SEPILOK BULLETIN

VOLUMES 25 & 26 . JUNE 2017 . ISSN 1823-0067

SABAH FORESTRY DEPARTMENT

SEPILOK BULLETIN

A journal of tropical forestry and related subjects.

Published by the Forest Research Centre, Sabah Forestry Department, Sandakan, Sabah, Malaysia.

SEPILOK BULLETIN
Vols. 25 & 26 June 2017

CONTENTS

Front cover: A hyper-endemic species, *Nepenthes macrophylla*, in Mount Trus Madi. (Photo: Alviana Damit)

Sepilok Bulletin 25 & 26: 1-11 (2017)

Population structure and dispersion pattern of *Nepenthes* along the Kaingaran Trail of Mount Trus Madi, Sabah, Borneo

A. Damit[1*], R. Nilus[1] & M. Suleiman[2]

[1]*Forest Research Centre, Sabah Forestry Department, P.O. Box 1407, 90715 Sandakan, Sabah, Malaysia*
[2]*Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah, 88400 Kota Kinabalu, Sabah, Malaysia*
**Author for correspondence. Email: Alviana.Damit@sabah.gov.my*

Abstract. Ten 0.01 ha plots were set up along the Kaingaran trail of Mount Trus Madi to determine the species abundance, population dispersion pattern and population structure of *Nepenthes* in Mount Trus Madi. A total of 631 pitcher plants of three species, *Nepenthes tentaculata*, *N. macrophylla*, *N. lowii* and one natural hybrid *N.* x *trusmadiensis*, were enumerated from all the plots. *Nepenthes tentaculata* is the most abundant species with a total of 479 individuals (76%), followed by *N. lowii* with 76 individuals (12%), *N. macrophylla* with 68 individuals (11%) and *N.* x *trusmadiensis* with eight individuals (1%). *Nepenthes macrophylla*, *N. lowii* and *N.* x *trusmadiensis* have a narrow altitudinal distribution range and are confined to the upper montane forests and summit scrub zone of the mountain. The population dispersion patterns of all the *Nepenthes* species from this study are significantly aggregated. For all *Nepenthes* communities, the population structure exhibits higher number of mature individuals than the number of seedlings and juveniles.

Keywords: Borneo, Mount Trus Madi, *Nepenthes*, pitcher plant, population

INTRODUCTION

Nepenthes is a genus of tropical pitcher plants, belonging to the monotypic family Nepenthaceae. These carnivorous plants produce pitchers from their modified leaves to trap and digest prey as their nutrient source. At present, there are about 160 species of *Nepenthes* worldwide. Of these, 39 species are found in Borneo and 22 species are found in Sabah. Six out of the 22 species are endemic to Sabah, with four endemic to Mount Kinabalu (*N. burbidgeae*, *N. edwardsiana*, *N. rajah*, *N. villosa*), one endemic to Mount Trus Madi (*N. macrophylla*) and one obligate ultramafic species (*N. macrovulgaris*) (Lamb *et al.* 2007).

Mount Trus Madi is the second highest mountain in Malaysia with a height of 2642 m above sea level. It is located in the Tambunan District of Sabah, in northern Borneo. The mountain is located within the protected area of Nuluhon Trusmadi Forest Reserve (74,736 hectare), a Class 1 Protection Forest managed by the Sabah Forestry Department (Sabah Forestry Department, 2013). The mountain is covered by three types of vegetation; lower montane forest, upper montane forest and summit scrub. The montane forest on Mount Trus Madi is very similar to Mount Kinabalu in species composition and appearance (Kitayama *et al.* 1993).

Nepenthes macrophylla and its natural hybrid, *Nepenthes* x *trusmadiensis* (*N. macrophylla* x *N. lowii*) are both hyperendemic species confined to the montane vegetation of Mount Trus Madi (Kulip & Butler 2011). Both species are considered critically endangered due to their single known locality and small area of distribution. In a study of the potential impact of climate change on the distribution of *Nepenthes* and Dipterocarps of the Trus Madi Forest Reserve, *N. macrophylla* was predicted to be the most severely affected species, with its preferred climate envelope predicted to disappear from Trus Madi by the year 2050 (Maycock *et al.* 2011). *Nepenthes* x *trusmadiensis* used to be quite common on the mountain but the population may have declined due to tourist activities (Clarke 2001). A preliminary survey on the population of *Nepenthes* x *trusmadiensis* concluded that the northern area of the mountain summit had a higher density population than the southern part (Kulip 2011).

The objectives of this study were to (1) identify the species composition and abundance of *Nepenthes*; and (2) determine the population dispersion pattern and population structure of each of the *Nepenthes* species recorded along Kaingaran trail to Mount Trus Madi summit. The results of this study provide an insight into the status of the *Nepenthes* communities on Mount Trus Madi and have implications to their conservation.

MATERIALS & METHODS

The research design was based on the methodology used in the demographic study of *Nepenthes* at Mount Kinabalu by Adam (2002). A total of 10 plots, each measuring 10 m × 10 m (0.01 ha), were established in August 2016, along the Kaingaran Trail of Mount Trus Madi (Table 1). Plot sites were chosen subjectively along the trail based on occurrence and diversity of *Nepenthes*, as well as site safety and accessibility. It covered a total distance of 4.9 km and an elevation range between 1638 m and 2642 m from the Kitingan starting point to the highest peak.

Each plot was divided into 25 subplots measuring 2 m × 2 m, to determine the spatial distribution pattern of individuals in the population that is also known as population dispersion pattern. The dispersion patterns were determined by calculating the Morisita's Index of Dispersion (I_d) and the departure of an observed dispersion pattern from randomness was assessed statistically using Chi-square test (χ^2) (Brower & Zar 1977). All individual plants of *Nepenthes* species in each plot were identified, mapped, tagged, measured and recorded in the field.

The life stage of each plant was categorized into three classes (seedlings, juveniles and mature plants) based on their stem lengths to analyze the population structure. The small *Nepenthes* species was classified into seedlings with stem lengths < 10 cm, juveniles 10 – 20 cm and mature > 20 cm, while large *Nepenthes* species were divided into seedlings with stem lengths < 20 cm, juveniles 20 – 60 cm and mature > 60 cm. Mature fertile male and female plants were also recorded by observing their inflorescences.

Regeneration status of species was determined by comparing the population size of seedlings, juveniles and mature individuals. The status was good regeneration if seedlings and juvenile are more than mature individuals (seedling > juvenile > mature individuals); fair regeneration if mature individuals are more than the seedling and juvenile (seedling > or ≤ juvenile ≤ mature individuals); poor regeneration if the species have no seedling (juvenile may be ≤ or ≥ mature individuals); not regenerating if there are only mature individuals present without seedling and juvenile (Dhaulkhandi *et al.* 2008).

RESULTS & DISCUSSION

A total of 631 pitcher plants representing three species and one natural hybrid were enumerated from all the ten 0.01 ha plots. These species were *Nepenthes tentaculata*, *N. macrophylla*, *N. lowii* and natural hybrid *N.* x *trusmadiensis* (Plate 1). Based on their stem length, *N. tentaculata* is considered as a small species, whereas *N. macrophylla*, *N. lowii* and *N.* x *trusmadiensis* are considered as large *Nepenthes* species. The most common species was *N. tentaculata* with a total of 479 individuals (76% of total enumerated individuals), followed by *N. lowii* with 76 individuals (12%), *N. macrophylla* with 68 individuals (11%) and *N.* x *trusmadiensis* with eight individuals (1%) (Table 1). *Nepenthes tentaculata* was present in 9 of the 10 plots sampled. This is in agreement with the previous observation that the natural distribution of *N. tentaculata* is the most ubiquitous montane pitcher plant and occurs on most mountains in Borneo (Cheek & Jebb 2001).

Table 1. Number of *Nepenthes* enumerated from all plots.

Plot	Altitude (m)	Vegetation Zone*	*Nt*	*Nm*	*Nl*	*Nx*	Total
1	1686	LMF	17	0	0	0	**17**
2	1802	LMF	23	0	0	0	**23**
3	1932	LMF	30	0	0	0	**30**
4	2000	UMF	114	0	0	0	**114**
5	2077	UMF	194	0	0	0	**194**
6	2357	UMF	53	0	68	0	**121**
7	2421	UMF	7	0	0	8	**15**
8	2554	SS	1	30	8	0	**39**
9	2558	SS	40	4	0	0	**44**
10	2642	SS	0	34	0	0	**34**
Total (%)			**479 (76%)**	**68 (11%)**	**76 (12%)**	**8 (1%)**	**631**

*Kitayama *et al.* (1993)
LMF = lower montane forest, UMF = upper montane forest, SS = summit scrub.
Nt = N. tentaculata, Nm = N. macrophylla, Nl = N. lowii, Nx = N. x trusmadiensis.

Individuals of *N. macrophylla* were only present in the three highest elevation plots (above 2554 m) while *N. lowii* individuals were only present in Plot 6 and Plot 8 (elevation at 2357 m and 2554 m) respectively. Pitcher plants of the least abundant *N.* x *trusmadiensis* were only recorded in Plot 7 (near the old Gibon Cabin). All three species were absent in the five lowest elevation plots, which were below 2300 m elevation (Figure 1). This indicates that *N. macrophylla, N. lowii* and *N.* x *trusmadiensis* have a narrow altitudinal distribution range.

The highest abundance of pitcher plants was recorded in Plot 5 (n = 194) while the lowest was in Plot 1 (n = 17). The five lowest elevation plots (Plot 1 to Plot 5) had only one single species, *N. tentaculata*, and the abundance of this species corresponds to the increase in elevation (Table 1).

In addition, an individual of the epiphytic *Nepenthes fusca* was observed at the resthouse (nearest plot is Plot 5), but was not enumerated in this study as it was found outside the plots. Three more species, namely *N. stenophylla*, *N. chaniana* and *N. veitchii*, were also recorded on this mountain (Lamb *et al.*, Sugau *et al.* 2013 & Damit 2014) but not found in any of the study plots.

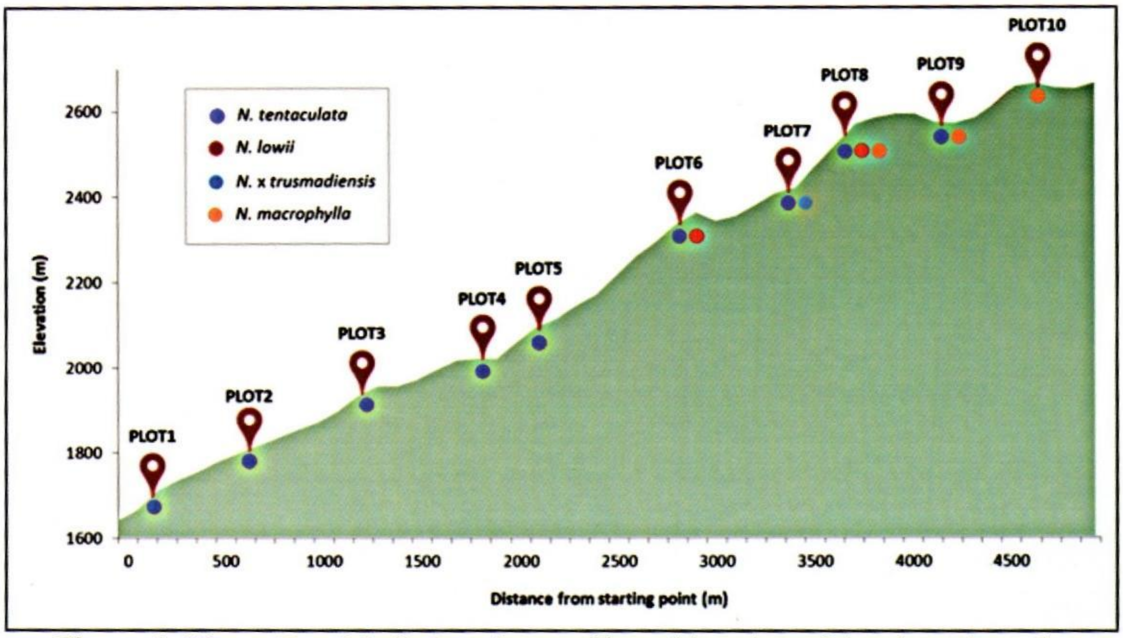


Figure 1. Mount Trus Madi elevation profile and location of the plots along the Kaingaran trail.

The numbers of *Nepenthes* for each species were summed up at 250 m altitudinal intervals along the trail to graphically show the relation of their estimated density to vegetation type, as illustrated in Figure 2. The graph shows that *N. tentaculata*, *N. lowii* and *N.* x *trusmadiensis* have their highest estimated density at the upper montane forest while *N. macrophylla* is most abundant at summit scrub. The only species that is present in the lower montane forest is *N. tentaculata*.

