the biodiversity analysis, they might provide useful information about the distribution of the species.

Table 2. List of specimens collected at Poring Hot Springs and Danum Valley using an UV light-trap. Classification follows the traditional systematics of Beier, revised by Ehrmann and Roy (Ehrmann 2002). Asterisks indicate species previously unreported for Borneo (*) or entirely undescribed species (**). For sampling site designations see Materials & Methods.

Species	PorC	DanS	DanP
Amorphoscelidae			
Amorphoscelis spec. 1			3
Amorphoscelis spec. 2			1
Hymenopodidae			
Acromantis spec.	5	1	4
Citharomantis spec. (probably *C. falcata*)*		1	
Creobroter spec.	2	6	1
Hestiasula spec. 1		2	
Pachymantis bicingulata	1		
Psychomantis borneensis	1		
Rhomantis moultoni			1
Unidentified species (probably *Ephestiasula* spec. nov.)**			4
Liturgusidae			
Humbertiella ocularis	1		
Theopompa spec. 1		1	
Theopompa spec. 2			3
Tarachodidae			
Leptomantella spec. 1	4	1	10
Leptomantella spec. 2	4	1	
Iridopterygidae			
Tropidomantis tenera	11		1
Xanthomantis flava		7	2
Mantidae			
Ceratocrania macra	1		
Deroplatys truncata	1		
Euchomenella matilei	3		3
Euchomenella heteroptera	1		
Gimantis insularis			2
Hierodula spec. 1	2		2
Hierodula spec. 3	1	6	1
Phyllothelys spec.	1		
Rhombodera spec.		1	
Unidentified species	1		
Unidentified species (probably *Mythomantis* spec. nov.)**		1	

Table 3. Species caught accidentally in Poring Hot Springs and Danum Valley, but not included in the biodiversity analysis.

Species	Poring Hot Springs	Danum Valley
Hymenopodiae		
Hestiasula spec. 2		*
Pachymantis bicingulata		*
Liturgusidae		
Theopompa spec. 1	*	
Iridopterygidae		
Hapalopeza spec.	*	
Mantidae		
Deroplatys desiccata	*	
Deroplatys truncata		*
Hierodula spec. 2	*	

Estimations of the true species richness, shown in Table 4, convey a similar picture as the observed species richness. The cultivated area near Poring Hot Springs contains the highest estimated number of species (25 to 29), while the primary and secondary forest habitats in Danum Valley are estimated to contain 17 to 20 and 17 to 24 species, respectively. Jack-knifing ranks the three habitats in the same way as the observed species richness and Fisher's α. The abundance-based estimators Chao1 and ACE, on the other hand, rank the primary forest as the least diverse habitat.

Table 4. Estimated species richness as calculated by the estimators Chao1, ACE and Jack-knife1. All estimators rank the cultivated area as the site with the richest species inventory.

Sampling site	Chao1	ACE	Jack-knife1
PorC	29	29	25
DanS	22	24	17
DanP	17	19	20

According to the Jaccard index the mantid communities of all habitats are moderately similar to each other, as shown in Table 5. Cultivated area and secondary forest have 23% of their species in common, secondary forest and primary forest 25%, and primary forest and cultivated area share 30% of their species. When taking abundance data into account the similarity between primary forest and cultivated area grows more substantial: the NESS index value ($m = 10$) amounts to 0.71 for these two habitats while all other habitat combinations have values of only around 0.5.

Table 5. Between-habitat diversity expressed as Jaccard and NESS index values. The similarity of the species inventory is highest between the primary forest and the farmland site.

Sampling sites (pairwise)	Jaccard index	NESS (m = 10)
PorC — DanS	0.23	0.48
DanS — DanP	0.25	0.49
DanP — PorC	0.30	0.71

DISCUSSION

Surprisingly, species richness, within-habitat diversity (Fisher's α) and estimated "true" species number were highest on the farmland site, followed by the primary forest site and the secondary forest site. In contrast to the results of this study, similar studies on other insect taxa have shown a general decline of species richness with increasing human habitat disturbance (e.g. Lawton *et al.* 1998, Floren *et al.* 2001, Beck *et al.* 2002). Several biotic and abiotic factors may account for this effect. Abiotic factors include direct mechanisms like alterations of microclimatic conditions or habitat structure, while biotic or indirect factors include changes in the food web like the loss of important food species or fluctuations in the population size of predators that in turn control the population sizes of their prey. This pattern cannot be applied universally, though, as no group studied so far has been found to serve as a good indicator taxon for changes in the species richness of other groups (Lawton *et al.* 1998). While a decline of mantid species richness from the undisturbed primary forest canopy to the moderately disturbed secondary forest understorey could be observed, the highly disturbed farmland habitat seemed to provide unexpected good living conditions for many praying mantids. Why could this be the case?

In general, a few species are always able to profit from the altered conditions in disturbed habitats (because of a decline of their predators or competing species, for example), rising to high abundances (e.g. Floren *et al.* 2001, Beck *et al.* 2006). As mantids are generalist predators that feed on a wide variety of taxa (e.g. Iwasaki 1998, Schwarz 2003 and pers. observation), they are not dependent on the fate of distinct prey species. Moths, orthopterans and dipterans – all constituting suitable prey for a mantid – exist in high numbers on farmland sites (pers. observation during the light-trapping, see also Beck *et al.* 2002, 2006). In addition, bushes along the field margins and wild growth provide sufficient habitat structure. The highly productive farmland habitat might thus provide perfect conditions for high abundance and diversity of Mantodea. However, members of the mantid families Amorphoscelidae and Liturgusidae were almost completely absent at the farmland site (see Table 3), probably because these flat bark-mimics require tree trunks as habitat. They were also largely missing in the secondary forest site, but five species could be discovered in the primary forest.

Alternatively, the farmland area might experience a constant influx of mantids from less disturbed habitats in the vicinity. However, the colonization ability of mantids is considered to be limited, as females are usually poor flyers (Ehrmann 2002). With the nearest primary forest 7 km away, it seems therefore probable that the species found in PorC indeed form an established community.

The similarity of the species composition between cultivated area and primary forest site might be due to microclimatic similarities. Both habitats – the farmland site lacking large trees and the primary forest site being located in the open upper canopy layer (40 m height) – exhibit a higher exposure to the sun than the shady margin of the secondary forest. These conditions favour the thermophilic Mantodea. Unfortunately, no comparative measurements of solar irradiation or temperature were undertaken. Also, data from a primary forest understorey site would have been desirable to examine vertical stratification effects and for better comparability with the secondary forest site, which was located on the ground. It is nonetheless conceivable that microclimatic conditions affect the distribution of mantids more strongly than effects of disturbance, at least in this case.

The question why mantids are attracted to light remains to be further explored. Since many fully winged mantids fly over longer distances at night, especially males searching for mates, it can be supposed that they use similar orientation patterns as other nocturnal insects do (e.g. position of the moon). Consequently, they might be irritated by an artificial light source in the same way as, for instance, moths are (see e.g. Muirhead-Thompson 1991). However, many individuals could be observed hunting near the light or even on the gauze screen without any obvious orientation problems (as opposed to many moths). Maybe mantids are initially attracted by the light itself, but then stay mainly because of the concentration of prey around the light (as do spiders, bats and occasionally mice). It is interesting to note that 98% of the collected specimens were indeed males. As noted above, this can be attributed to the fact that the females of many species are less mobile and in some cases not even able to fly. In other studies, females of species that are fully winged in both sexes were also attracted, though more rare (e.g. Edmunds 1986).

Light-trapping, a frequently employed method in biodiversity research (e.g. Southwood & Henderson 2000), proved an effective means to collect praying mantids. Searching the vegetation along transects was substantially more time-consuming and is more difficult to standardize. Of course light-trap data measure activity and responsiveness to light rather than representing the true population structure. Some mantid species might not be attracted as strongly to light as others (Schwarz 2003), and – even more important – some species might not be attracted to light at all. However, this problem of selective sampling applies to all sampling methods (Southwood & Henderson 2000), and light sampling provided by far more species with much less effort than transect sampling. Further research is certainly needed to assess which species or larger taxonomic groups might be generally missed by light-trapping. Weather factors like temperature, relative humidity, rainfall and moonlight might also influence the activity of mantids, as it is known for moths (e.g. Holloway *et al.* 2001). However, while there is no knowledge of the attraction radius of light sources on mantids, for Lepidoptera the radii of attraction are surprisingly small (e.g. Muirhead-Thompson 1991) – even for hawkmoths (Sphingidae), which are certainly by far faster and more active flyers than mantids, effective attraction radii normally do not exceed 30 m (Beck & Linsenmair 2006). Therefore, situating a light source within a 'homogenous' habitat should be sufficient to attract mainly species from that habitat. Differences in the number of individuals, which might still result from different openness at the sampling site, can be normalized by appropriate (e.g. sample size independent) diversity measures like Fisher's α and NESS in order to provide valid evaluations of mantid biodiversity in many situations. It would be desirable to repeat sampling, so effects of seasonality and annual differences could be taken into account. Particularly outside of the humid tropics seasonality might influence biodiversity estimates considerably.