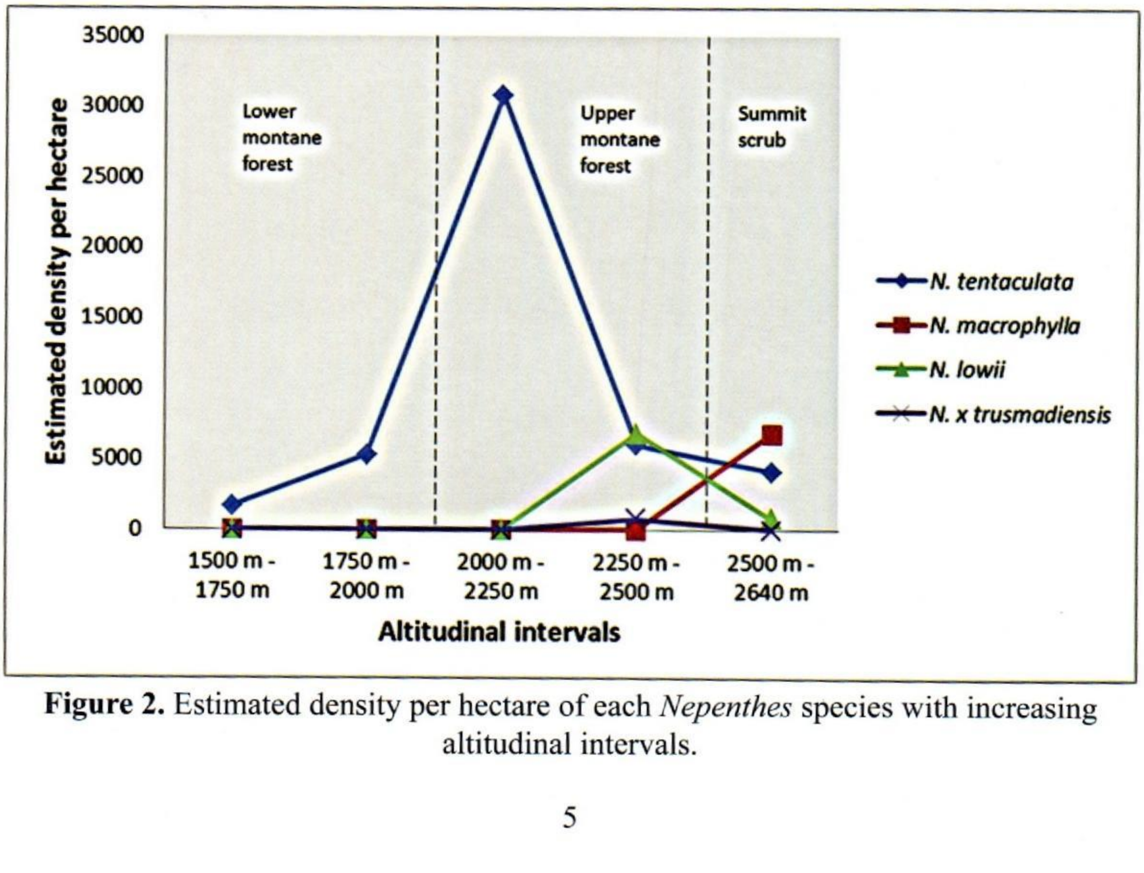


Figure 2. Estimated density per hectare of each *Nepenthes* species with increasing altitudinal intervals.

Population Dispersion Pattern

Table 2 summarizes the results of the dispersion pattern of each Nepenthes species in all plots using Morisita's Index of Dispersion (I_d) and Chi-square test (χ^2). The values of Morisita's Index of Dispersion (I_d) were all greater than 1, indicating that the population dispersion patterns of these plants were significantly aggregated. This finding is further supported as the computed values of chi-square (χ^2) were greater than the critical value of chi-square ($\chi^2_{0.05,24}$) which is 36.415. Both I_d values for *N.* x *trusmadiensis* in Plot 7 and *N. lowii* in Plot 8 were calculated as 25.0 (= number of subplots), showing that the dispersion pattern is maximally aggregated and indicating that all of the individual plants enumerated occurred in one subplot or 4 m^2 in size. Thus, with relatively small area of occupancy, these pitcher plants could be highly vulnerable to habitat disturbance. The dispersion pattern of *N. tentaculata* in Plot 8 was not calculated because of the small number of individuals in the plot.

Table 2. The Morisita's Index of Dispersion (I_d) and Chi-square test (χ^2) of all *Nepenthes* from all plots.

Plot	**Species**	I_d	χ^2
1	*N. tentaculata*	11.4	190.35
2	*N. tentaculata*	9.78	217.22
3	*N. tentaculata*	3.10	85.00
4	*N. tentaculata*	2.60	204.86
5	*N. tentaculata*	1.71	161.93
6	*N. tentaculata*	4.15	188.04
	N. lowii	2.14	100.38
7	*N. tentaculata*	4.76	46.57
	N. x *trusmadiensis*	25.0	192.00
8	*N. tentaculata*	-	-
	N. macrophylla	1.89	50.00
	N. lowii	25.0	192.00
9	*N. tentaculata*	5.96	217.50
	N. macrophylla	12.5	58.50
10	*N. macrophylla*	1.51	41.00

Identifying the dispersion pattern is important since the degree of aggregation of each plant species may have a greater impact on the population (Brower & Zar 1977). Aggregated dispersion also known as grouped, clumped, contagious or sub-dispersion, occurs when individuals tend to survive best in particular favorable patches. In this case, factors that may influence the aggregated patterns of the *Nepenthes* species include growing habit of the plant, light intensity and moss cover. Many *Nepenthes* species tend to grow in clumps, live in the open, stunted forest with nutrient-poor acid soils, which are seasonally soggy. The absence of these plants in certain areas can be attributed to the much drier soil and heavily shaded vegetation condition (Phillipps *et al.* 2008). In this study, it is suggested that the smaller-sized individuals of *N. tentaculata* could occupy a wider range of forest gaps and become more common than the larger-sized *Nepenthes* individuals that are restricted to only large gaps.

Population Structure

Population structure of all *Nepenthes* species in all plots, in terms of proportions of seedlings, juveniles and mature individuals, varied greatly (Table 3). Of all the *Nepenthes* plants enumerated from the plots, 46% were matured sterile plants, 26% seedlings, 22% juveniles, 5% matured male and 1% matured female plants. The overall percentages and most of the species showed fair regeneration with the number of mature individuals higher than the number of seedling and juvenile (seedling > juvenile < mature individuals). The low count of seedlings and juveniles could have been due to many reasons, such as habitat disturbance caused by visitors (trampled or collected) or climatic factors (prolonged drought or climate change related attributes). These factors operating singly or in combination may have influenced the flowering pattern, seed germination or successful growth of seedling to juvenile stage. Moreover, young individuals of any species are more vulnerable to any kind of environmental stress and anthropogenic disturbance.

Table 3. Population structure of all *Nepenthes* from all plots.

Plot	Species	No. of seedlings	No. of juveniles	Mature sterile	Mature male	Mature female	Total
1	*N. tentaculata*	5	5	7	0	0	17
2	*N. tentaculata*	6	11	6	0	0	23
3	*N. tentaculata*	11	9	10	0	0	30
4	*N. tentaculata*	38	26	49	1	0	114
5	*N. tentaculata*	39	48	107	0	0	194
6	*N. tentaculata*	19	13	21	0	0	53
	N. lowii	20	4	14	29	1	68
7	*N. tentaculata*	2	1	4	0	0	7
	N. x *trusmadiensis*	1	1	6	0	0	8
8	*N. tentaculata*	0	0	1	0	0	1
	N. macrophylla	8	8	12	2	0	30
	N. lowii	1	1	4	2	0	8
9	*N. tentaculata*	8	6	26	0	0	40
	N. macrophylla	0	1	3	0	0	4
10	*N. macrophylla*	7	3	20	0	4	34
Total		**165 (26%)**	**137 (22%)**	**290 (46%)**	**34 (5%)**	**5 (1%)**	**631**

Nepenthes is a dioecious plant in which male and female reproductive structures are in separate individual plants. Table 3 summarizes the number of plants that produced inflorescence during the observation. In Plot 6, *N. lowii* consists of more male (29) than female plants (1). The higher number of male plants may be a reproductive strategy to ensure effective cross-pollination process of the species (Adam *et al.* 2011). For the *N. macrophylla* species, two male plants were recorded in Plot 8 while four female plants were recorded in Plot 10. Out of the 479 plants of *N. tentaculata*, only one individual produced a male flower in Plot 4.

CONCLUSIONS

Three species and one natural hybrid of *Nepenthes*, namely *Nepenthes tentaculat*a, *N. macrophylla*, *N. lowii* and natural hybrid *N.* x *trusmadiensis*, were recorded along the altitudinal gradient. *Nepenthes tentaculata* is the most common species along the Kaingaran trail. The three Bornean montane pitcher plants, *N. macrophylla*, *N. lowii* and natural hybrid *N.* x *trusmadiensis*, have a narrow altitudinal range from 2357 m to 2642 m, i.e. they are confined to the upper montane forests and summit scrub zone of the mountain. The population dispersion patterns of all *Nepenthes* species from this study were significantly aggregated. The overall population structure of the *Nepenthes* community shows higher total number of mature individuals in comparison to the number of seedling and juvenile plants (seedling > juvenile < mature individuals).

Considering the increase number of visitors to the Trus Madi mountain park, anthropogenic disturbance is expected to become a serious threat to *Nepenthes* communities at the study site. The growth, survival and reproductive potential of *Nepenthes* species may be jeopardized in the near future if the present threats continue or increase. Close monitoring of *Nepenthes* populations is important to identify any new threats or changes of conditions.

Although the present study has yielded some preliminary findings, the limitation of this study is acknowledged. Owing to the patchiness of these plants, dissected nature of the terrain and safety reason, only limited numbers of plots were able to be established in the study area. Therefore, this could have resulted in an inaccurate representation of the actual *Nepenthes* abundance along altitudinal gradient of Mount Trus Madi. Furthermore, there are other main ridges that may have different distributional pattern, population structure and abundance of *Nepenthes* plants.

ACKNOWLEDGEMENTS

We are grateful to the District Forestry Officer of Tambunan, Mr. Salleh Intang and his staff for permitting this fieldwork and providing logistic support. We also thank Mr. Jemson Jumian and Ms. Nur Adillah Mohd Yusof for their dedicated assistance in the fieldwork and data collection. The field guide and porter services provided by Mt. Trusmadi Travel & Tours Sdn. Bhd. are also appreciated.

REFERENCES

Adam, J.H. (2002). Demographic study of *Nepenthes* species (Nepenthaceae) recorded along the trail to the summit of Mount Kinabalu in Sabah, Malaysia. *Pakistan Journal of Biological Sciences* 5(4): 419-426.

Adam, J.H., Hamid, H.A., Juhari, M.A.A., Tarmizi, S.N.A. & Idris, W.M.R. (2011). Species composition and dispersion pattern of pitcher plants recorded from Rantau Abang in Marang District, Terengganu State of Malaysia. *International Journal of Botany* 7: 162-169.

Brower, J.E. & Zar, J.H. (1977). *Field and laboratory methods for general ecology*. Wm. C. Brown Co. Publishers, Dubuque, Iowa. 194 pp.

Cheek, M. & Jebb, M. (2001). Nepenthaceae. *Flora Malesiana* Vol. 15: 1-161.

Clarke, C. (2001). *A guide to the pitcher plants of Sabah*. Natural History Publications (Borneo), Kota Kinabalu. 44 pp.

Damit, A. (2014). A trip to Mount Trus Madi – the *Nepenthes* wonderland. *Carnivorous Plant Newsletter* 43(1): 19-22.

Dhaulkhandi, M., Dobhal, A., Bhatt, S. & Kumar, M. (2008). Community structure and regeneration potential of natural forest site in Gangotri, India. *Journal of Basic and Applied Sciences* 4(1): 49-52.

Kitayama, K., Kulip, J., Nais, J. & Biun, A. (1993). Vegetation survey on Mount Trus Madi, Borneo: A prospective new mountain park. *Mountain Research and Development* 13(1): 99-105.

Kulip, J. (2011). A preliminary survey on the present status of *Nepenthes* x *trusmadiensis* population and distribution in Mount Trus Madi (FMU10). (In) Rahim, S., Anuar, M. & Chey, V.K. (eds.), Conservation of biodiversity in Trus Madi Forest Reserve. Sabah Forestry Department, Sandakan. Pp. 115-122.

Kulip, J. & Butler, E.D. (2011). *Nepenthes* species along the trail to the summit of Mount Trus Madi, Tambunan. *Sepilok Bulletin* 13 & 14: 43-57.

Lamb, A., Phillipps, A. & Gunsalam, A. (2007). The distribution and conservation of *Nepenthes* species in Sabah, Malaysian Borneo. (In) Lee, C.C. & Clarke, C. (eds), *Proceedings of the 2007 Sarawak Nepenthes summit*. Kuching. Pp. 101-115.

Maycock, C.R., Majapun, R., Khoo, E., Pereira, J.T., Sugau, J.B. & Burslem, D. (2011). The potential impacts of climate change on the distribution of *Nepenthes* and Dipteropcarps of the Trus Madi Forest Reserve. (In) Rahim, S., Anuar, M. & Chey, V.K. (eds.), *Conservation of biodiversity in Trus Madi Forest Reserve*. Sabah Forestry Department, Sandakan. Pp. 95-104.

Phillipps, A., Lamb, A. & Lee, C.C. (2008). *Pitcher Plants of Borneo*. Natural History Publications (Borneo), Kota Kinabalu. 298 pp.

Sabah Forestry Department (2013). *Revised Conservation Area Management Plan (CAMP) for Forest Management Unit (FMU) 10*. Sabah Forestry Department.

Sugau, J.B., Andi Maryani, A.M., Pereira, J.T., Suzana, S., Damit, A. & Nur Adillah, M.Y. (2013). *Vegetation and plant diversity of Trusmadi Forest Reserve*. Sabah Forestry Department (unpublished report for the EIA of FMU 10).