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Plate 1

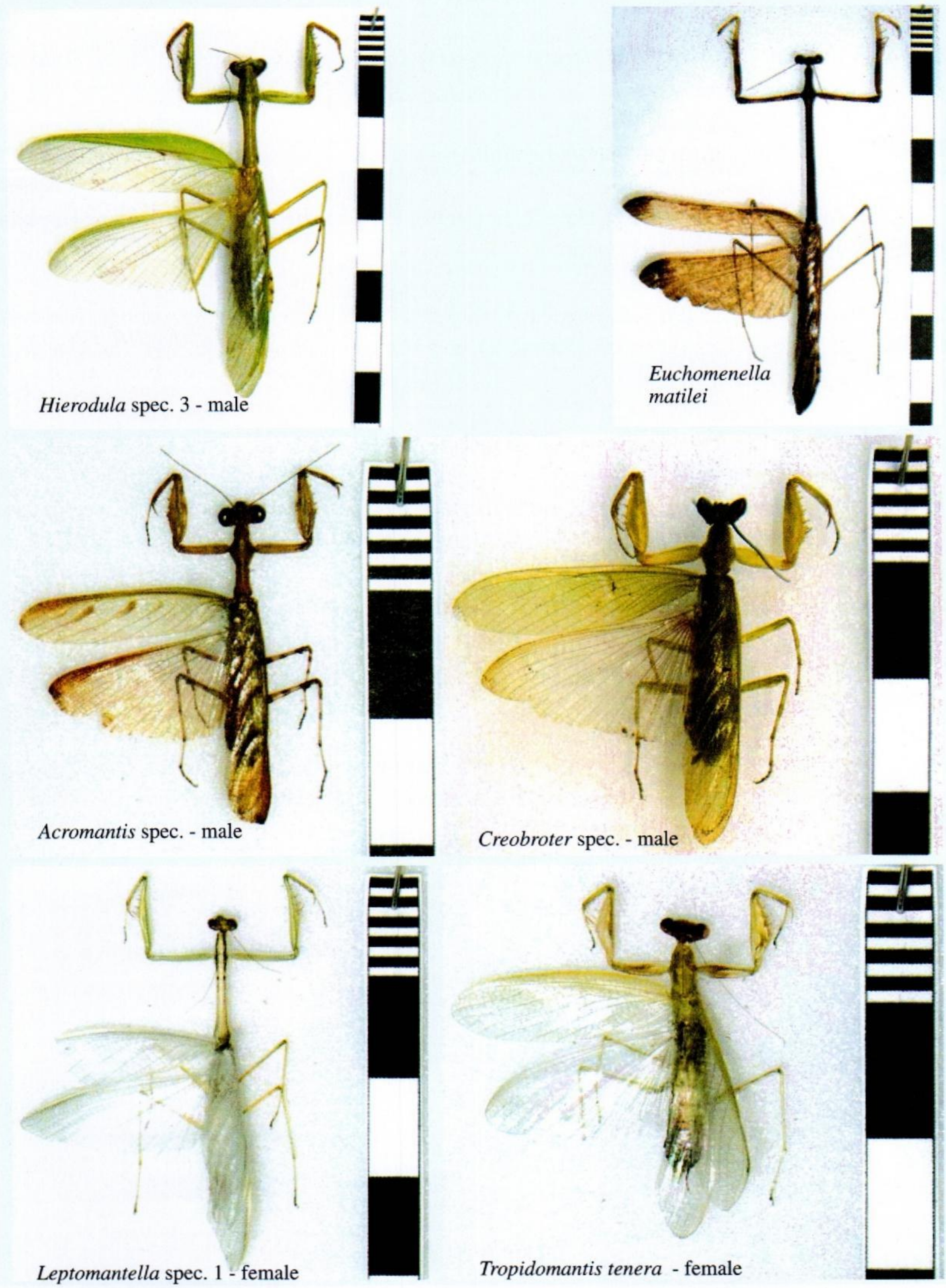

Plate 1. Examples of praying mantids frequently encountered in Sabah, Borneo.

Plate 2

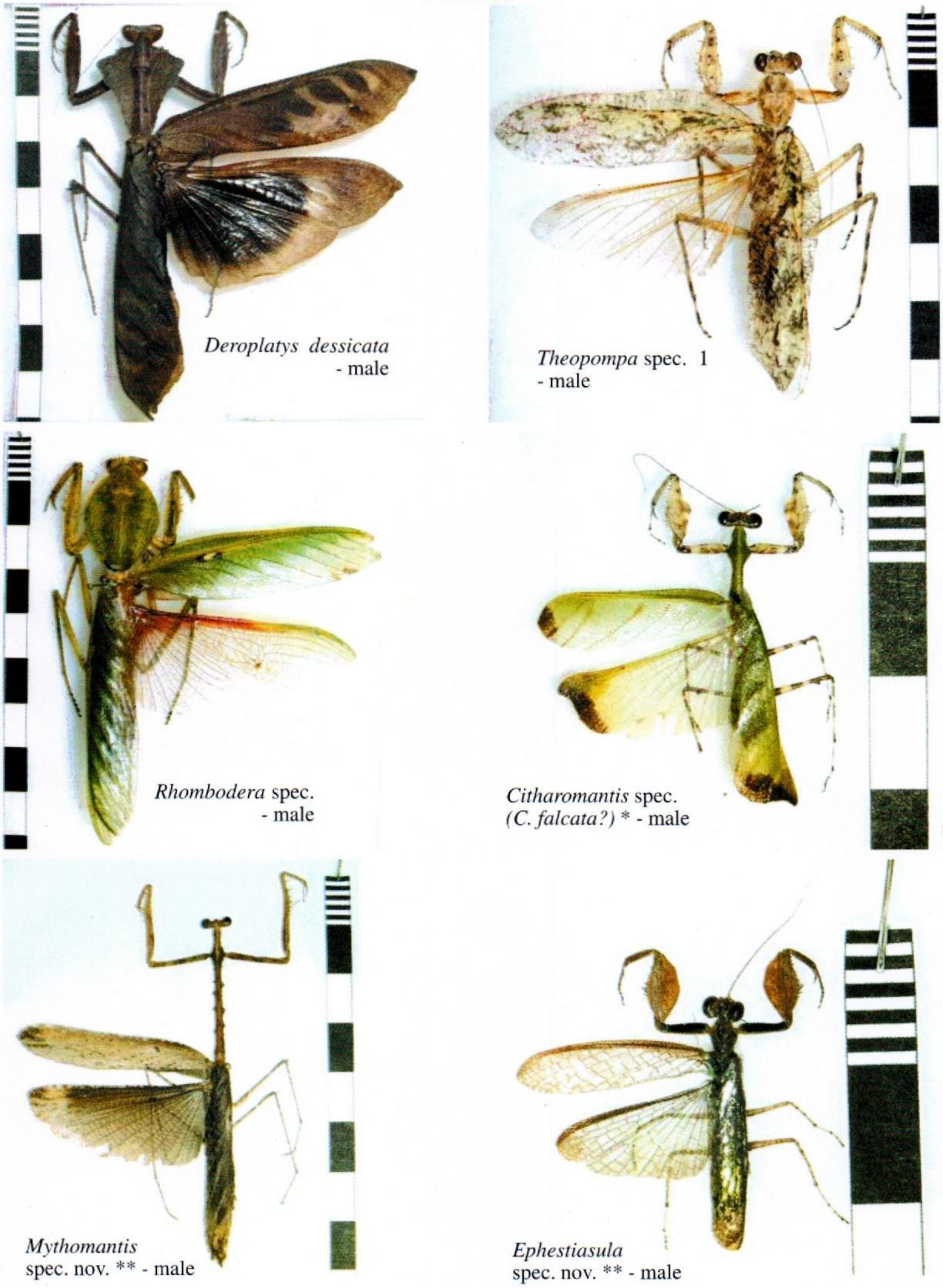

Plate 2. Examples of especially conspicuous or previously unreported mantids collected in Sabah, Borneo. Asterisks as in Table 2.

Sepilok Bulletin 7: 15-22 (2007)

Parastheneboea imponens (Brunner, 1907) of Kinabalu Park

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Abstract. A wingless female of the stick insect *Parastheneboea imponens* (Brunner, 1907) was collected at Bundu Tuhan Trail, Kinabalu Park. The main dignostic features for the species are the presence of V-shaped crest on the head, the distribution of the clusters of spines on the pronotum, mesonotum and metanotum, and the presence of first and second paired posterior spines on the abdomen. The general greenish-reddish-brown body appearance in the field is characteristic of the species. This is the first detailed report on the species.

Keywords: Borneo, *Parastheneboea imponens*, Phasmida

INTRODUCTION

Borneo, a tropical rainforest island in South East Asia, has a large and diverse phasmid fauna (order: Phasmida), widely known as stick and leaf insects. About 10% of the world's described phasmids, estimated to be about 3000 species, are from Borneo and much of the island is still unexplored (Bragg 2001). The main habitats of Borneo support different sub-groups of phasmids depending on the types of trees, food plants and elevation. The mangrove forest, peat swamp forest and agricultural areas support fewer phasmids compared to well-developed secondary and montane forests. In primary lowland forests, phasmids are usually found along riverbanks and tracks when vegetation is close to the ground.

All known phasmids are sexually dimorphic with males being much slender, shorter, different in body shape and colour. In many cases the dimorphism is so great that the identifications of wingless phasmids can only be certain if they are found during copulation.

The phasmid taxonomy at the moment is in a state of flux as new species are being discovered or the old ones being renamed and their classifications being rearranged. The current classification of the Bornean phasmids has been based on Bradley & Galil (1977) with some modifications (Bragg 2001). Much work is needed to review the genera or tribes with new descriptions of males or females of previously known species and descriptions of eggs.

MATERIALS & METHODS

The collecting was done at night in 2006 on low vegetation along the Bundu Tuhan Trail, Kinabalu Park, E116° 33', N06°00', at 1500 m a.s.l. using torchlight and headlamps. The located phasmid was then photographed digitally, collected by hand together with the leaves of the plant where the phasmid was found. The phasmid collected was put in a plastic bag, air-filled by blowing air into it. It was subsequently brought to the laboratory.

The phasmid was killed by using ethyl acetate, pinned and then dried in the oven at 40-45°C. The sampled phasmid was then measured by using a vernier scale and detailed morphological studies were done by using an image analyser (Leica, UK) at various levels of magnification.

RESULTS & DESCRIPTIONS

The collected specimen was a wingless female of *Parastheneboea imponens* (Brunner, 1907) (Phasmida: Heteronemiidae: Necrosciinae), and the living phasmid is shown in Figure 1. The body and the legs are reddish-brown with greenish colour on the head, spines and lobes.

The measurements obtained of the dried specimen of *Parastheneboea imponens* are shown in Table 1.

The head is longer than broad (6.0 mm x 4.0 mm). The back of the head bears at least 10 spines in two clusters of 5 spines forming a V-shaped crest pointing upwards and outwards. The heights of the spines range from 1.3 mm to 2.9 mm and the distance between the two peaks of the crest is 2.4 mm. There are 2 medium-sized tubercules between the eyes surrounded by smaller ones (anteriorly).

The antennae are banded with lighter and darker areas, each segment ranges from 0.6 mm to 2.2 mm long. The total length of the antenna is 36.4 mm.

Figure 1. *Parastheneboea imponens* in Bundu Tuhan, Kinabalu Park.

Table 1. Body length measurements (in mm) of wingless female of *Parastheneboea imponens*.

		mm
Body length		49.6
Antenna		36.4
Head		6.0
Pronotum		3.6
Mesonotum		7.8
Metanotum		6.6
Median segment		2.9
Fore leg	femur	12.0
	tibia	13.1
	tarsus	6.5
Middle leg	femur	12.0
	tibia	9.6
	tarsus	4.4
Hind leg	femur	14.1
	tibia	14.8
	tarsus	6.4

The prothorax is small, broader anteriorly (3.6 mm). The dorsal plate has two sets of V-shaped clusters of spines, the anterior cluster being bigger consisting of 3-4 spines of 1.5 mm, and the posterior cluster consisting of spines of 0.7 mm and surrounded by some tubercules.

The mesothorax is longer (7.8 mm) and the segment is broader anteriorly, the central portion is depressed and that the two clusters of spines are raised towards each end of the segment. The spines on the raised portion of the mesothorax are V-shaped, the front ones being slightly longer (2.1 mm).

The metathorax, which is covered with tubercules, is shorter than the mesothorax but the segment is longer than broad (6.6 mm x 3.7 mm). There is a posterior metanotal mound with raised spines pointing upwards and outwards (1.8 mm) almost forming rather a V-shaped cluster anterior to the first abdominal segment (the median segment). There is also a cluster of lateral spines (1.0-1.6 mm), the supracoxals, just before each coxa of the hind legs. There is also a lateral spine (0.6 mm) occurring in the middle of the metapleuron, and tubercules on the anterior half of the ventrolateral margin.

Figure 2. Detailed structure of the head of *Parastheneboea imponens*.

Figure 3. Mesal spines on the abdomen of *Parastheneboea imponens*.

Figure 4. End of the abdomen of *Parastheneboea imponens* (female).

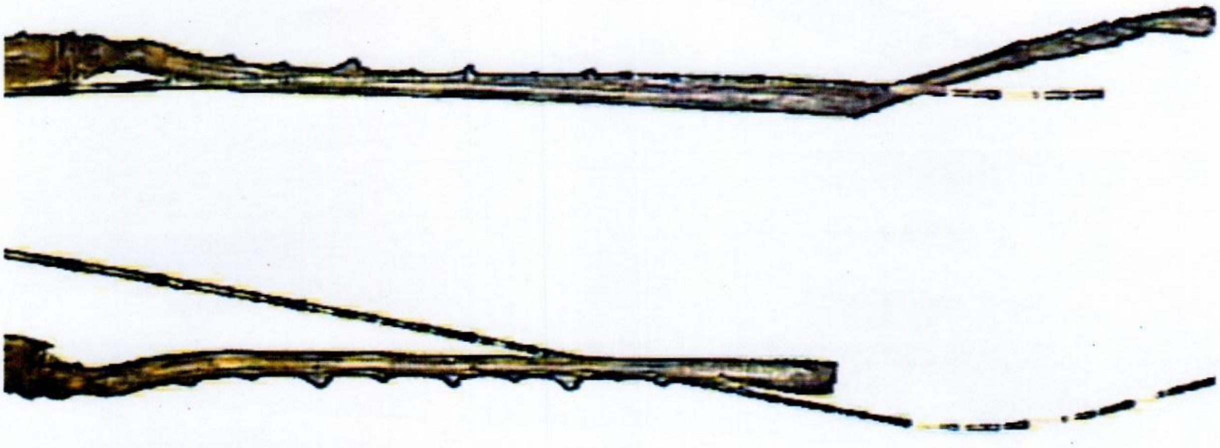

Figure 5. Tibiae of fore legs of *Paratheneboea imponens*. Bottom tarsus broken off.

The abdomen is slender tapering gradually towards the anus. The median segment is indistinct with two posterior mesal spines close to one another almost forming like a V-shape. Segments 2-5 are rectangular in shape (4.2-2.4 mm x 3.5-2.5 mm). The abdominal tergum has distinct first paired posteriors with smaller second paired posteriors. There are smaller spines anterior to these posteriors. The mediolaterals are also present forming lobes (see Figure 4). Segments 6-10 are armed with posterior mesals which are reduced to tubercules. The lamina supraanalis is as long as segments 9-10 combined. All these segments have tubercules on their surfaces.

All femoral carinae are armed with spines (0.2-0.6 mm). The fore femur has only one carina armed with spines whereas the femur of the middle leg as well as hind leg has three carinae armed with spines (see Figure 3). The tibia of all the legs has only one carina covered with raised tubercules (see Figure 5).

DISCUSSION

The presence and the distribution of spines on the body of *Parastheneboea imponens* are of significance in diagnosing the species concerned. Following are its main characteristics:

(*a*) The phasmid is spinose.

(*b*) The back of its head has posterior coronals forming two clusters like a V-shaped crest which could be typical of the species.

(*c*) The prothorax has two clusters of spines, the anterior pronotals being more prominent and the posterior ones are shorter and pointed outwardly.

(*d*) The mesotorax has two clusters of spines, the anterior marginal spines are more prominent than the posterior mesal mesonotals.

(*e*) The abdominal tergum has two sets of paired posteriors, first paired posteriors being the mesal spines.

(*f*) All the femora have spined carinae and the tibia of all legs has one carina with tubercules and fine hairs.

Parastheneboea imponens is not uncommon in Kinabalu Park at 1500 m a.s.l. (C.L. Chan, pers. comm.). The holotype of the species is a female, and the first author is in preparation to describe the male of the species.

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Gingers in Sabah and their traditional uses

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Abstract. A study on the traditional uses of Zingiberaceae was conducted in Sabah, Malaysia. A total of 36 ginger species wild and exotic used by the local people in Sabah was recorded and listed in this survey. It is interesting to note that the native communities in Sabah utilized many species of ginger, about 26% of all known Bornean Zingiberaceae. Among the uses were for medicine, food, ornamentals and construction purposes. *Etlingera* and *Alpinia* species were the most common gingers utilized by the locals in Sabah, followed by *Zingiber.*

Keywords: ethnobotany, gingers, Sabah, Zingiberaceae

INTRODUCTION

Sabah, one of the 13 states within the Federation of Malaysia, is located in the northernmost part of Borneo island. It is the second largest state in Malaysia with a landmass of approximately 7.4 million hectares. The total forested area is 4.7 million hectares. The climate is marine equatorial with an average temperature of 23.9-32.2°C (Kulip 2007).

The population of Malaysian citizens in Sabah as at 2006 is about 2.2 million (Department of Statistics 2007). There are 36 indigenous ethnic groups living in Sabah, of which the Kadazan/Dusun is the majority followed by Bajau and Murut. Sabah native communities commonly use plants surrounding their houses or in the forest for various purposes in their everyday life.

The Zingiberaceae is a moderately-sized family of relatively advanced monocotyledonous plants of the order Zingiberales. Zingiberaceous plants are rhizomatous, perennial and aromatic herbs found throughout the tropical and subtropical regions with their main distribution in Asia. The group has about 50 genera and 1,500 species (Larsen *et al.* 1999). The Indo-Malayan region is reportedly the centre of diversity of Zingiberaceae with at least 172 species (including varieties), 80% of which are found in Borneo (Poulsen 2006). Many of the species recorded in Sabah are predominantly wild, growing in various habitats ranging from riverine to montane regions. Gingers are most abundant in lowland forests between the altitudes of 200 and 500 metres above sea level, becoming less frequent higher up and scarce in very high altitudes.

Gingers are loosely called 'Halia' in Malay, and several species of economic importance include the common ginger itself 'Halia' (*Zingiber officinale*), turmeric or 'Kunyit' (*Curcuma* *domestica*) and cardamom (*Elettaria cardamomum*). Gingers are characterized by their aromatic parts and are used as spices, made into condiments, essential oils and medicine, and grown as ornamentals.

In Malaysia, about 30-40 species of Zingiberaceae have long been used in traditional medicine. A large number of species from the ginger family has been cultivated for use as food, medicine and ornamentals (Ibrahim 1992). However the usefulness of the native species has not been fully appreciated and exploited especially in Sabah.

Zingiberaceae was chosen in this study because it is widely used amongst the natives in Sabah. This study was conducted to improve our ethnobotanical knowledge on Zingiberaceae, and this will help both the local communities and government to protect the species and to enhance the wise utilization of this family.

METHODOLOGY

This study was conducted by fieldwork and literature review. Fieldwork involved interviews, recording of uses of plants and plant collecting. Literature review involved recording previous ethnobotanical studies conducted in Sabah and examining herbarium specimens. This study covered all native ethnic groups in Sabah.