Plate 1. The *Nepenthes* of Mount Trus Madi. **A.** *Nepenthes tentaculata*; **B.** *Nepenthes macrophylla*; **C.** *Nepenthes lowii*; **D.** *Nepenthes* x *trusmadiensis*. (All photos by Alviana Damit)

Sepilok Bulletin 25 & 26: 12-19 (2017)

Effects of two different treatments on phloem and xylem vessels in the infructescence stalks of nipa palm (*Nypa fruticans*)

A.M. Nadirah[1*], A. Berhaman[1], J. Josue[2] & J.K. Lajanga[2]

[1]*International Tropical Forestry Management Program, Faculty of Science and Natural Resources, Universiti Malaysia Sabah, Jalan UMS, 88400, Kota Kinabalu, Sabah, Malaysia*
[2]*Forest Research Centre, Sabah Forestry Department, P. O. Box 1407, 90715 Sandakan, Sabah, Malaysia*
**Author for correspondence. Email: nadira.am@gmail.com*

Abstract. Nipa palm (*Nypa fruticans*) produces sugar sap or nira from the infructescence stalk when the stalk is subjected to certain treatments. We investigated the number and total area of phloem and xylem vessels in the stalk treated with two different methods of tapping nira. The methods used are the traditional method of massaging the stalk (*massage treatment*) and the use of heated water (80-90°C) (*heat treatment*) poured directly onto the stalk. The results show that there is no significant difference in the number of xylem vessels among all three stalks (p-value = middle part = 0.097; outer part = 0.196). There is a significant difference in total xylem area in all three stalks (p-value=1.95×10^{-7} and 0.0196). The heat treatment has resulted in the largest area in both parts (1711.02 μm^2). There is no significant difference between phloem area in middle part (p-value = 0.556). However, there is a highly significant difference between the *massage treatment*, *heat treatment* and *control* in the outer part (p-value = 3.12×10^{-3}) with heat resulting in the largest area (120.05 μm^2). Theoretically, the stalk that possesses large area generates a higher flow of sap. In this case, it is the heated stalk. However, heat treatment did not result in more *nira* compared to traditional method of massaging the stalk. Therefore, this needs further investigation to explore the best heat method for *nira* tapping.

Keywords: *Nypa fruticans*, nipa palm, *nira*, sugar sap, infructescence, phloem, xylem vessels, Sabah

INTRODUCTION

Nipa (*Nypa fruticans* Wurmb.) is a common and widely distributed palm that can be found in the mangrove forests of Southeast Asia (Tsuji *et al.* 2011). Nipa palm has been used for generations by locals in Southeast Asia for various purposes, from roof thatching, cigarettes, vinegar, sugar, alcohol to traditional medicine (Päivöke 1996). Nipa sugar sap or '*nira*' is widely used as an ingredient in a variety of food and food products consumed by people living near the coastal areas of Malaysia. MARDI (*Malaysian Agricultural Research and Development Institute*) has been actively producing many varieties of food products from nira including pasteurized canned drinks and carbonated drinks, maple-like syrups, toffee and caramel, vinegar, jelly and many others (Samsiah *et al.* 2008).

According to Nadirah *et al.* (2016), six nipa palms can produce a total of 370.4 L (91 days) using traditional method. Five nipa palms produced 58.74 L (50.2 days) by using heated method. *Heat* treatment did not produce more *nira* even though the total area of both xylem vessels and phloem are larger than traditional method (*massage*). However, sugar concentration for heat treatment was slightly higher (19.5%) than traditional method (18.45%) (Nadirah *et al.* 2016).

From the results, *massage* and *heat* stalks for both Cube A and Cube B differed significantly in which *massage* stalk constantly had smaller total area compared to *heat* stalk. We know that there was no other disturbance on the stalk during the process of massaging. Thus the total area of xylem and phloem may not be affected. The massaging process could only facilitate the flow of sap (Päivöke 1985) although it is not known the effect of *massage* to the stalk and why this traditional method can produce nira. The plants used in this study may also not be of the similar age thus may affect our results. A limitation of this study is that the experiment has not been properly replicated. Therefore, the results are only tentative. It is recommended a statistically sound, adequately replicated study be carried out in future.

CONCLUSIONS

The different methods of tapping *nira* is an interesting topic for further investigation. The *heat* treatment, which has the largest cross sectional surface area of both phloem and xylem vessels theoretically should produce more *nira*. However, this was not the case since *nira* yield was lower in the *heat* treatment. According to previous work, traditional method still produces better yields than the *heat* method. There is a need for more comprehensive studies on the changes in mechanical and chemical properties of infructescence stalk besides anatomy. Bigger sample size is also needed for better analysis. The *heat* method needs more research on the best temperature and application method to the stalk. There are other treatment methods apart from heated water that can be explored. We may not need water after all. Development of economical and environmentally friendly technologies such as solar power heat generator would help greatly in this study.

ACKNOWLEDGEMENTS

We thank Dr. Lee Ying Fah of Forest Research Centre, Sabah Forestry Department for his advice and guidance. Forest Research Centre provided a small fund for this study. We are grateful to Labuk Bay Proboscis Monkey Sanctuary (LBPMS) for the permission to work in the site. We thank Mr. Ignatius Bernard and Mr. Abdullah Osman for their assistance in the laboratory. We thank Mr. Selamat Mail, Mr. Salamat Ali, Mr. Rizwan Malijau, Ms. Nurul Shabariah Abu Bakar and Mr. Janni for their help in the field.

REFERENCES

Altinok, M., Ozalp, M. & Korkut, S. (2010). The effects of heat treatment on some mechanical properties of laminated beech (*Fagus orientalis* L.) wood. *Wood Research* 55 (3): 131-142.

Berg, L.R. (2008). *Introductory Botany: Plants, People, and the Environment*. Thomson Brooks/ Cole. 649 pp.

Esteves, B.M. & Pereira, H.M. (2009). Wood modification by heat treatment: A review. *BioResources*. 4(1): 370-404.

Fassio, C., Heath, R., Arpaia M.L. & Castro, M. (2009). Sap flow in 'Hass' avocado trees on two clonal rootstock in relation to xylem anatomy. *Scientia Horticulturae* 120: 8-13.

Glasziou, K.T. & Gayler, K.R. (1972). Storage of sugars in stalks of sugar cane. *The Botanical Review* 38(4): 471-490.

Hacke, U.G. & Sperry, J.S. (2001). Functional and ecological xylem anatomy. *Urban & Fischer Verlag* 4(2): 97-115.

Jiang, W., Chang, S., Li, H., Oleskowics-Popiel, P. & Xu, J. (2015). Liquid hot water pretreatment on different parts of cotton stalk to facilitate ethanol production. *Bioresource Technology* 176: 175-180.

Mazela, B., Zakrzewski, R., Grzeszkowiak, W., Cofta, G. & Bartkowiak, M. (2004). Resistance of thermally modified wood to basidiomycetes. *Wood Technology* 7(1): 253-62.

Nadirah, A.M., Colin, R.M. & Berhaman, A. (2015). Sugar production and reproductive phenology of *Nypa fruticans* (Palmae) in Labuk Bay, Sabah. *Proceedings of Sabah's Ramsar Conference 2015*. Sabah Forestry Department. Pp. 79-93.

Nguyen, D.V., Rabemanolontsoa, H. & Saka, S. (2016). Sap from various palms as a renewable energy source for bioethanol production. *Chemical Industry and Chemical Engineering Quarterly* 1-39.

Päivöke, A.E.A. (1985). Tapping practices and sap yields of the nipa palm (*Nipa fruticans*) in Papua New Guinea. *Agriculture, Ecosystems and Environment* 13: 59-72.

Päivöke, A.E.A. (1996). *Nypa fruticans* Wurmb. http://www.proseanet.org. (Date accessed: 08-April-2014)

Rozainah, M.Z. & Aslezaeim, N. (2010). A demographic study of a mangrove palm, *Nypa fruticans*. *Scientific Research and Essays* 5(24): 3896-3902.

Sevanto, S., Holita, T. & Holbrook, N.M. (2011). Effects of the hydraulic coupling between xylem and phloem on diurnal phloem diameter variation. *Plant, Cell and Environment* 34: 690-703.

Samsiah, M.S. & Hasidah, N.S. (2008). Pembangunan hasil makanan berpotensi dari nipah. Paper presented at the Prosiding Seminar Pengurusan dan Pemuliharaan Hutan Nipah 2008, Hotel Vistana, Pulau Pinang.

Tamunaidu, P., Matsui, N., Okimori, Y. & Saka, S. (2013). Nipa (*Nypa fruticans*) sap as a potential feedstock for ethanol production. *Biomass and Bioenergy* 52: 96-102.

Tsuji, K., Ghazalli, M.N.F., Zulhairil, A., Nordin, M.S., Khaidizar, M.I., Dulloo, M.E. & Sebastian, L.S. (2011). Biological and ethnobotanical characteristics of Nipa Palm (*Nypa fructicans* Wurmb.): A Review. *Sains Malaysiana* 40(12): 1407-1412.

Tyree, M.T. (1983). Maple sap uptake, exudation and pressure changes correlated with freezing exotherms and thawing endotherms. *Plant Physiology* 73: 277-285.

Tyree, M.T. & Zimmermann, M.H. (1983). Xylem structure in different parts of the tree in xylem structure and the ascent of sap. *Springer Berlin Heidelberg*. 218.

van Die, J. & Tammes, P.M.L. (1975). Phloem exudation from monocotyledonous axes. (In) Zimmermann, M.H. & Milburn, J.A. (eds.), *Transport in Plants I: Phloem Transport*. Springer-Verlag, Berlin, Heidelberg & New York. Pp. 196-222.

Zhang, Y.M., Yu, Y.L. & Yu, W.J. (2013). Effect of thermal treatment on the physical and mechanical properties of Phyllostachys pubescen bamboo. *European Journal of Wood and Wood Products* 71: 61-67.

Distribution and species diversity of black flies (Diptera: Simuliidae) in selected rivers and streams in Ranau and Tambunan Districts, Sabah

E. Stephen[1*], M.L.T. Lardizabal[1], H. Takaoka[2] & A.H. Nur Ashiqin[1]

[1]Faculty of Science and Natural Resources, Universiti Malaysia Sabah, UMS Road, 88400 Kota Kinabalu, Sabah, Malaysia
[2]Institute of Biological Sciences, Faculty of Science, University Malaya, 50603 Kuala Lumpur, Malaysia
**Author for correspondence. Email: estherpenistephen@yahoo.com*

Abstract. This study focused on the species diversity of black flies in Ranau and Tambunan Districts, Sabah. There were 12 sampling stations located in the highland and lowland areas. Larvae and pupae were manually collected from substrates in the streams and rivers. A total of 12 data sets were collected over a period of six months, which started from October 2015 to March 2016. Data collection was conducted once every fortnight. Preliminary results from this study recorded 16 species of black flies. Among the 16 species recorded, *Simulium (Gomphostilbia) alienigenum* is a new record for Malaysia, and for Sabah as well. All the 16 species of black flies recorded in this study belong to three subgenus: *Simulium*, *Nevermania* and *Gomphostilbia*. The highest abundance recorded was from the subgenus *Simulium*. Diversity indices ranged from 0.04 to 1.69, thus indicating a substantial diversity of black flies at the 12 sampling stations.

Keywords: aquatic insect, Simuliidae, black fly distribution

INTRODUCTION

Black flies (Diptera; Simuliidae) have been extensively studied almost worldwide and are globally distributed (Crosskey 1990). This group of insects may serve as biological indicators for water quality, as they prefer clean water to breed. Black flies are aquatic insects from the order Diptera, family Simuliidae (Crosskey 1990). The immature stages of black flies are very important components in freshwater ecosystems, because they play an important role in the aquatic food chain. Black fly larvae and pupae feed on organic particles in fast flowing water ecosystems (Zhang *et al.* 1998). The environmental characterization in freshwater ecosystems may affect the distribution of species and community of the black flies (Kazanci 2006). Previous studies done in South Africa reported that certain species are categorized as disease vectors that can transmit Onchocerciasis (river blindness) disease (Crosskey 1990).

To date, there is a total of 2189 black fly species recorded worldwide (Adler & Crosskey 2015). In Malaysia, there are more than 69 species (Adler & Crosskey 2011, Takaoka *et al.*, 2011a & 2011b) of which 6 in Sarawak (Takaoka 2001) and more than 24 species recorded in Sabah. So far, diversity studies of black flies in Sabah have not been well documented yet.

This study is a research project which focuses on the distribution and species diversity of black flies (Diptera: Simuliidae) in Ranau and Tambunan Districts, Sabah. Previous studies suggest that altitude and velocity of river flow affect the distribution of black flies species (Gallardo-Mayenco & Toja 2002). The aim of this study is to determine the distribution and species diversity of black flies in Ranau and Tambunan Districts in Sabah.

MATERIALS & METHODS

Study Sites

Ranau District is situated about 100 km east of Kota Kinabalu city which covers a total area of 3,556 km^2, while Tambunan District is located about 80 km from Kota Kinabalu city and covers a total area of 1,347 km^2. A total of 12 sampling stations were chosen in both districts. The sampling stations were located in a range of altitude between 370 and 1427 meters above sea level (m.a.s.l.), as shown in Figure 1.

Figure 1. Location of the 12 sampling sites in Ranau and Tambunan Districts.

Black Fly Sampling

Sampling of black flies was conducted in four stages which consisted of larva and pupa sample collection, sorting of specimens, rearing of pupa and lastly species identification. The larvae and pupae were manually collected from substrates found in between rocks under the fast flowing water of selected streams and rivers. Sampling was done once every fortnight for a period of six months (October 2015 to March 2016). Live pupa samples collected from substrates found in river and streams were placed into a test tube and brought back to the laboratory for rearing. Adult black flies that emerged were preserved along with the pupa skin in an eppendorf tube containing 80% ethanol, for further species identification. Black fly larvae were preserved in Carnoy's solution. In this study, the habitat characteristics were recorded and summarized in Table 1, while the physiochemical parameters are described in Table 4 for each of the sampling stations.