During interviews, local dialects were used. Unidentified ginger specimens were numbered and brought to the herbarium to be examined further. No collection was made when they were identified in the field. Voucher specimens were deposited in the ethnobotany herbarium of the Forest Research Centre (FRC), Sepilok, Sandakan.

Among the local villagers of various ethnic groups interviewed by the author were the Kadazan/Dusun, Murut, Lundayeh, Orang Sungai and Bajau. Localities of study were Keningau, Tongod, Tambunan, Penampang, Tawau, Ranau, Sipitang, Sook and Kudat.

Identifications of specimens were done by the author based on recent publications and also by comparing specimens in the SAN herbarium, Sepilok, Sandakan.

RESULTS

A total of 36 species in 12 genera of Zingiberaceae in Sabah was surveyed. This is about 26% of the species found in Borneo. The distribution of species with traditional uses is shown in Table 1. This shows that *Etlingera*, *Alpinia* are the most common genera utilized by the people in Sabah, followed by *Zingiber*.

Table 1. Genera of Zingiberaceae surveyed in Sabah and number of species with ethnobotanical uses.

Genus	No. of species with traditional uses
Alpinia	6
Boesenbergia	3
Curcuma	2
Etlingera	6
Geocharis	1
Globba	3
Hedychium	2
Hornstedtia	3
Kaempferia	1
Plagiostachys	2
Tamijia	2
Zingiber	5

Among the uses were for medicine, food, ornamentals, and construction purposes. Most of the Zingiberaceae species were used as medicine. Plant parts used were mostly rhizomes. The most well-known and widely consumed native species was *Etlingera coccinea* or Tuhau. Its pith is sold as pickles and can be found in many local supermarkets especially in the west coast of Sabah. It is also widely sold in 'tamu' and roadside stalls.

1. *Alpinia capitellata.*

Figure 1. *Alpinia capitellata.*

Local name: Tubu Bachit (Lundayeh).
Locality: Kg. Mendulong, Sipitang.
Habitat: Edge of secondary forest.
Uses: Edible ripe fruit (sweet).

2. *Alpinia latilabris*.

Figure 2. *Alpinia latilabris*.

Locality: Sukau, Kinabatangan.
Habitat: Undisturbed forest floor.
Uses: Ornamental (Yusoff *et al.* 2003).

3. *Alpinia galanga* (syn. *Languas galanga*).

Figure 3. Rhizomes of *Alpinia galanga* sold in 'tamu' (open market).

Local name: Lengkuas (Malay).

Collection no: SAN 132422.

Locality: Kg. Delayan Baru, Sook.

Habitat: Cultivated.

Uses: Widely cultivated. Rhizome is used for digestive, stomach problems and for skin disease.

4. *Alpinia amentacea.*

Figure 4. *Alpinia amentacea.*

Locality: FRC Ethnobotanic Garden, Sepilok.
Habitat: Open area.
Uses: Ornamental.

5. *Alpinia* sp. 1.

Local name: Tolidus (Kadazan/Dusun).
Collection no: FRCSE 207.
Locality: Kg. Nalumad, Ranau.
Habitat: Primary forest.
Uses: Whole plant is used to treat skin disease.

6. *Alpinia* sp. 2.

Local name: Limpuyang (Tidung).
Locality: Kg. Apas, Tawau.
Uses: Rhizome is used to treat smelly menstruation of women.

7. *Boesenbergia stenophylla.*

Local name: Kaburo Apad (Lundayeh).
Locality: Long Pasia, Sipitang.
Uses: Rhizome is used for stomachache and poisoning (Poulsen 2006).

8. *Boesenbergia pulchella.*

Local name: Lipat (Kadazan/Dusun).
Collection no: FRCSE 230.
Locality: Kg. Nalumad, Ranau.
Habitat: Primary undisturbed forest.
Uses: Sap for bathing to cure skin disease.

9. *Boesenbergia* sp. 1.

Local name: Layo Tutumolong.
Collection no: FRCSE 120.
Locality: Kg. Napagang, Tongod.
Habitat: Primary forest.
Uses: The whole plant is used to treat rheumatism.

10. *Curcuma domestica.*

Figure 5. *Curcuma domestica.*

Figure 6. Rhizomes of Kunyit being sold in 'tamu'.

Local name: Kunyit.

Locality: Throughout Sabah.

Habitat: Cultivated.

Uses: The rhizome is pounded together with white pepper and tamarind, mixed with hot water for drinking to cure coughs. It is also used to treat internal bleeding, sprains, fractures and as post-natal aid (Yusoff *et al.* 2003), as well as to treat skin disease (Kulip 2007). Leaves used to treat jaundice.

11. *Curcuma xanthorrhiza.*

Figure 7. *Curcuma xanthorrhiza.*

Local name: Temu Lawak, Kunyit Hitam (Orang Sungai).

Locality: Kg. Sukau, Kinabatangan.

Habitat: Open area, cultivated.

Uses: Rhizome to treat toothache (Yusoff *et al.* 2003).

12. *Etlingera coccinea* (syn. *Etlingera punicea*).

Figure 8. *Etlingera coccinea* plant in the FRC Ethnobotanic Garden, Sepilok.

Figure 9. Inflorescence of *Etlingera coccinea*.

Figure 10. The edible piths (Tuhau).

Local name: Tuhau (Kadazan/Dusun).

Collection no: SAN 132096, SAN 132408.

Locality: Kg. Giring-Giring, Ranau; Kg. Delayan Baru, Sook.

Habitat: Common along roadside and in plantation.

Uses: The pith is eaten as vegetable. Consumed heavily by the Kadazan/Dusun community in Sabah, and sold in roadside shops and supermarkets in Sabah as pickles. It is also used to reduce high blood pressure and as a blood cleanser (Kulip 2007).

13. *Etlingera elatior*.

Figure 11. Inflorescence of *Etlingera elatior*.

Figure 12. *Etlingera elatior* plant.

Local name: Topu (Kadazan/Dusun).

Collection no: SAN 132085, FRCSE 58.

Locality: Kg. Giring-Giring, Ranau; Kg. Rompon, Tambunan.

Distribution: All over Sabah.

Habitat: Edge of primary forest.

Uses: Inflorescence as vegetable. It is also used to reduce fever. Rhizome and pith are also used as vegetable.

14. *Etlingera brevilabrium*.

Locality: Kallang waterfall, Tenom; Brantian, Kalabakan.
Habitat: Dense primary forest.
Uses: Ornamental.

15. *Etlingera fimbriobracteata*.

Local name: Tolidus (Kadazan/Dusun).
Collection no: SAN 143546.
Locality: Common in Sabah.
Habitat: Edge of forest. Lowlands to 850 m a.s.l.
Uses: Fruit, seeds edible. Leaves used to make hat and roof for forest hut.

16. *Etlingera littoralis*.

Locality: Lahad Datu; Gunung Tambuyukon, Ranau.
Habitat: Primary forest floor.
Uses: Fruit edible (Smith 1986).

17. *Etlingera* sp. 1.

Local name: Teriwad/ Tolivad (Dusun).
Collection no: SAN 138533.
Locality: Tambunan; Kg. Sogo-Sogo, Tongod.
Habitat: Secondary forest.
Uses: Flower and young stem (pith) are used to treat piles and promote menstruation.

18. *Geocharis fusiformis* var. *borneensis*.

Locality: Telupid, Sandakan.
Habitat: Roadside.
Uses: Ornamental.

19. *Globba atrosanguinea.*

Local name: Tubu.
Locality: Danum Valley, Lahad Datu.
Habitat: Primary undisturbed forest.
Uses: Ornamental.

20. *Globba francisii.*

Local name: Layo Timbaan.
Locality: Kg. Sukau, Kinabatangan.
Habitat: Undisturbed forest near water.
Uses: Rhizome used to lower body heat (Yusoff *et al.* 2003).

21. *Globba propinqua.*

Local name: Mazolozo (Kadazan/Dusun).
Collection no: SAN 132379.
Locality: Kg. Payes, Kudat.
Habitat: Primary forest.
Uses: Rhizome and pith of young stem are used to cure excessive bleeding due to miscarriage/menstruation.

22. *Hedychium* sp. 1.

Local name: Sidbu (Kadazan/Dusun).
Collection no: SAN 135623.
Locality: Kg. Timbou, Tambunan.
Habitat: Primary forest.
Uses: Rhizome is used to stop bleeding and promote healing.

23. *Hedychium* sp. 2.

Local name: Sidbu (Kadazan/Dusun).
Collection no: SAN 131568.
Locality: Sook.
Habitat: Primary forest.
Uses: Base of stem and rhizome are used as antidote for insect sting.

24. *Hornstedtia havilandii.*

Local name: Buah Taladan (Lundayeh), Tolidus (Kadazan/Dusun).
Collection no: SAN 140641.
Locality: Kg. Mendulong, Sipitang; Kg. Kirokot, Tambunan.
Habitat: Primary undisturbed forest.
Uses: Fruit edible.

25. *Hornstedtia* sp. 1.

Local name: Tolidus (Kadazan/Dusun).
Locality: Kg. Giring-Giring, Ranau.
Habitat: Edge of primary forest.
Uses: Fruit edible.

26. *Hornstedtia* sp. 2.

Local name: Baku Tabu (Lundayeh).
Collection no: SAN 140583.
Locality: Mesapol, Sipitang.
Habitat: Edge of secondary forest.
Uses: Rhizome used to treat cold.

27. *Kaempferia galangal.*

Local name: Cekur (Malay), Kusur (Orang Sungai).
Locality: Kg. Sukau, Kinabatangan.
Habitat: Cultivated land.
Uses: The whole plant is boiled and consumed as vegetable (tonic). Leaves are used for poultice and lotion, and also to treat stomachache. Root decoction as post-natal tonic (Yusoff *et al.* 2003).

28. *Plagiostachys albiflora.*

Local name: Wongking (Dusun).
Collection no: SAN 121504.
Locality: Kg. Nosorong, Ranau.
Habitat: Primary undisturbed forest.
Uses: Fruit edible.

29. *Plagiostachys* sp. 1.

Local name: Tubu Bachit (Lundayeh).
Collection no: SAN 140628.
Locality: Kg. Mendulong, Sipitang.
Habitat: Primary forest.
Uses: Fruit edible.

30. *Tamijia* sp. 1.

Local name: Sisibu (Kadazan/Dusun).
Collection no: SAN 138611.
Locality: Kg. Timpangoh, Penampang.
Habitat: Primary forest.
Uses: Rhizome is used to treat stomachache.

31. *Tamijia* sp. 2.

Local name: Kamlimigi Sarou (Paitan).
Collection no: SAN 137002.
Locality: Mangkawagu Forest Reserve, Tongod.
Habitat: Primary forest.
Uses: Rhizome is used as antidote for food poisoning.

32. *Zingiber officinale.*

Figure 13. *Zingiber officinale.*

Local name: Hayo/ Hazo (Kadazan/Dusun), Halia (Malay).

Locality: Kg. Kaingaran, Tambunan.

Habitat: Cultivated widely in Tambunan.

Uses: Rhizome mixed with a little alcohol is used to massage sprained muscles or for rheumatism. Also used to remove wind from body.

33. *Zingiber purpureum.*

Local name: Dangalai (Rumanau), Bonglai (Bisaya).
Collection no: SAN 138437.
Locality: Kg. Langkabung, Tongod.
Habitat: Cultivated.
Uses: Rhizome eaten as salad, tonic.

34. *Zingiber zerumbet.*

Local name: Limpuyang (Tidung), Lempoyang (Bisaya).
Collection no: SAN 142018.
Locality: Kg. Apas, Tawau.
Habitat: Cultivated.
Uses: Rhizome eaten as salad, tonic.

35. *Zingiber* sp. 1.

Local name: Tolidus (Kadazan/Dusun).
Collection no: SAN 132083.
Locality: Kg. Giring-Giring, Ranau.
Habitat: Edge of primary forest.
Uses: Young shoot is used to treat toothache.

36. *Zingiber* sp. 2.

Local name: Dangalai Taragang.
Collection no: FRCSE 178.
Locality: Kg. Napagang, Tongod.
Habitat: Primary forest.
Uses: Rhizome and leaves are used to treat diarrhoea and excessive vomiting.

CONCLUSION

In conclusion, this study shows that members of the ginger family Zingiberaceae were widely used by the native communities in Sabah. Zingiberaceae species are of major economic importance. There are still many species of wild gingers in the forests of Sabah that need attention and are waiting to be discovered and documented. It is essential to conserve Sabah's forests not only because they are home to many of the world's gingers, but also because this group of plants has huge potential to be developed into a variety of commercial products. The loss of species and genetic resources that results from extracting timber, agriculture and other developments means that many wild species of ginger will become extinct before ethnobotanists have the chance to record them.

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NOTES

Some notes on *Jatropha curcas* (a potential biodiesel tree for agroforestry plantations) at the nursery stage

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Jatropha is a genus of approximately 175 succulents, shrubs and trees (some are deciduous, e.g. *J. curcas* L.), from the family Euphorbiaceae. The genus is native to Africa, North America and the Caribbean, and was introduced as a valuable hedge plant to Asia and India by the Portuguese traders. *J. curcas*, also known as 'Jarak Pagar' or 'Tangan-Tangan' in Malay, is a drought-resistant perennial plant, which grows in tropical and sub-tropical regions. The plant is reported to have tremendous potential as a source of biodiesel, therefore offering an alternative to fossil-based fuel (Selvarajah-Jaffery 2006).

It is a small tree or shrub with smooth gray bark, which exudes a whitish coloured, watery, latex when cut. Normally, it grows between three and five metres in height, but can attain a height of up to eight or ten metres under favourable conditions. It can thrive on the poorest stony soils, including gravel, sand and saline soils. It can grow even in the crevices of rock, can survive in low rainfall conditions (200 mm) and in hot climatic conditions. This indicates that *J. curcas* can adapt to adverse conditions and can grow in all kinds of areas, including degraded forest and marginal land. *Jatropha* trees start to bear fruits in the second year and crop yields up to 40-50 years can be expected (Kaushik & Kumar 2006). The yield of *Jatropha* has been estimated at 1-2.5 kg seeds/tree/year from the third year after planting (Kaushik & Kumar 2006). In commercial cultivation, the plants are pruned regularly to increase the production of seeds and facilitate harvesting. *Jatropha* has the potential to be intercropped with timber species due to its growth characteristics.

In Sabah, *J. curcas*, or locally known as 'Sougi', is found in the interior areas, such as Ranau, Tambunan, Tenom and Kinabatangan (J.B. Sugau, pers. comm.). It is planted mainly for fencing by local people (Figures 1 & 2). Its leaves and seeds were traditionally used to treat a wide variety of medical ailments, from stomachache to sore eyes (Lele 2006).

Figure 1. *Jatropha curcas* bearing fruits. Bundu Tuhan, Ranau. (Photo: John Baptist Sugau)

Figure 2. *Jatropha curcas* planted for fencing. Bundu Tuhan, Ranau. (Photo: John Baptist Sugau)

Importance of *Jatropha curcas*

J. curcas is considered as a potential biodiesel tree for agroforestry plantations due to its seeds having a high content of inedible oil, up to 40% under optimal conditions. The oil is extracted by crushing the seeds and can be refined into high quality biodiesel (Lele 2006). For centuries, *Jatropha* oil has been used in lamps in homes, but there was no serious attempt to promote the plant as a source of oil for industrial fuel (Selvarajah-Jaffery 2006). *Jatropha* oil can also be used as a raw material for pharmaceutical and cosmetic industries, as well as in the manufacture of candles and soap (Sunder 2006).

Currently the Indian government runs dozens of vehicles on *Jatropha*-based biodiesel, and has identified more than 39 million hectares of land to grow *Jatropha* – hoping to replace 20% of diesel consumption in five years. The Indian government intends to start mixing 5% of *Jatropha* oil into diesel by 2007 (Selvarajah-Jaffery 2006).

Seed germination and pretreatment

The Sepilok Forest Research Centre recently received some *J. curcas* seeds provided by Mr Tay Soon Poh (Figure 3). Experiments were carried out to determine the germination of two batches of seeds by soaking one group overnight with tap water as a pretreatment and another group without pretreatment. The germination medium was a mixture of soil, sand and compost in the ratio of 7:3:2, respectively. Each batch of seeds was divided into 8 replicates. Four replicates were selected randomly for sampling. The replicates were monitored and the numbers of germinated seeds were recorded daily over a period of 4 weeks. The seeds started to germinate 4 days after sowing and lasted for 5 weeks (Figures 4 & 5), and pricking process started 2 weeks after germination (Figure 6). The overall germination percentage of *Jatropha* is shown in Table 1. The seeds from Sabah showed the highest germination percentage of 85%. The low germination percentage for seeds from Thailand might be due to the long storage period, which reduced seed viability.

Table 1. Germination percentage of *Jatropha curcas* seeds at the Forest Research Centre, Sepilok.

Source	Total seeds	Total germinated seeds	Germination (%)
Sabah	2048	1747	85
Thailand	6714	2278	33

Figure 3. Dry seeds of *Jatropha curcas*. (Photo: Kelvin K.N. Pang)

Figure 4. Seeds germinating after 4 days. (Photo: Kelvin K.N. Pang)

Figure 5. Sprouts of *Jatropha curcas*. (Photo: Kelvin K.N. Pang)

Figure 6. Seedlings ready for pricking 2 weeks after germination. (Photo: Kelvin K.N. Pang)

In contrast to the findings by Kaushik & Kumar (2006), it was observed that untreated seeds seemed to give a higher germination percentage as compared to pretreated seeds (Figure 7). However, analysis using t-test showed that there was no significant difference in terms of germination between soaked and unsoaked seeds for both sources as shown in Table 2. The optimal germination percentage started at the 7th day for seeds from Sabah and lasted for 3-4 weeks (Figure 7*a*). The optimal germination percentage for seeds from Thailand started at the 18th day and lasted for about 2 weeks (Figure 7*b*), but the optimal germination rate lasted for 2-3 weeks (Figure 8*b*). The germination period was longer compared to 10 days as reported by Lele (2006) for the Indian source. This indicates that different seed sources might have different germination periods.