Table 1. Habitat characterization of the 12 sampling sites in Ranau and Tambunan Districts.

Sites	Longitude	Latitude	Dominant Substrate	Canopy Cover	Riparian Vegetation	Land use
Nikgold	06^0 01' 25.3"	116^0 44' 38.6"	Leaves	Open	Shrubs	Agriculture
Libang	05^0 57' 26.9"	116^0 44' 38.6"	Leaves, Rock	Open	Shrubs	Residential
Poring	06^0 02' 43.0"	116^0 42' 12.8"	Roots	Open	Shrubs	Recreational
Lohan	06^0 01' 25.3"	116^0 44' 39.0"	Leaves	Open	Bamboo	Residential, Road
Ranau 1	05^0 54' 01.1"	116^0 37' 34.3"	Roots	Close	Fruit trees	Road, Fruit Orchard
Ranau 4	05^0 52' 19.0"	116^0 32' 44.8"	Leaves	Close	Fruit Trees	Road, Fruit Orchard
Sg. Kirokot	N05^{0}49'33.1"	E116^{0}29'39.5"	Leaves, litter	Open	Shrubs	Residential
Sg. Pegalan	N05^{0}42'47.1"	E116^{0}24'28.2"	Leaves	Open	Shrubs	Residential
Sg. Lumondou	N05^{0}42'54.7"	E116^{0}24"08.8"	Leaves	Open	Shrubs	Road, Paddy Field
Sg. Tambunan	N05^{0}41'42.6"	E116^{0}22'57.4"	Leaves	Open	Shrubs	Paddy field
Sg. Malunggung	N05^{0}37'35.2"	E116^{0}17'12.7"	Leaves, Roots	Open	Shrubs	Agriculture
Sg. Kinabaan	N05^{0}43'46.9"	E116^{0}23'27.5"	Leaves, litter	Open	Shrubs	Paddy Field

RESULTS & DISCUSSION

Distribution of Black Flies in Ranau & Tambunan Districts

A total of 16 black fly species from three subgenera, namely *Gomphostilbia*, *Nevermania* and *Simulium*, were recorded from the 12 sampling sites located in Ranau and Tambunan districts. Among the 16 species, *Simulium alienigenum* (Figure 5) and *Simulium nobile* (Figure 6) were only recorded at the Lohan site, both of which are located in lowland areas. *S. alienigenum* recorded in this study was the first specimen recorded in Malaysia, as the species was first reported from the Philippines (Takaoka 1983), while, *S. keningauense*, *S. sabahense*, *S.* sp. and *S. beludense* were widely distributed in almost all the sampling stations (Table 2).

Previous studies suggest that *S. keningauense* (Figure 3) and *S. sabahense* (Figure 4) are considered common species in Sabah, as both species can be found in various environmental conditions (Smart & Clifford 1968, Takaoka 2001). Both species are able to tolerate various water temperatures ranging from 14°C to 24°C, and can be found in both highland and lowland areas (Takaoka 2008).

In this study, *S. aureohirtum* recorded was classified as a complex species by Thajarern *et al.* (2014) because this species is geographically widespread and inhabits diverse habitat characteristics although it prefers to inhabit in open area habitat with rocky bed streams. In this study, *S. aureohirtum* was sampled from streams that are located in open area near agricultural land and paddy field. Findings from this study agree with report in previous studies which reported that this species can tolerate polluted streams well (Ya'cob *et al.* 2016, Thaijarern *et al.* 2014).

The species *S. borneoense* from subgenus *Nervermania* was only recorded in Nikgold, which is a highland area located at the altitude of 1427 m.a.s.l, and average stream water temperature of 19°C. This is supported by a previous study by Takaoka (2001), who found that *S. borneoense* only inhabits upstream rivers which are up to 1400 m.a.s.l.

Table 2. Black fly distribution in 12 selected rivers and streams in Ranau and Tambunan Districts, Sabah.

Species	Nikgold	Libang	Poring	Lohan	Ranau 1	Ranau 4	Sg. Kirokot	Sg. Pegalan	Sg. Lumondou	Sg. Tambunan	Sg. Malunggung	Sg. Kinabaan
S. alienigenum				x								
S. sarawakenes			x			x						
S. sheilae		x	x		x				x	x		
S. parahiyangum							x			x		x
S. (nr) trangense			x		x							
S. rayohense			x		x							
S. aureohirtum	x									x		x
S. borneoense	x											
S. alberti			x		x							
S. beludense		x		x			x	x	x	x	x	x
S. keningauense		x	x	x	x	x	x	x	x	x	x	x
S. laterale					x	x						
S. nobile				x								
S. sabahense		x	x	x	x	x	x	x	x	x	x	x
S. sp.			x	x	x	x	x	x			x	x
S. alberti					x	x						

The Species Diversity of Black Flies

The Margalef species richness index value at most sites was less than 1, which indicates low species richness of black flies in both districts (Table 3). However, Ranau 1 has the highest species richness index value (*D.mg*) of 1.30, with a total of nine species recorded, being the highest among all sites. Ranau District had higher number of species than Tambunan District due to the habitat preferences by the black flies. Moreover most of the study sites in Ranau were near to fruit orchards, which likely have an effect on the number and type of substrate for the black flies adult to lay their eggs. The species diversity index *H'*, ranged between 0.04 and 1.69, which also indicates a low diversity of black flies in all sites where the number of recorded species ranged between 2 to 9 species in a site. The highest species diversity was in Ranau 1 (*H'*= 1.69) while the lowest was in Sg. Lumondou (*H'*= 0.04). The lowest species diversity record in Sg. Lumondou was likely due to flash floods which occurred during the sampling months. During the flash flood, substrates were washed away along with the black flies pupae, leaving very little specimens available for collection during sampling. The evenness index value *E*, scored near to the value '1', which indicates an even distribution of black flies communities in the 12 sampling sites in Ranau and Tambunan Districts (Table 3).

Table 3. Diversity Indices for 12 selected rivers and streams in Ranau and Tambunan Districts of Sabah.

Sites	N	Margalef (D_{mg})	Shannon Weiner (H')	Evenness (E)
Nikgold	426	0.17	0.41	0.75
Libang	240	0.53	0.41	0.38
Poring	435	1.15	1.57	0.61
Lohan	180	0.96	1.15	0.52
Ranau 1	472	1.3	1.69	0.6
Ranau 4	560	0.79	1.01	0.46
Sg. Kirokot	615	0.62	0.53	0.34
Sg. Pegalan	1780	0.4	0.33	0.35
Sg. Lumondou	2903	0.38	0.04	0.26
Sg. Tambunan	177	0.97	1.42	0.69
Sg. Malunggung	2697	0.38	1.06	0.72
Sg. Kinabaan	398	0.84	0.74	0.35

Black Fly Abundance Associated with Physiochemical Characteristics

The linear regression graphs shown in Figure 2, indicate that environmental parameters such as velocity (p value= 0.002, r^2 value= 0.425), Dissolved Oxygen (DO) (p value= 0.009, r^2 value= 0.068) and stream or river width (p value = 0.002, r^2 = 309) have a significant influence on the pupae abundance in all the sampling sites. According to Arimoro *et al.* (2007), fluctuation in the number of black fly larvae to attach on the substrate is related to water velocity and total DO (%) because most Simuliid species prefer to inhabit in fast flowing water, higher DO (%) and well-aerated water (Basoren & Kazanci 2011, Kazanci & Ertunc 2010). Fast flowing water has a higher oxygen concentration. In relation to that, Doisy *et al.* (1986) reported that most species of black fly larvae require at least 78% saturation of DO and some species require from 92 to 98% of saturation. Most black flies pupae and larvae collections in this study were sampled from substrates in running water with average water current velocity of 0.46m/s and 87% saturation of DO (%). The linear regression results show that stream width also is correlated with the total pupa assemblages. Previous studies have reported that the wider the width of a stream is associated with the abundance of black fly pupae and larvae. It was reported by Zhang (1998) that wider streams or rivers had higher abundance of black flies pupae and larvae. This is because wider streams provide more substrates for the larvae and pupa to attach to (Ya'cob *et al.* 2016, Basoren & Kazanci 2011). In this study, the highest pupa abundance with a total of 2903 pupae, was recorded in Sg. Lumondou site, with the river width of 7.65 meters.

Table 4. Physiochemical parameters in 12 rivers and streams in Ranau and Tambunan districts, Sabah.

Sites	Total Pupa	Velocity (m/s)	pH	Temperature (°C)	Conductivity (µS/cm)	TDS (ppm)	DO%	Depth (m)	Width (m)
Nikgold	443	0.29±0.12	7.16±0.30	19.01±0.50	111.58±13.54	106.25±15.49	68.97±19.60	0.19±0.06	0.65±0.26
Libang	260	0.50±0.13	7.23±0.12	26.86±0.81	216.05±14.19	203.78±14.2	92.53±2.71	0.37±0.08	5.92±0.19
Poring	344	0.25±0.10	7.25±0.11	24.59±0.82	110.56±52.75	132.15±32.39	77.94±12.32	1.04±0.45	0.11±0.06
Lohan	132	0.35±0.07	7.18±0.19	27.68±0.89	244.78±19.02	232.23±13.00	93.85±2.45	5.5±1.38	0.62±0.29
Ranau 1	388	0.31±0.17	7.25±0.13	23.02±1.04	246.42±21.71	230.38±20.28	89.00±3.69	1.5±0.48	0.37±0.08
Ranau 4	361	0.41±0.08	7.23±0.11	21.30±0.22	170.41±55.78	189.63±23.6	91.98±2.12	1.72±0.32	0.4±0.09
Sg. Kirokot	615	0.66±0.24	7.17±0.43	21.77±0.81	77.07±14.30	72.54±13.31	89.67±4.03	0.41±0.25	6.33±0.78
Sg. Pegalan	1780	0.67±0.52	7.14±0.42	23.78±1.02	69.44±19.31	61.73±15.70	89.13±2.60	0.63±0.77	6.92±1.83
Sg. Lumondou	2903	0.65±0.30	6.96±1.11	26.28±1.95	82.15±11.71	75.67±10.34	92.69±2.07	0.45±0.26	7.65±2.15
Sg. Tambunan	164	0.39±0.15	7.25±0.24	26.06±1.47	143.44±10.18	134.26±9.59	87.30±3.32	0.15±0.5	1.33±0.52
Sg. Malunggung	2716	0.56±0.2	6.92±1.18	24.79±0.92	123.98±20.19	116.27±15.9	91.93±3.09	0.27±0.18	2.75±0.75
Sg. Kinabaan	398	0.50±0.16	6.86±1.21	25.91±1.34	104.87±8.63	98.42±8.13	89.97±1.552	0.22±0.11	3.42±0.51

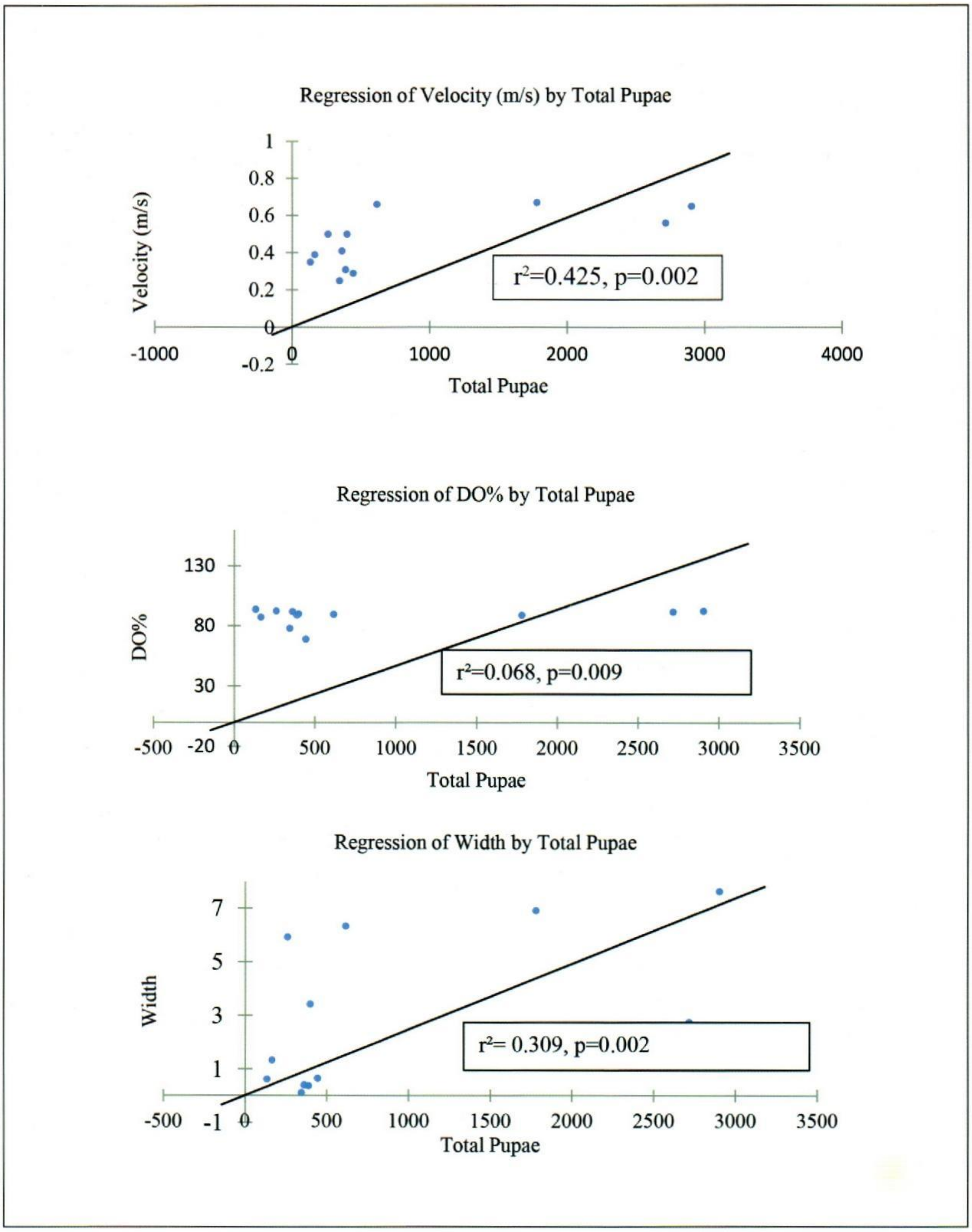


Figure 2. Relationship between total pupae with the physiochemical properties of the rivers and streams.