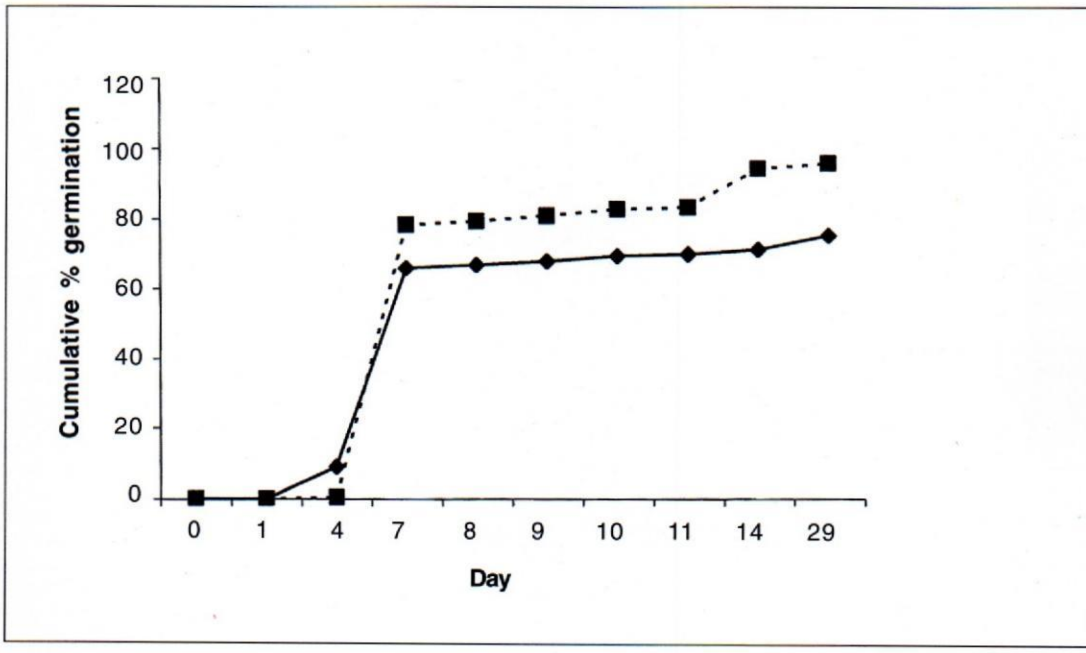
Table 2. Independent sample test for seeds from Sabah and Thailand.

Source	**t-test for equality of means**			
	Sig.	**t**	**Df**	**Sig. (2-tailed)**
Sabah	0.243	-0.427	18	0.675
Thailand	0.217	-1.422	10	0.185

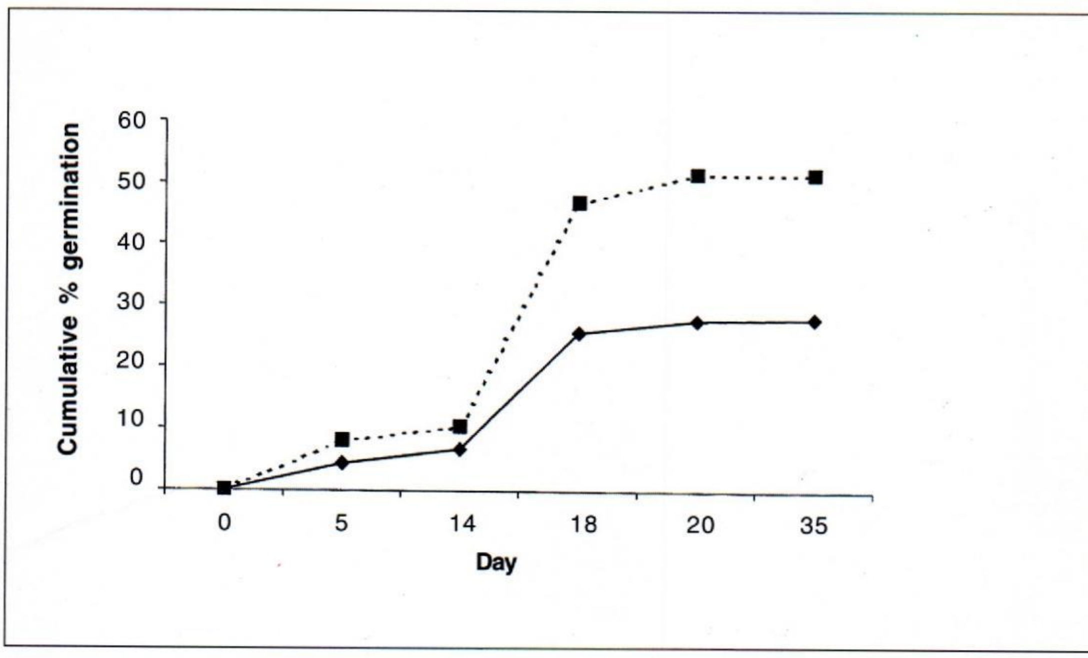
The highest daily germination rate was 12% at the 7th day for the *Jatropha* seeds from Sabah (Figure 8*a*). Analysis of variance shows that the pretreatment did not improve the germination rate of *Jatropha* seeds ($P > 0.095$). This indicates that *Jatropha* seeds are orthodox, and will normally germinate readily without pre-treatment. However, t-test analysis indicates that *Jatropha* seeds from Sabah had higher germination rate as compared to seeds from Thailand ($P < 0.002$). The germination trend for seeds from Thailand was fluctuating (Figure 8*b*). This trend might be due to the genetic background of seed sources that were collected from different germplasm lines.

Insect Pest

Some young *J. curcas* seedlings of about 3-4 weeks old were attacked by a leaf miner at the Sepilok Forest Research Centre's nursery in November 2006 and February 2007. The tiny yellowish light-green larva, measuring 5-6 mm, fed on the greenish leaf tissues, leaving the whitish paper-thin epidermal layer which eventually turned yellowish brown and withered (Figure 9). The larva, as well as the pupa was covered with a layer of almost translucent and firm silky web (Figure 10). The life cycle was short, within a week and the adult emerged about 2 days after pupation.

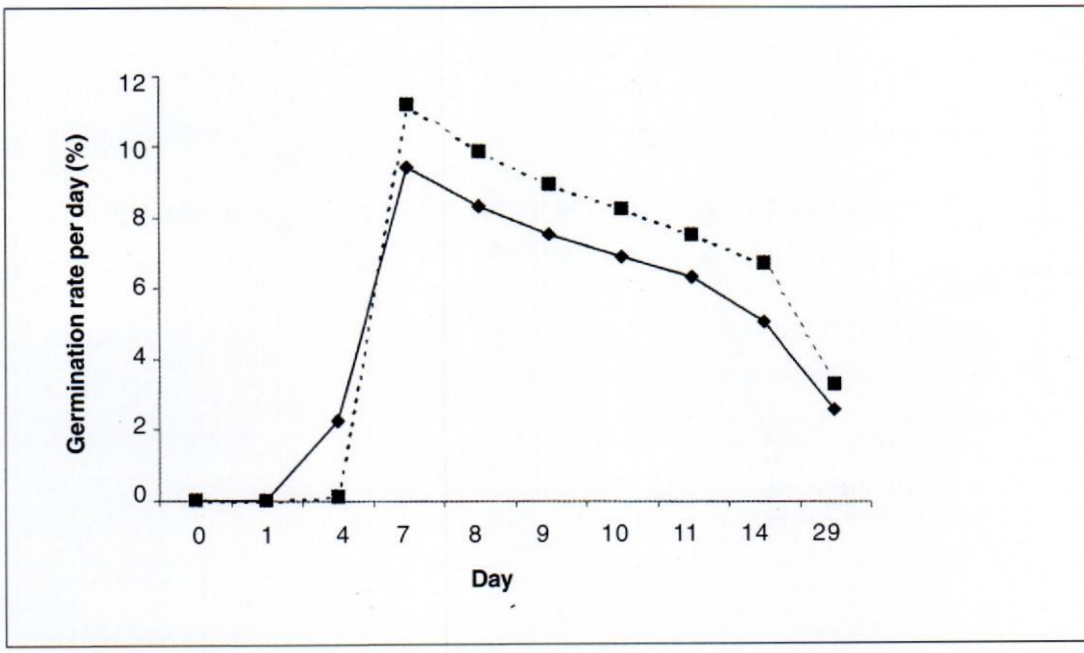


(*a*) Seeds from Sabah

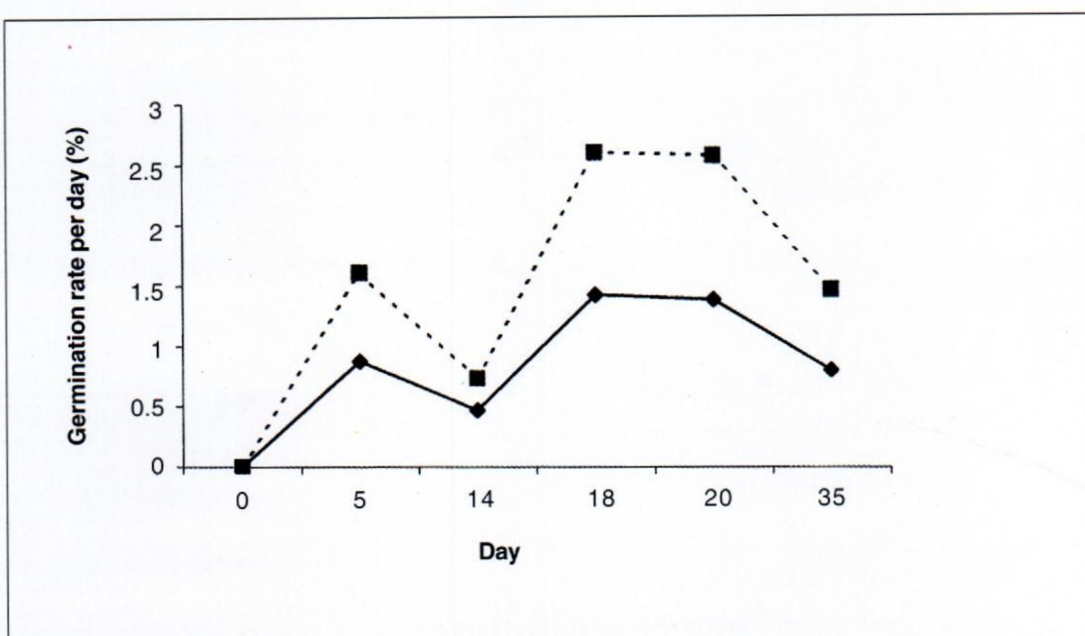


(*b*) Seeds from Thailand

Figure 7. Cumulative percentage germination of *Jatropha curcas* seeds from two different sources. Broken line = Control, Solid line = Treated.



(*a*) Seeds from Sabah



(*b*) Seeds from Thailand

Figure 8. Daily germination rates of *Jatropha curcas* seeds from two different sources. Broken line = Control, Solid line = Treated.

Based on Robinson *et al.* (1994) and Shanker & Dhyani (2006), the leaf miner was identified as *Stomphastis* sp. (Lepidoptera: Gracillariidae), and could be *S. thraustica*. Gracillariidae are micro-moths which fold their wings around their body and rest with their anterior elevated at an angle of about 45 degrees and the wing-tips almost touching the surface (Figure 11). This is the first record of *Stomphastis* attacking *J. curcas* in Sabah. *S. thraustica* was recorded earlier by Yunus & Ho (1980) in Robinson *et al.* (2001) feeding on *J. curcas* leaves in Peninsular Malaysia. This *Stomphastis* sp. has a wingspan of 7 mm and a body length of 4 mm. The moth appeared to be an eurythermal species since it could tolerate very low temperature (0°C) for more than 15 minutes (this was tested in the laboratory). Known also as the blister miner, *S. thraustica* has caused noticeable damage in India (Shanker & Dhyani 2006). Besides *Jatropha* leaves, *S. thraustica* feeds on *Sebastiania*, also from the family Euphorbiaceae. Another *Stomphastis* species that feeds on *Jatropha* leaves is *S. plectica* (Robinson *et al.* 2001).

Chemical spraying using cypermethrin (a synthetic pyrethroid insecticide) was effective in preventing the leaf miner from further damaging the leaves. It is a contact poison with fast knockdown effect. However, it should not be used indiscriminately or in high dosage as the pest may develop resistance towards it.

Figure 9. Damage on a leaf caused by the leaf miner. (Photo: Arthur Y.C. Chung)

Figure 10. Different larval and pupal stages. (Photo: Arthur Y.C. Chung)

Figure 11. A newly emerged *Stomphastis* moth. (Photo: Arthur Y.C. Chung)

ACKNOWLEDGEMENTS

Thanks are due to all the staff of Nursery Unit, Forest Research Centre, Sepilok for germinating the seeds. We thank John Baptist Sugau for providing some additional information.

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Sepilok Bulletin 7: 57-60 (2007)

A new record of defoliator on a medicinal herb (*Oxalis corniculata*)

V.K. Chey

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Oxalis corniculata Linnaeus (Oxalidaceae) is a cosmopolitan weed (Mabberley 1987), and those not in the know may treat it as a weedy pest. The Chinese, however, have long used it (known as 'Zha Jiang Cao' in Mandarin) as a medicinal herb for various ailments such as cold, fever, hepatitis, urinary tract infection, neurasthenia and hypertension (Cheung & Li 1981). It is a small herb distinguished by its compound leaves of three heart-shaped leaflets and its yellow flowers (Figure 1).

The herb is often found in gardens, and recently a caterpillar was spotted feeding voraciously on its leaves. The caterpillar was dark chocolate-brown in colour with lines of black and white spots running down the length of its body (Figure 2), and could reach 3 to 4 cm in length. It resembled the caterpillar of a moth *Spodoptera litura* Fabricius (Noctuidae: Amphipyrinae) illustrated in Holloway (1989).

The defoliating caterpillar soon entered pupation, and its pupa was light brown, turning darker towards emergence. The adult moth emerged 10 days later, and it was indeed *Spodoptera litura*. The forewing of the moth is brownish with a characteristic dark submarginal patch along its termen, while its hindwing is whitish (Figure 3).

The caterpillars of *Spodoptera litura* are known to be polyphagous defoliating a wide range of crops including oil palm. Barlow (1982) reported that the caterpillar stage lasts for about 23 days, meaning a good amount of damage can be done, and he further reported that outbreaks in oil palms do not generally develop into a second generation if untreated. So control measures may be unwarranted if their damage can be tolerated.

Robinson *et al.* (2001) compiled a long list of hostplants of numerous families for *Spodoptera litura* and its congeners, but no mention was made on Oxalidaceae. *Oxalis corniculata* is hence a new hostplant record for the caterpillar. Chey (2005) also recorded the caterpillar as a pest defoliator on Binuang (*Octomeles sumatrana*), a native tree which is gaining popularity in forest plantations.

The moth is very widely distributed in the Indo-Australian and Pacific tropics and subtropics (Holloway 1989).

ACKNOWLEDGEMENTS

The caterpillar was spotted by my wife Lee Yun Moi, and my colleagues in the Entomology Section of the Forest Research Centre (FRC) in Sepilok helped in the rearing of the caterpillar. Scientific name of the medicinal herb was provided by the FRC ethnobotanist Julius Kulip.

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Figure 1. *Oxalis corniculata*.

Figure 2. Caterpillar of *Spodoptera litura*.

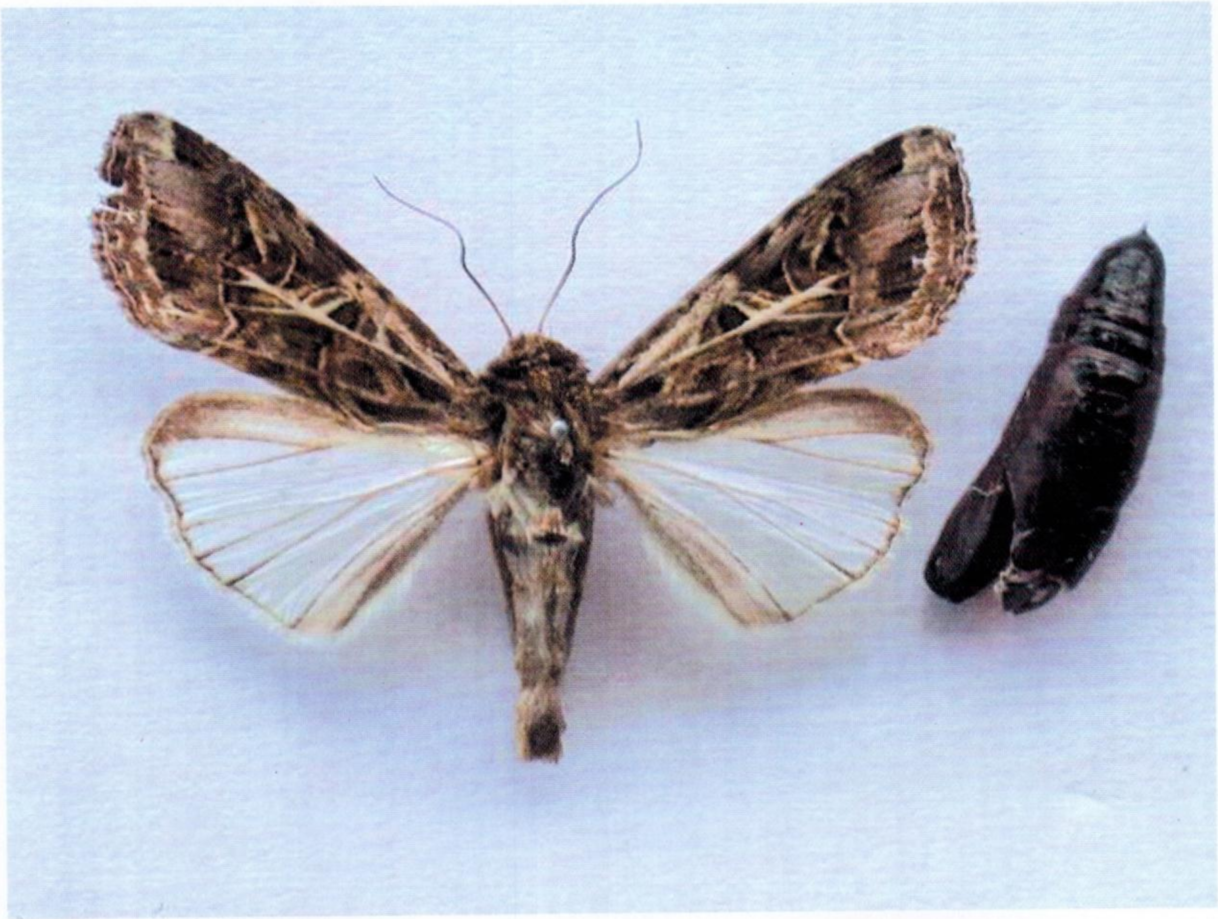
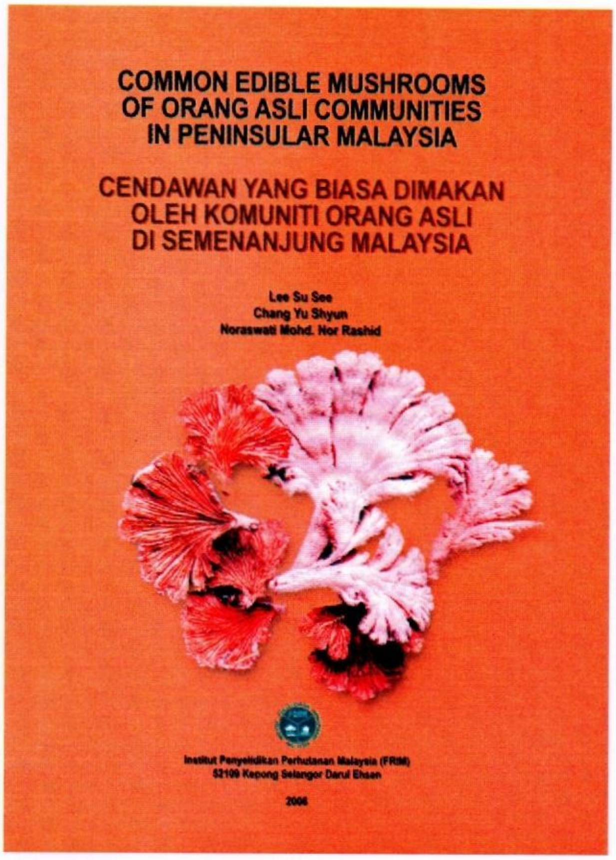


Figure 3. *Spodoptera litura* moth, with pupal case on the right. Wingspan 3 cm.