CONCLUSIONS

In this study, the biodiversity index score shows that species diversity of black flies in the 12 selected rivers and streams in Ranau & Tambunan is substantial, with 16 species of black flies recorded. The 16 species recorded represented 19% of the total black flies species in Malaysia (82 species) and 59% of the total black flies species recorded in Sabah (27 species). It is expected that more species will be discovered in Sabah, because there are many unexplored areas that could potentially be the habitat of black flies. In addition, by comparing the findings from this study with previous study that had been conducted in protected areas in Sabah, most of the species that were recorded in protected areas such as *S. crassimanum*, *S. kinabaluense* and *S. timpohonense* were not recorded in our study sites, in Ranau and Tambunan areas (Smart & Clifford 1969, Edwards 1993).

The results from this study also show that black flies species abundance has a significant relationship with the water quality parameter (velocity, width & DO) therefore making black flies suitable as biomonitoring agents for stream water quality.

ACKNOWLEDGEMENTS

First and foremost, we would like to express our gratitude to the management of Sabah Parks for allowing us to conduct this project within the Kinabalu Park and Crocker Range Park areas. Our sincere thanks to the Center of Research and Innovation, Universiti Malaysia Sabah for approving the research grant that funded this study through the SGPUMS research grant UMS/SBK 0107-STWN-2013 and also to the Ministry of Higher Education for providing the students MyBrain Scholarship. We also wish to express our sincere appreciation and gratitude to Prof. Dr. Hiroyuki Takaoka for helping in the species identification of the Simuliidae. Our sincere appreciation also goes to Prof. Dato' Dr. Mohd. Sofian Azirun and Dr. Chee Chen Dang from the Institute of Biological Sciences, Faculty of Science, University of Malaya for allowing us to attend the training for the Simuliidae species identification at University of Malaya. Last but not least, thank you to Mr. Justinus Guntabid and Mr. Fred Tuh (Kinabalu Parks Manager) and Mr. Yassin Miki (Crocker Range Park Manager) for facilitating this study for 12 months in the park area.

REFERENCES

Adler, P.H. & Crosskey, R.W. (2011). World blackflies (Diptera: Simuliidae): A comprehensive revision of the taxonomic and geographical inventory. *http://entweb.clemson. edu/biomia/pdfs/ blackflyinventory.pdf*.117 pp.

Adler, P.H. & Crosskey, R.W. (2015). World blackflies (Diptera: Simuliidae): A comprehensive revision of the taxonomic and geographical inventory. *http://entweb.clemson. edu/biomia/pdfs/ blackflyinventory.pdf*.123 pp.

Arimoro F.O., Ikomi, B.R. & Iwegbue, C.M.A. (2007). Water quality changes in relation to Diptera community patterns & diversity measured at organic effluent impacted stream in Niger Delta, Nigeria. *Elsevier* 7: 541-552.

Basoren, O.E. & Kazanci, V.N. (2011). The distributional data of Simuliidae (Insecta, Diptera) species in some streams of Yedigöller National Park (Bolu, Turkey). *Review of Hydrobiology* 4(2): 73-85.

Crosskey, R.W. (1990). The natural history of blackflies (Diptera: Simuliidae). *Journal of Natural History* 3 (8): 305-307 pp.

Doisy, K.E., Hall, R.D. & Fischer, F.J. (1986). The black flies (Diptera: Simuliidae) of an Ozark Stream in Southern Missouri and associated water quality measurement. *Journal of the Kansas Entomological Society* Vol. 59(1):133-142.

Edwards, F.W. (1993). Diptera Nematocera from Mount Kinabalu. *Journal of the Federated Malay States Museums* 17(2): 223-296.

Gallardo-Manyenco A. & Toja, J. (2002). Spatio-temporal distribution of simuliids (Diptera) and associated environmental factors in two mediterranean basins of Southern Spain. *International Revision Hydrobiology* 21(1-2): 47-57.

Kazanci, N. (2006). Ordination of Simuliidae and climate change impact. *Acta Entomologica Serbica Supplement* 69-76.

Kazancı, N. & Ertunç, Ö. (2010). Use of Simuliidae (Insecta: Diptera) species as indicators of aquatic habitat quality of Yeşilırmak River Basin (Turkey). *Revision Hydrobiology* 1: 27-36.

Smart, J. & Clifford, E.A. (1969). Simuliidae (Diptera) of Sabah (British North Borneo). *Zoological Journal of Linnean Society* 48: 9-47.

Takaoka, H. (1983). *The Blackflies (Diptera: Simuliidae) of the Philippines*. Japan Society for the Promotion of Science, Tokyo Japan. 199 pp.

Takaoka, H. (2001). Two new and three newly recorded species of black flies (Diptera: Simuliidae) from Sabah, Malaysia. *Japanese Journal of Tropical Medicine and Hygiene* 29(2): 221-230.

Takaoka, H. (2008). Taxonomic revision of tuberosum species-group of *Simulium* (Simulium) in Sabah and Sarawak, Malaysia (Diptera: Simulidae). *Japan Medical Entomology and Zoology* 59(2): 55-80.

Takaoka, H., Sofian-Azirun, M. & Hashim, R. (2011a). *Simulium (Gomphostilbia) sofiani*, a new species of black fly (Diptera: Simuliidae) from Peninsular Malaysia. *Tropical Biomedicine* 28: 389-399.

Takaoka, H., Sofian-Azirun, M., Hashim, R. & Ya'cob, Z. (2011b). Two new species of *Simulium* (*Gomphostilbia*) (Diptera: Simuliidae) from Peninsular Malaysia, with keys to Peninsular Malaysian members of the *Simulium ceylonicum* species-group. ZooKeys 118: 53-74.

Thaijarern, J., Sopaladawan, P. N., Wongpakam, K. & Pramual, P. (2014). Phylogeography of the black fly *Simulium aureohirtum* (Diptera: Simuliidae) in Thailand. *NRC Research Press*. 57: 411-417.

Ya'cob, Z., Takaoka, H., Pramual, P., Low, V.L. & Sofian-Azirun, M. (2016). Distribution pattern of black fly (Diptera: Simuliidae) assemblages along an altitudinal gradient in Peninsular Malaysia. *Parasites & Vectors* 9(219): 1-16.

Zhang, Y., Malmqvist, B. & England, G. (1998). Ecological processes affecting structure of blackfly larvae in regulated and unregulated rivers: A regional study. *Journal of Applied Ecology* 35: 673-686.

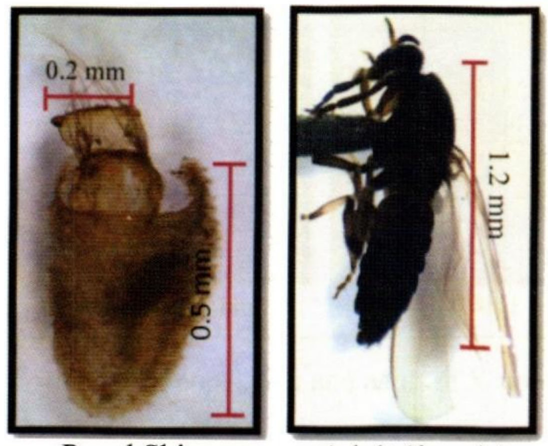


Figure 3. The pupal skin and adult of *S. keningauense.*

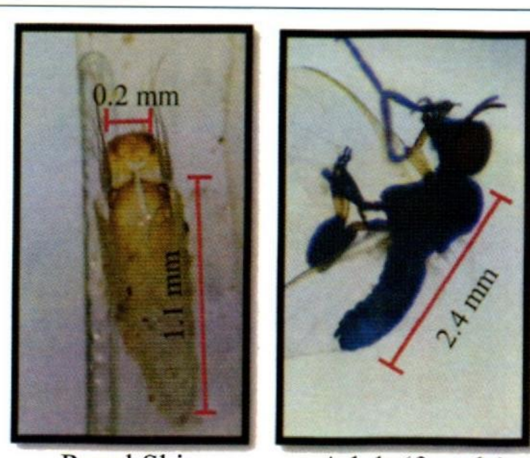


Figure 4. The pupal skin and adult of *S. sabahense.*

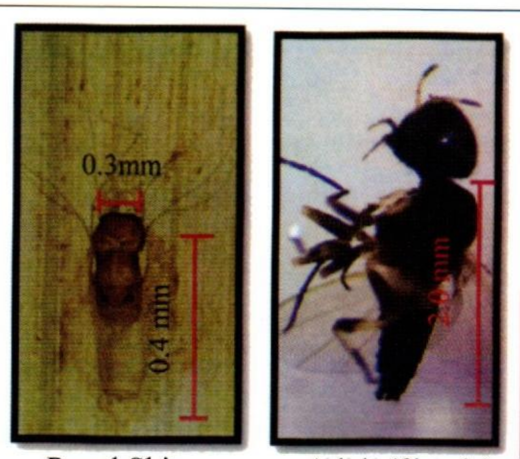


Figure 5. The pupal skin and adult of *S. alienigenum.*

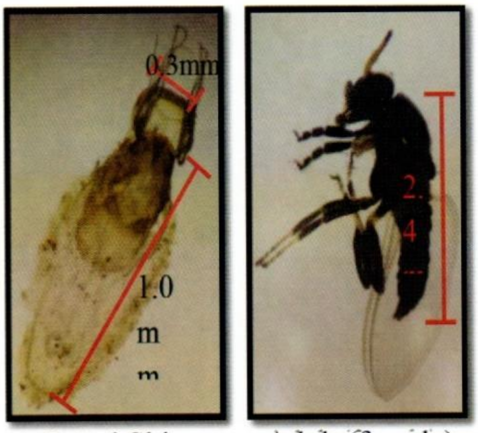


Figure 6. The pupal skin and adult of *S. nobile*.

Sepilok Bulletin 25 & 26: 33-35 (2017)

A new record of *Streblote helpsi* (Lepidoptera, Lasiocampidae) defoliating *Sonneratia caseolaris*

J. Tangah & A.Y.C. Chung*

Forest Research Centre, Sabah Forestry Department, P. O. Box 1407, 90715 Sandakan, Sabah, Malaysia
**Author for correspondence. Email: Arthur.Chung@sabah.gov.my*

Sonneratia caseolaris belongs to the family Sonneratiaceae. Known locally as 'Perepat Laut', it is a common mangrove tree in Sabah. This tree is widely distributed from Sri Lanka throughout Southeast Asia, to northern Australia, the Solomon Islands and the New Hebrides. It is mostly found in the less saline parts of the mangroves, near the banks of tidal rivers in brackish water, and along riverbanks where tidal influence is still present. The young fruits are edible, sour, and are used as a traditional medicine, especially for treatment of coughs (Nilus *et al.* 2010).

In February 2017, thousands hairy caterpillars were observed feeding on young and mature *Sonneratia caseolaris* trees on the mudflats of Sg. Weston, within the Weston Forest Reserve in the west coast of Sabah. Approximately 50 ha of this mangrove species along the river were affected by the defoliation. This area was identified for mangrove rehabilitation under a collaboration between the Sabah Forestry Department and the International Society for Mangrove Ecosystems (ISME) (Tangah *et al.* 2015).

Some of the trees were completely defoliated within a short time. The caterpillar is whitish brown in colour with darker brown patterns on the body. It can grow up to 80 mm in length. The mature caterpillar pupated and was encapsulated in a whitish silky cocoon which was attached to the branches or twigs of the hostplant. This defoliation phenomenon was detected by the staff of the Forest Research Centre, Sepilok while conducting field planting of mangrove propagules (*Rhizophora apiculata*) in the area. A few of these cocoons were brought back to the Forest Research Centre, and they were observed in captivity.

The emerged moth was identified as *Streblote helpsi* Holloway (Lepidoptera: Lasiocampidae). The male moth has narrow brown variegated forewings, with a body length of 3 cm and a wing span of 4.5 cm. The bulky female moth was larger than the male, with a body length of 4 cm and more rounded forewings, with a wing span of 6 cm. Details of this species are given by Holloway (1998). Interestingly, this moth species is endemic to Borneo.

Holloway (1998) recorded *Casuarina equisetifolia* as a hostplant for this moth. Chung (2011) documented this caterpillar attacking the African Mahogany, *Khaya senegalensis*, in Sandakan, Sabah. *Sonneratia caseolaris* is a new hostplant record for this pest as it has not been recorded previously, based on Robinson *et al*. (2001) and through internet search.

By end of March, i.e. a few weeks after the attack, the defoliated trees flushed on new leaves. Hence, control measure was not necessary. The natural control of the caterpillars by birds and parasitoids could have significantly reduced the population of the caterpillars.