BOOK REVIEWS



Common edible mushrooms of Orang Asli communities in Peninsular Malaysia by Lee Su See, Chang Yu Shyun, Noraswati Mohd Nor Rashid. Published by Forest Research Institute Malaysia, Kepong, 2006. Pp. 16. ISBN 983-2181-72-0.

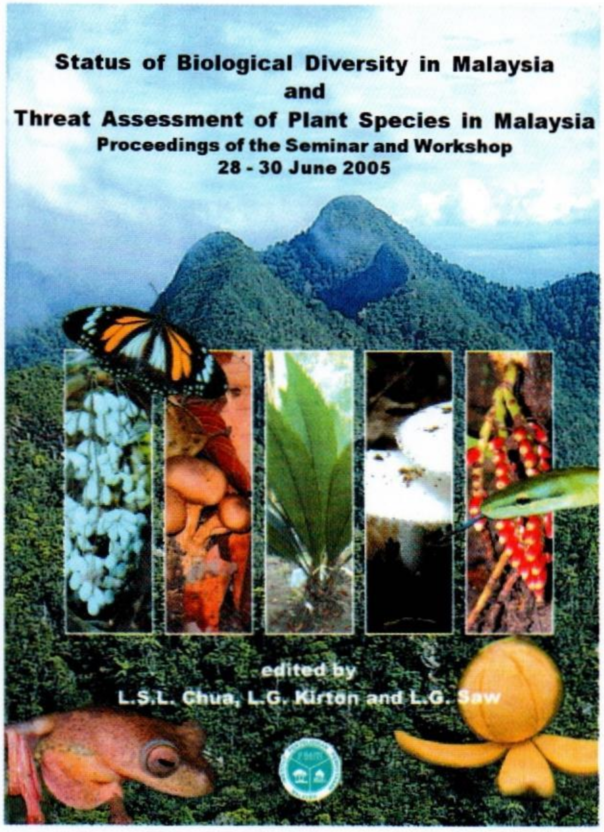
Reviewed by V.K. Chey

As the authors point out in their Introduction, the public in general is quite ignorant about wild mushrooms. This traditional forest related knowledge (TFRK) is passed down from one generation of the Orang Asli to the next by word of mouth and is seldom documented.

To address this problem, the authors conducted a survey of mushroom utilization by the Orang Asli communities in Peninsular Malaysia, namely the Semai, Temuan, Bateq, Che Wong and Jakun. The outcome is this booklet, which contains the twelve most commonly consumed mushrooms of the selected local communities.

Each of the mushrooms is illustrated in full colour, with its scientific name as well as the various vernacular names used by the different local communities surveyed. This is very helpful in the identification of edible mushrooms, to avoid confusion with those poisonous ones. The authors also include interesting notes on the taste of the mushrooms as well as ways to cook them. Reference is also made to other countries where the mushrooms are also consumed. So the booklet will also appeal to gourmets and those who enjoy cooking.

Dr Lee Su See and colleagues have done an important job in compiling this booklet. Interest on wild mushrooms among the younger generation of Orang Asli is on the wane and such information if undocumented could be lost. Furthermore the booklet is bilingual in both English and Malay, and not many scientific publications are available in Malay. My only complaint is that it is a booklet and a bit too short. Perhaps the next step would be to document all the edible mushrooms together with their known medicinal properties.



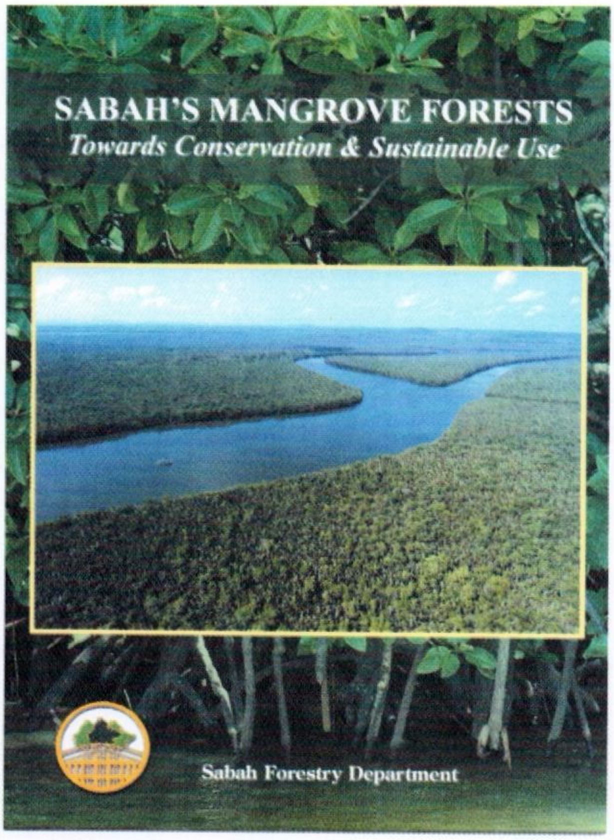
Status of biological diversity in Malaysia and threat assessment of plant species in Malaysia. Proceedings of the seminar and workshop. 28-30 June 2005. Edited by L.S.L. Chua, L.G. Kirton & L.G. Saw. Published by Forest Research Institute Malaysia, Kepong, 2007. Pp. 290. ISBN 978-983-2181-88-0.

Reviewed by M. Ajik

This publication presents status of Malaysia's biodiversity research and conservation until 2005, and it marks a significant addition to the country's National Policy on Biological Diversity formulated in 1998. The proceedings, originating from a national forum held at Kepong in June 2005, contain the most recent revisions and additions to the checklists of the vertebrates, invertebrates, fungi and plants in Malaysia. Some findings on threat assessment and conservation status of plant species in Malaysia are also included in the proceedings.

All papers are grouped based on the four main disciplines: vertebrates, invertebrates, fungi and plants. There are two contributions (pages 29 and 243) which provide only abstracts and not full papers. It is a huge disappointment to readers who specifically seek detailed information on the topics addressed. I also noticed that at least three pages are with poor printing quality. The font size used is way too small, hence readers may have problems reading the book.

The publication is seen as a key catalyst for scientists and forestry officers to work together closely in the monitoring, protection and conservation of the nation's rich biodiversity. No doubt that the proceedings mark another milestone in improving the conservation of the unique and diverse flora and fauna of Malaysia. Despite the shortcomings of the publication, using it one can access the currently available information on the rich biodiversity of Malaysia.



Sabah's mangrove forests: towards conservation & sustainable use. Compiled & edited by Robert C. Ong & George H. Petol. Published by Sabah Forestry Department, Sandakan, 2007. Pp. 38. ISBN 983-9554-20-5.

Reviewed by M. Ajik

The mangrove forests cover about 340,000 hectares of Sabah's land mass, accounting for more than half of the country's total. More than 90% of the original mangrove forests are still intact. Although the mangrove ecosystems are seen by many as unproductive and inhospitable, the benefits they bring to society are immense.

The importance in the protection, conservation and management of mangroves has been triggered by the catastrophic Indian Ocean tsunami that took over 200,000 lives in December 2004. A total allocation of RM8 million was approved by the Federal Government for various mangrove-related projects in Sabah under the 9th Malaysia Plan (2006-2010). This shows the Forestry Department's total commitment to manage and conserve mangrove forests in a proper and sustainable manner.

This publication covers the early and current silvicultural management of mangrove forests in Sabah, their function in fisheries and aquaculture, their huge potential in tourism and recreational activities, and also their conservation, restoration and wise use. The main purpose of this publication is to stimulate greater interest and awareness of the importance of mangroves.

With beautiful pictures of the mangrove forests to savour and the useful information given, I personally find the publication very informative and enjoyable to read. This publication definitely appeals to the general public. I noticed a typo on page 7 where the sentence ends with a comma instead of a period.

Overall, this publication serves to remind us of the importance of healthy mangrove ecosystems and the need for their proper management.

GUIDE TO CONTRIBUTORS

Sepilok Bulletin is a biannual peer-reviewed journal published by the Forest Research Centre of the Sabah Forestry Department. The Bulletin publishes manuscripts addressing subjects related to tropical forestry, in Borneo and elsewhere. Manuscripts may be in the form of original research papers, short communications, review articles, monographs, book reviews, and announcements.

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For abbreviations, standard chemical symbols may be used in the text, e.g. IBA, NaOH, and for scientific names, the generic name may be abbreviated to the initial, but the full term should be given at time of first mention. Measurements should preferably be in SI units with the appropriate symbols.

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Vol. 7 December 2007

CONTENTS

A first look at the biodiversity of praying mantids (Insecta: Mantodea) in Sabah, Borneo	M.E. Helmkampf, C.J. Schwarz & J. Beck	1
Parastheneboea imponens (Brunner, 1907) of Kinabalu Park	B.M. Noramly, B.L. Maklarin & J. Lapidin	15
Gingers in Sabah and their traditional uses	J. Kulip	23
NOTES		
Some notes on *Jatropha curcas* (a potential biodiesel tree for agroforestry plantations) at the nursery stage	F.R. Chia, K.K.N. Pang & A.Y.C. Chung	45
A new record of defoliator on a medicinal herb (*Oxalis corniculata*)	V.K. Chey	57
BOOK REVIEWS		61

Front cover: *Jatropha curcas* seeds, a source of biodiesel (Photo: Kelvin K.N. Pang)