ACKNOWLEDGEMENTS

We thank the staff of the Mangrove Unit, Forest Research Centre, Sepilok, namely Fabian Koret, Dauni Seligi and Jamiss Aribin. We are grateful to Fidelis Edwin Bajau, the Deputy Chief Conservator of Forests (Development) and the District Forestry Officer for Beaufort, George Angampun, for their support in this research work.

REFERENCES

Chung, A.Y.C. (2011). New records of insects associated with the African mahogany *Khaya senegalensis*. In Gan, K.S., Mahmudin, S. & Mohd. Nor, M.Y. (eds.) Proceedings of the International Symposium on Forestry & Forest Products – Addressing Global Concerns & Changing Societal Needs. Forest Research Institute Malaysia. Pp. 245-248.

Holloway, J.D. (1998). *The moths of Borneo (part 3): superfamily Bombycoidea: families Lasiocampidae, Eupterotidae, Bombycidae, Brahmaeidae, Saturniidae, Sphingidae*. Southdene Sdn. Bhd., Kuala Lumpur. 199 pp.

Nilus, R., Chung, A.Y.C., Pereira, J., Sugau, J., Tangah, J., Sabran, S. & Chong, R.F.Y. (2010). *Mangroves of Sabah – an introduction to the flora and fauna*. Sabah Forestry Department. 150 pp.

Robinson, G.S., Ackery, P.R., Kitching, I.J., Beccaloni, G.W. & Hernandez, L.M. (2001). *Hostplants of the moth and butterfly caterpillars of the Oriental Region*. The Natural History Museum, London & Southdene Sdn. Bhd., Kuala Lumpur. 744 pp.

Tangah, J., Bajau, F.E., Jilimin, W., Baba, S., Chan, H.T. & Kezuka, M. (2015). *Rehabilitation on mangroves in Sabah: the SFD-ISME collaboration (2011-2014)*. Sabah Forestry Department, ISME & Tokio Marine & Michido Fire Insurance Co., Ltd. 56 pp.

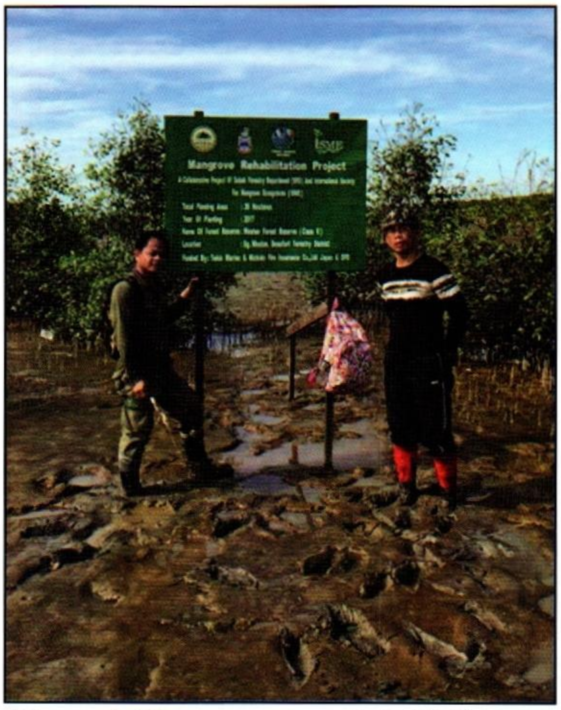


Figure 1. The mangrove rehabilitation area in Sg. Weston, Sabah.

Figure 2. Infestation of *Streblote helpsi*, showing some of the cocoons on the branches.

Figure 3. Caterpillars of *Streblote helpsi*.

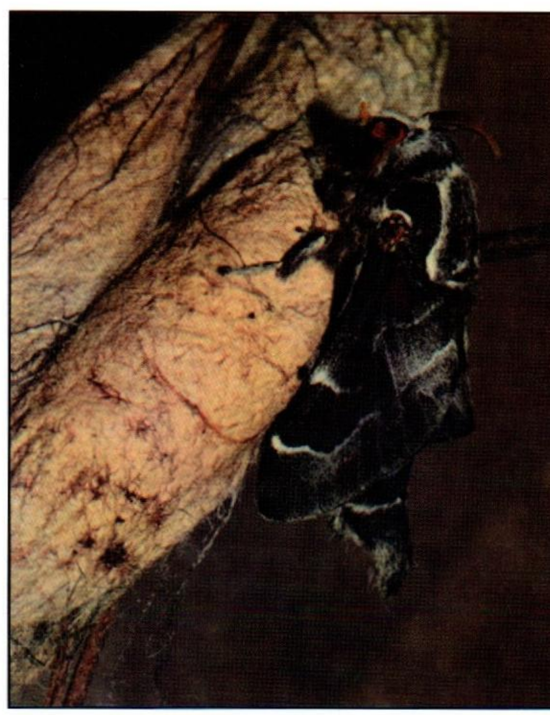


Figure 4. A newly emerged adult male moth of *Streblote helpsi* on the whitish silky cocoon.

Sepilok Bulletin 25 & 26: 36-41 (2017)

Vegetative propagation of selected species at the Forest Research Centre (FRC) Nursery, Sepilok

S.M. Chin[1*], K. Kimjus[2] & M. Ajik[2]

[1]*Faculty of Science and Natural Resources, Universiti Malaysia Sabah, UMS Road, 88400 Kota Kinabalu, Sabah, Malaysia*
[2]*Forest Research Centre, Sabah Forestry Department, P.O.Box 1407, 90715 Sandakan, Sabah, Malaysia*
**Author for correspondence. Email: su_mi9166@yahoo.com*

Vegetative propagation is a means to produce planting materials without the use of seed. Stem cutting, a most common asexual propagation technique, was used in this study. Four species i.e. *Hibiscus mutabilis* (Cotton Rose), *Alstonia angustiloba* (Pulai), *Terminalia copelandii* (Talisai Paya) and *Neolamarckia macrophylla* (Laran Merah) were selected for this study owing to their respective huge potential in timber industry, as well as medicinal plants.

Belonging to the Malvaceae family, *Hibiscus mutabilis* (Cotton Rose) is widely cultivated as ornamental plant because the most notable characteristic of this plant is that the flowers open pure white and change color over a three-day period until they are deep pink and then finally turning dark 'blue-pink' hue as they wilt. The species has medicinal properties particularly in its roots, leaves and flowers (Anonymous 2006). Apart from its highly prized soft and easily shaped timber, the tree of *Alstonia angustiloba* (Pulai) contains latex which can be extracted by tapping and is used by various local communities in native medicines, being commonly applied to sores and skin diseases (Browne 1955).

Terminalia copelandii (Talisai Paya) is one of the native species currently being studied in the 11th Malaysia Plan Project entitled "Establishment of Demonstration Plots for Potential Native Timber Species" while *Neolamarckia macrophylla* (Laran Merah), a newly introduced species to Sabah, is known to have more favourable wood properties compared to *Neolamarckia cadamba* (Chung *et al.* 2016) but its vegetative propagation potential has not yet been fully explored. Thus, the inclusion of these two species in this experiment is deemed suitable.

The main purpose of this study was to look at the rooting feasibility of the selected species. The experiment was also conducted as part of the main author's industrial training in the course she attended in Universiti Malaysia Sabah.

The methodology followed Schmidt (1993) where cuttings were cut slanted about 5 cm in length at the base with remaining leaf attached, if any, was trimmed to half of its size to minimize water loss through transpiration. Half of the cuttings of each species were treated with Spectra (a commercial rooting hormone) while the rest was left untreated and labelled as

Control. The cuttings then were set onto two different rooting media, i.e. sieved river sand and peat moss.

The study was conducted in a mist propagation unit at the Forest Research Centre from May to June 2016. The relative humidity and temperature in the propagation unit ranged from 62% to 92% and 25°C to 32°C respectively, giving a favourable environment for rooting development. The misting interval was set at 30 seconds of burst every 10 minutes. Observation on rooting was recorded weekly.

The results (Table 1) show that the *Hibiscus mutabilis* (Cotton Rose) could be easily rooted, with or without the use of rooting hormone, in both rooting media (Plates 1 & 2) with an overall rooting percentage of 86.5%. Similarly, *Neolamarckia macrophylla* (Laran Merah) appeared to root well too in both rooting media, with or without the application of the exogenous rooting hormone, with an overall rooting percentage of 76.3%. Laran Merah cuttings rooted well in the river sand media, with or without the application of rooting hormone, with rooting percentage of 85.0%. However, it was observed that there were relatively more roots produced on the cuttings (Plates 3 & 4) in the peat moss media compared to those in the river sand media (Chin 2016), an indication that the peat moss might be a better rooting media for Laran Merah.

Plate 1. Rooted cutting of *Hibisus mutabilis* (Cotton Rose) in peat moss with the application of Spectra at Week 1. (Photo: Chin Su Mi)

Plate 2. Rooted cutting of *Hibiscus mutabilis* (Cotton Rose) in river sand with the application of Spectra at Week 1. (Photo: Chin Su Mi)

Plate 3. Rooted cutting of *Neolamarckia macrophylla* (Laran Merah) in peat moss with the application of Spectra at Week 2. (Photo: Kuina Kimjus)

Plate 4. Rooted cutting of *Neolamarckia macrophylla* (Laran Merah) in river sand with the application of Spectra at Week 2. (Photo: Kuina Kimjus)

The initiation of first rooting was also observed as early as within 1 week for *Hibiscus mutabilis* (Cotton Rose) and *Neolamarckia macrophylla* (Laran Merah).

Alstonia angustiloba (Pulai) failed to root, repeating the findings by Ajik & Kimjus (2014). The only consolation was that one cutting did produce root, a noteworthy result indicating that this species could be vegetatively propagated but with much difficulties. *Terminalia copelandii* (Talisai Paya), on the other hand, showed a very low rooting success in both rooting media, either with or without rooting hormone application.

The findings show that it is feasible to root *Hibiscus mutabilis* (Cotton Rose) and *Neolamarckia macrophylla* (Laran Merah), with or without the use of exogenous rooting hormone, and in both rooting media of sieved river sand and peat moss. No conclusive recommendations could be made for *Terminalia copelandii* (Talisai Paya) and *Alstonia angustiloba* (Pulai) due to the high mortality of the cutting materials.

Table 1. Rooting ability of the four selected species in two different rooting media.

Species	Number of cuttings (N)	Treatment	Rooting medium	Observation of first rooting (week)	Rooting % (Number of rooted cuttings)
Hibiscus mutabilis (Cotton Rose)	13	Spectra	River Sand	1	85.0 (11)
Hibiscus mutabilis (Cotton Rose)	13	Control	River Sand	1	85.0 (11)
Hibiscus mutabilis (Cotton Rose)	13	Spectra	Peat Moss	1	100.0 (13)
Hibiscus mutabilis (Cotton Rose)	13	Control	Peat Mos s	1	77.0 (10)
				Overall rooting % = 86.5	
Alstonia angustiloba (Pulai)	13	Spectra	River Sand	8	0.1 (1)
Alstonia angustiloba (Pulai)	13	Control	River Sand	0	0.0
Alstonia angustiloba (Pulai)	13	Spectra	Peat Moss	0	0.0
Alstonia angustiloba (Pulai)	13	Control	Peat Moss	0	0.0
				Overall rooting % = 1.9	
Terminalia copelandii (Talisai Paya)	8	Spectra	River Sand	0	0.0
Terminalia copelandii (Talisai Paya)	8	Control	River Sand	4	12.5 (1)
Terminalia copelandii (Talisai Paya)	8	Spectra	Peat Moss	4	25.0 (2)
Terminalia copelandii (Talisai Paya)	8	Control	Peat Moss	4	25.0 (2)
				Overall rooting % = 15.6	
Neolamarckia macrophylla (Laran Merah)	20	Spectra	River Sand	1	85.0 (17)
Neolamarckia macrophylla (Laran Merah)	20	Control	River Sand	1	85.0 (17)
Neolamarckia macrophylla (Laran Merah)	20	Spectra	Peat Moss	1	65.0 (13)
Neolamarckia macrophylla (Laran Merah)	20	Control	Peat Moss	1	70.0 (14)
				Overall rooting % = 76.3	

ACKNOWLEDGEMENTS

We thank Alex Hastie and Jaffirin Lapongan of FRC for providing the stockplants of *Neolamarckia macrophylla* (Laran Merah) and *Hibiscus mutabilis* (Cotton Rose), respectively, and Joseph Kapis of FRC Nursery for helping in the vegetative propagation work.

REFERENCES

Ajik, M. & Kimjus, K. (2014). Vegetative propagation of some selected species in Kebun Cina (Sandakan Rainforest Park). *Sepilok Bulletin* 19 & 20: 97-103.

Anonymous. (2006). Herbalpedia. Rose, Cotton. The Herb Growing & Marketing Network. http://www.herbalpedia.com (date accessed February 14, 2017)

Browne, F.G. (1955). *Forest trees of Sarawak and Brunei and their products*. Government Printing Office, Kuching 63-65.

Chung, A.Y.C., Pereira, J.T., Hastie, A. Paul, V. & Johnlee, E.B. (2016). New records of insects associated with Red Laran (*Neolamarckia macrophylla*) in Sabah. *Sepilok Bulletin* 23 & 24: 1-13.

Schmidt, L. (1993). *Vegetative propagation: guidelines on grafting, air-layering and cuttings*. UNDP/FAO regional project on improved productivity of man-made forests through application of technological advances in tree breeding and propagation (RAS/91/004). Field Manual No. 5. 27 pp.

Chin, S.M. (2016). Industrial training report. Unpublished report submitted to Faculty of Science and Natural Resources, UMS. 62 pp.

Sepilok Bulletin 25 & 26: 42-50 (2017)

Growth performance of 19-year-old *Eucalyptus pellita* in Lungmanis Forest Reserve, Sabah

E.B. Johnlee*, K.K.N. Pang & M. Anuar

Forest Research Centre, Sabah Forestry Department, P.O. Box 1407, 90715 Sandakan, Sabah, Malaysia
** Author for correspondence. Email: ElneBetrece.Johnlee@sabah.gov.my*

Abstract. A *Eucalyptus pellita* Provenance Trial was established at Kolapis B Research Station, Lungmanis Forest Reserve in 1996. Assessment conducted at the 19-year old plot revealed that *Eucalyptus pellita* provenances from Tozers Gap, Queensland (SEP No. 17875) and Lankelly Creek, Queensland (SEP No. 17874) showed the highest survival rate of 58%. The best growth was exhibited by the provenance from South Bloomfield (8 km), Queensland, with a mean diameter at breast height (MDBH) of 30.35 cm (MAI dbh of 1.6 cm/year) and a mean height of 32 m (MAI of height of 1.68 m/year) at the age of 19 years. The other provenances which showed good diameter growth were South of Kiriwo West Province, Queensland (SEP 15254) with a MDBH of 28.8 cm and Tozers Gap, Queensland (SEP No. 17875) with a MDBH of 28.40 cm. The species is becoming an important plantation tree species in Sabah as an alternative species to *Acacia mangium* which is currently being adversely affected by the *Ceratocystis* disease.

Keywords: *Eucalyptus*, dbh, height, mean annual increment

INTRODUCTION

Eucalyptus pellita (family: Myrtaceae) also known as large-fruited red mahogany, is considered a good choice for commercial tree plantations because of its rapid growth under monocultural conditions. It can grow up to 40 m in height and approximately 1 m in diameter at breast height (Dombro 2010). The tree can grow on gentle to moderate slopes, and can also be found on steep, well-drained slopes of large ridges. It is best grown in tropical lowland regions with uniform rainfall (Orwa *et al.* 2009).

The wood is of decent quality (Dombro 2010), strong and durable, mainly used for heavy construction and heavy ornamental works (Orwa *et al.* 2009). *Eucalyptus pellita* is easily propagated compared to other eucalypts (Harwood 1998). It is recommended for planting on well-drained, sandy soils where a dense crown that shades out weed will form in the early stage (Orwa *et al.* 2009). Considering the increasing seriousness of the pathogenic *Ceratocystis* affecting *Acacia mangium* plantations, planters in Sabah, Malaysia, have started planting *E. pellita* on a large scale.

Eucalyptus pellita has been tested in many countries, including China, Brazil, India, South Africa, Thailand and the Philippines as well as in Australia since the 1980s (Doran & Turnbull 1997). It is an attractive species for plantation because of its special attributes, such as fast growth, good coppicing ability, adaptability to a wide range of environment, good resistance to pests and diseases and suitability for a variety of timber products.

This study presents an assessment of 19-year-old data from *E. pellita* planting trial established in eastern Sabah, Malaysia.

MATERIALS & METHODS

The study site is located at Kolapis B Research Station which forms part of the Lungmanis Forest Reserve, 65 km west of Sandakan town. The site is located on moderate hills with altitudes reaching 75 m and slopes are between 10 and 20 degrees. The types of soils are mainly Kretam and Lungmanis Associations, with small areas of Rumidi, Kalabakan and Lokan Associations.

The trial was established in May 1996 over an area of approximately 0.39 hectares. The planting distance was 4 m x 4 m with 4 replicates; in which each replicate consists of two blocks. The species planted was *Eucalyptus pellita* from fourteen different provenances (refer Table 1). The parameters measured include the total height, diameter at breast height (dbh) and survival rate.

Table 1. Provenances of *Eucalyptus pellita* at Kolapis B.

No.	SEP	Provenance	
1	18148	North West Ingham	Queensland
2	18149	South East Cardwell	Queensland
3	17875	Tozers Gap	Queensland
4	18199	Serisa Village West Province	Papua New Guinea
5	13826	Bloomfield/Daintree	Queensland
6	13165	Julatten	Queensland
7	18147	North Mossman	Queensland
8	14916	North of Kuranda	Queensland
9	17859	North West Kuranda	Queensland
10	18198	North East of Coen (13.4km)	Queensland
11	17874	Lankelly Creek	Queensland
12	18602	Orchard Melville	Queensland
13	18197	South of Kiriwo West Province	Papua New Guinea
14	15254	South Bloomfield (8km)	Queensland

RESULTS & DISCUSSION

Survival Rate

Figure 1 shows the survival rate for all fourteen provenances of *Eucalyptus pellita* planted in Kolapis B, Lungmanis Forest Reserve. The provenances from Tozers Gap, Queensland (SEP No. 17875) and Lankelly Creek, Queensland (SEP No. 17874) show the highest survival rate of 58%, followed by the provenance from Serisa Village West Province, Queensland with a survival rate of 54% at 19 years old. The other provenances show survival rate ranging from 21% to 46%.

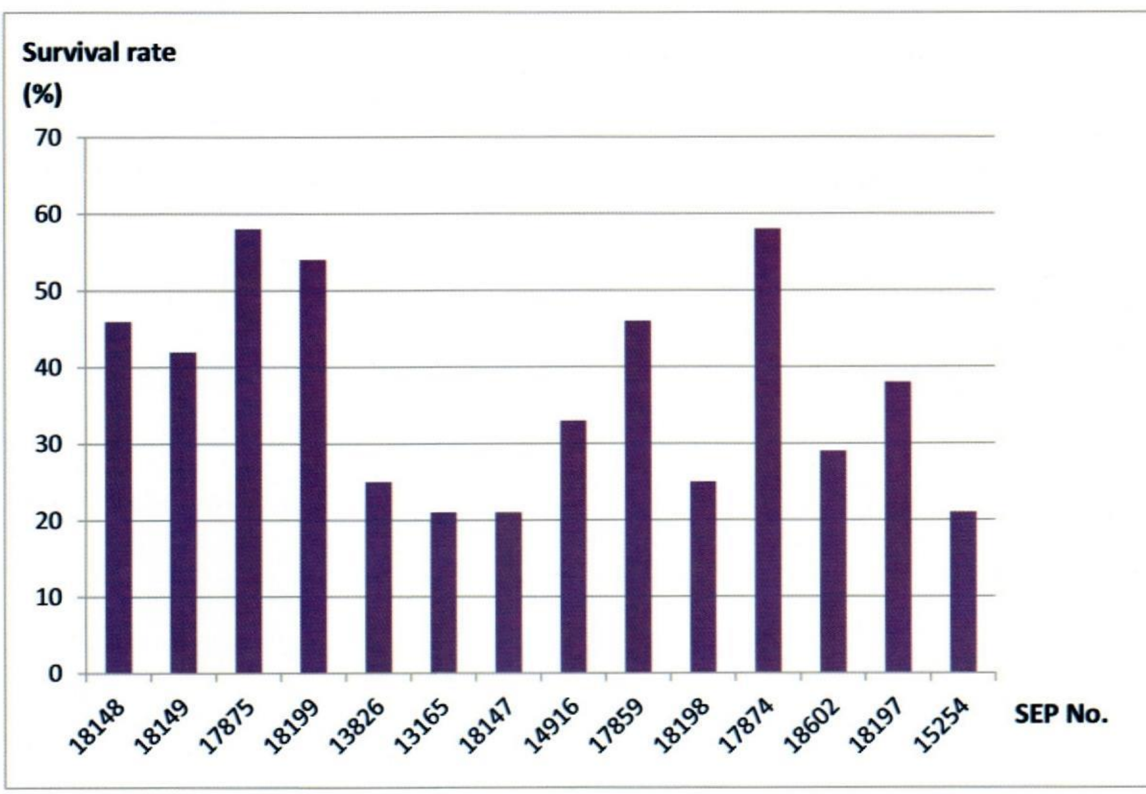


Figure 1. Survival rate of *Eucalyptus pellita* at 19 years old.

Mean Height and Mean Diameter at Breast Height

Table 2 shows the mean height and the mean diameter at breast height of all fourteen provenances in Kolapis B Research Station, Lungmanis Forest Reserve. The provenance from South Bloomfield (8km), Queensland (SEP No. 15254) shows the highest mean height at 32 m and the largest mean diameter at breast height at 30.35 cm. The second largest mean diameter was exhibited by South of Kiriwo West Province, Papua New Guinea (SEP No. 18197) followed by Tozers Gap, Queensland (SEP No. 17875).

In terms of mean height growth, the second best was exhibited by Tozers Gap, Queensland (SEP No. 17875) at 25.2 m, followed by North East of Coen, Queensland (SEP No. 18198).

Table 2. Mean height & mean DBH of *Eucalyptus pellita* at 19 years old in Kolapis B.

No.	SEP	Provenance		Mean Height (m)	Mean DBH (cm)
1	18148	North West Ingham	Queensland	19.57	22.00
2	18149	South East Cardwell	Queensland	19.25	22.30
3	17875	Tozers Gap	Queensland	25.20	28.40
4	18199	Serisa Village West Province	Papua New Guinea	23.73	25.93
5	13826	Bloomfield/Daintree	Queensland	10.60	26.23
6	13165	Julatten	Queensland	22.80	17.65
7	18147	North Mossman	Queensland	17.65	16.55
8	14916	North of Kuranda	Queensland	21.50	25.43
9	17859	North West Kuranda	Queensland	17.90	23.05
10	18198	North East of Coen (13.4km)	Queensland	25.00	19.16
11	17874	Lankelly Creek	Queensland	14.27	17.83
12	18602	Orchard Melville	Queensland	17.85	19.37
13	18197	South of Kiriwo West Province	Papua New Guinea	23.65	28.83
14	15254	South Bloomfield (8km)	Queensland	32.00	30.35

Mean Annual Increment of Height

Figure 2 shows the mean annual increment (MAI) of the total height (m) for all fourteen provenances of *Eucalyptus pellita* planted in Kolapis B, Lungmanis Forest Reserve. The provenance from South Bloomfield (8km), Queensland (SEP No. 15254) shows the highest MAI of total height with 1.68 m/year, followed by Tozers Gap, Queensland (SEP No. 17875) with an MAI of total height with 1.33 m/year and North East of Coen (13.4km), Queensland (SEP No. 18198) with an MAI of total height of 1.32 m/year. The other provenances show MAI of the total height ranging from 0.56 m/ year to 1.25 m/year.

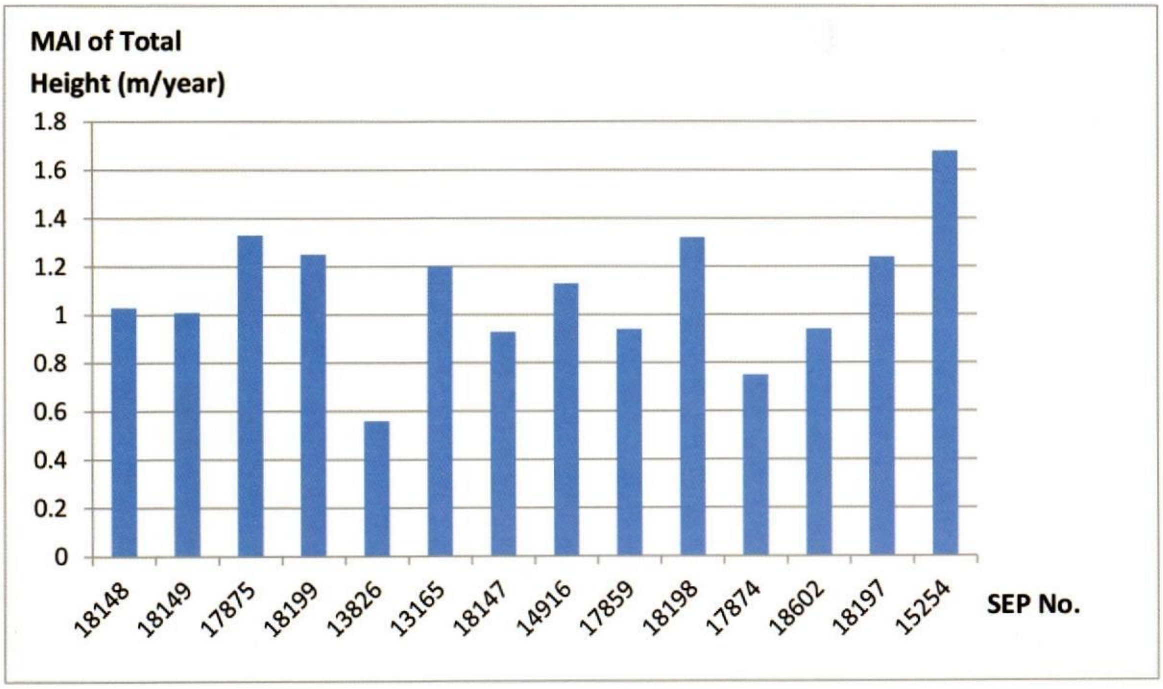


Figure 2. Mean annual increment of total height (m/year) for *Eucalyptus pellita* at 19 years in Kolapis B.

Mean Annual Increment of Diameter at Breast Height

Figure 3 shows the mean annual increment (MAI) of the diameter at breast height (cm) for all fourteen provenances of *Eucalyptus pellita* planted at Kolapis B, Lungmanis Forest Reserve. The provenance from South Bloomfield (8km), Queensland (SEP No. 15254) shows the highest MAI of diameter at breast height of 1.6 cm/year, followed by South of Kiriwo West Province, Papua New Guinea (SEP No. 18197), with an MAI of diameter at breast height of 1.52 cm/year and Tozers Gap, Queensland (SEP No. 17875) with an MAI of diameter at breast height of 1.49 cm/year. The other provenances show MAI of diameter at breast height ranging from 0.87 cm/year to 1.38 cm/year.

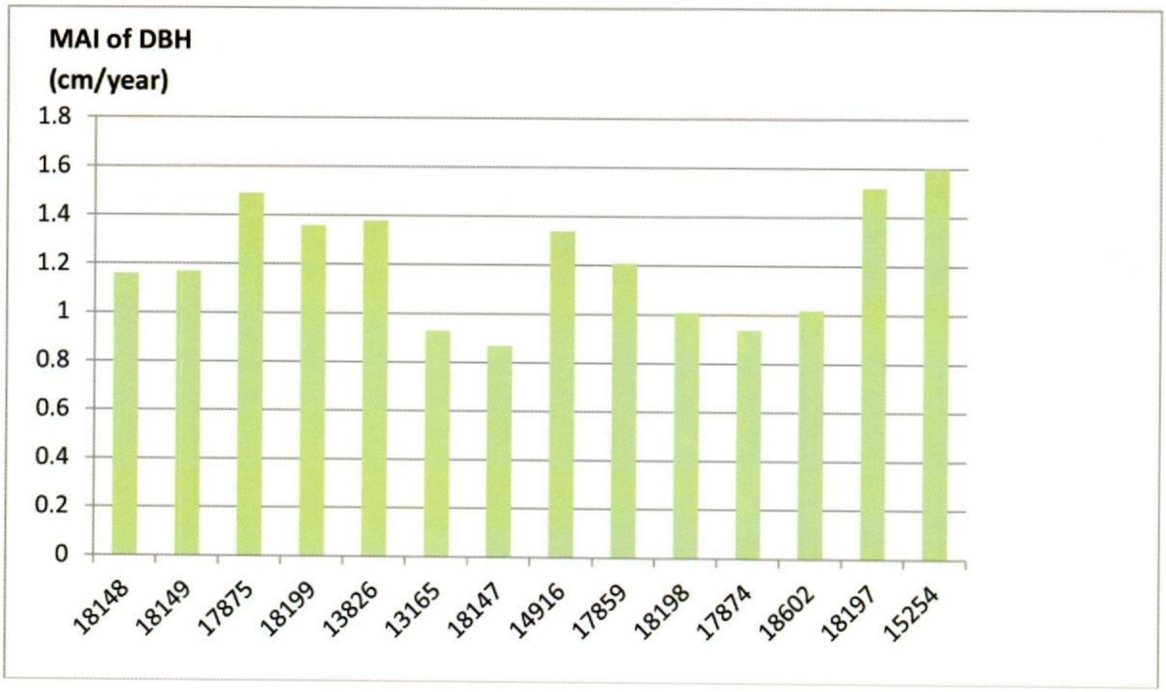


Figure 3. Mean annual increment of diameter at breast height (cm/year) for *Eucalyptus pellita* at 19 years in Kolapis B.

CONCLUSIONS

The provenance from South Bloomfield (8km), Queensland (SEP No. 15254) can be considered as the best provenance in terms of growth because it shows the highest MAI of total height with 1.68 m/year and the highest MAI of diameter at breast height with 1.6 cm/year at 19 years old. At that age, the mean height was 32 m and the mean diameter at breast height was 30.35 cm.

In terms of survival rate, provenances from both Tozers Gap, Queensland (SEP No. 17875) and Lankelly Creek, Queensland (SEP No. 17874) show the highest survival rate at 58%.

Planting materials from the best performing provenances and individuals from this trial have been collected for further experimental plantings and the establishment of gene bank and seed stands. The addition of other selected good provenances from other sources is also being carried out to further diversify existing seed sources for future trial in search of better seed source for future planting.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the contribution of the staff from Agroforestry Section, Forest Plantation Section, Wood Section, Non-Timber Plantation Section, Tree Breeding Section and Seed Section of the Forest Research Centre especially Mr. Ajis Ampawih, Mr. Ahmad Mustapha, Mr. Japirin Hasman and Mr. Abdul Ajik Oyong, for without them the study would not have been possible. The authors would also like to acknowledge the assistance rendered by Lok Yen Chi, Ivy Moureen Ramlie and Mohammad Shahrul Bin Shahpuan of Universiti Malaysia Sabah.

REFERENCES

Dombro, D.B. (2010). Amazonia Reforestation's Red Mahogany. *Planeta Verde Reforestación*. 8 pp.

Doran, C.J. & Turnbull, J.W. (1997). *Australian trees and shrub species for land rehabilitation and farm planting in the tropics*. ACIAR Monograph 24: 384.

Harwood, C.E. (1998). *Eucalyptus pellita - an annotated bibliography*. CSIRO Publishing, Collingwood, Australia. 70 pp.

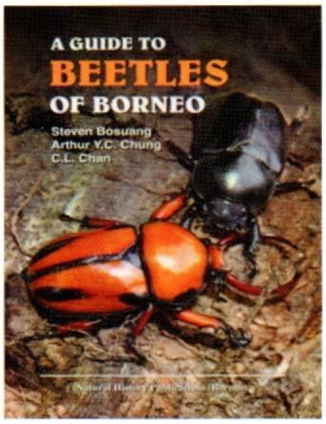
Mueller, F.J.H. von (1864). *Eucalyptus pellita. Fragmenta Phytographiae Australiae* 4: 159.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R. & Anthony, S. (2009). *Agroforestree Database: a tree reference and selection guide version 4.0.* World Agroforestry Centre, Kenya. http://www.worldagroforestry.org/

Plate 1. The 19-year-old *Eucalyptus pellita* plot in Kolapis B Research Station, Lungmanis Forest Reserve.

Plate 2. Coppices were successfully collected from 19-year-old *Eucalyptus pellita* stump in Kolapis B Research Station, Lungmanis Forest Reserve.

Plate 3. Successfully rooted cuttings from coppices of 19-year-old *Eucalyptus pellita* stump in Kolapis B Research Station, Lungmanis Forest Reserve.



A guide to Beetles of Borneo by Steven Bosuang, Arthur Y.C. Chung & C.L. Chan. Published by Natural History Publications (Borneo), Kota Kinabalu, 2017. Pp 252. ISBN 978-983-812-172-9.

Reviewed by E. Khoo

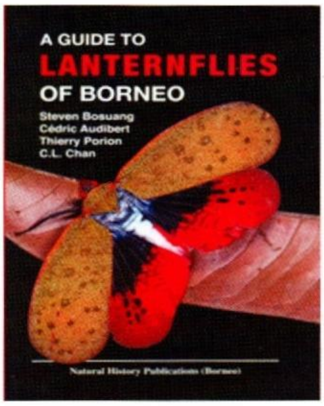
Many are no strangers to the science-fiction franchise of the Alien series. With the release of "Alien: Covenant" in May 2017, although the opening of the movie has brought in USD 36.1 million, which is short of what was expected, however this franchise series that was started in 1979 continues to draw its own crowd and fans. It is interesting to note that the Alien's lifecycle was actually based on real life parasitic wasps, of all things a wasp! This leads one to ponder why and how fascinating insects can be?

As one reads through the recent publication on Beetles of Borneo, it cannot be helped but to be drawn by the uncommonness of the common beetle. In the world of insects, the beetles of all groups should make up of two fifths of the insect species. That aside, the tiny creature should have a prominent role in the ancient Egyptian culture and mythology. In terms of structures and size, the group possesses amazing features, such as the male Rhinoceros beetle's ability to lift up weights 850 times its own weight. The authors of the book have provided to the readers very clear and concise background information on the global perspective of the beetles, its life cycle, feeding habits, protective habits and the importance of the group in the tropical ecosystem. The book also includes a selection of beetle species that can be found in Borneo, with details, such as the species description, distribution, etymology, habitat and ecology. Here and there, some short notes are included to enlighten the readers on interesting features that one might want to take note of. Readers would not be bogged down with just words, but will also be treated to an amazing display of high resolution photos and close-up view of every single species listed in the book. Flipping through the pages, one cannot help to think such a common insect can actually be so beautiful. It is definitely a must have book for the library collection, or to be considered as a gift to any aspiring entomologist or naturalist.

To conclude, the insect world is not just fascinating in how nature has been so brilliant in exhibiting the designs and colours but also in its inspirational aspect. The humble firefly (which also happens to be a beetle) has inspired researchers in the University of Namur in Belgium to come up with a LED design that shines brighter, with a further 55% light output. This was done through studying the jagged scales of the firefly's abdomen!

"Any foolish boy can stamp on a beetle, but all the professors in the world cannot make a beetle."

Arthur Schopenhauer



A guide to Lanternflies of Borneo by Steven Bosuang, Cederic Audibert, Thierry Porion & C.L. Chan. Published by Natural History Publications (Borneo), Kota Kinabalu, 2017. Pp 127. ISBN 978-983-812-174-3.

Reviewed by E. Khoo

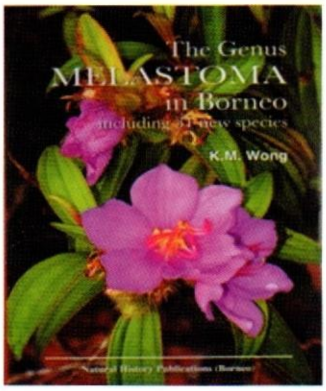
The first time coming across a Lanternfly (*Pyrops sultanus*) was during an expedition in Ulu Kalumpang. At a casual glance, the insect looks anything but interesting due to its whitish mottled appearance. However, upon closer inspection, it has this strange feature on its head that looks like a long "snout". It reminds one of Carlo Collodi's children fictional character "Pinnochio" (The Adventures of Pinnochio), whereby every single time Pinnochio tells a lie, his nose grows longer. As for whether this strange feature, (of which the scientific term for it is "head process") serves any specific function or purpose, it is yet to be determined and the question of why certain genera of the group have it while the others do not is yet to be addressed.

Going through the guide, one is continually surprised at how apt this group is in being the masters of disguise in one moment by camouflaging itself within the natural surrounding through the mimicking of patterns; and next they can be show stealers with fantastic display of vibrant aposematic colours on its hind wings when threatened. With such features, it is not surprising why there are worldwide interests in photographing lanternflies. The photos in the guide are not just stunning, but have also successfully showcased the bizarre patterns and features of each of the 34 taxa in Borneo. Information such as descriptions, distribution and etymology is presented for each taxa, when it is possible, attempts have been made to include photographs of both sexes within the checklist. In the introduction, the authors have provided an overview of the lanternfly classification, identification, defence, colouration and camouflage, and at the same time highlighted the issue of the existing gap in understanding the group's biology and Borneo's diversity. Take for example, *Polydictya tanjiewhoei*, to date there is only one single female specimen within the collection. Therefore, striking as the lanternflies are, they remain shrouded in mystery while awaiting the curious naturalists to unveil its many secrets.

This is definitely a book for either personal or general library collection, or to be given as a gift to inspire a one's inborn sense of interest in the exciting and mysterious world of the lanternflies.

"We live in a scientific age, yet we assume that knowledge of science is the prerogative of only a small number of human beings, isolated and priest like in their laboratories. This is not true. The materials of science are the materials of life itself. Science is part of the reality of living; it is the way, the how and the why for everything in our experience."

Rachel Carson



The genus Melastoma in Borneo including 31 new species by K.M. Wong. Published by Natural History Publications (Borneo), Kota Kinabalu, 2016. Pp 184. ISBN 978-983-812-171-2.

Reviewed by E. Khoo & C.D. John

Going around in Sabah, it is not unusual for one to see the scrawny *Melastoma malabathricum* woody shrubs with purple flowers growing wild in the open and degraded areas; it can hardly be considered as attractive or appealing. However, take a stroll in the ultramafic forest, it is guaranteed that one will have a changed perspective of the genus and be enamoured by the striking *M. ultramaficum*, with its amazing foliage and showy flowers. It is just one of the many attractive species that can be found in Borneo. Therefore, it is not hard to understand the author's view of the potential of the genus in the ornamental plant industry.

In the publication, the author has provided details in terms of the genus morphology, taxonomic use of various characters, classification, biogeographical aspects, ecology, reproductive biology, potential in ornamental horticulture and last but not least, the identification keys and the taxonomic enumeration for the genus. For the latter, the author has made a point to include information, such as the origin of the species name along with publication, type specimens referred, synonyms, species description, habitats and distribution and amazing photographs. This is helpful not just to those who are into botanizing, but also provides ample information for those who are interested in looking the genus for its horticultural and medicinal values. As mentioned by Mr Tan Jiew Hoe in his foreword, "*The economic and medical uses are still not so well documented...*" is rightly so. In reference to Dr Hanne Christensen's book on the "Ethnobotany of the Iban & the Kelabit", apart from being used as a cure for various aches and bites, plant parts, such as the common *M. malabathricum* has been used as food flavouring and in religious ceremonies. In essence, there remains immense knowledge to be discovered in the group of plants.

"Nomenclature, the other foundation of botany, should provide the names as soon as the classification is made... If the names are unknown knowledge of the things also perishes... For a single genus, a single name."

Carolus Linnaeus

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.

SUBMISSION OF MANUSCRIPTS

Manuscripts should be in English. They may be submitted by email, on a CD or as a hardcopy. Authors should keep an identical set of the manuscript and illustrations. Sepilok Bulletin bears no responsibility for material that may be lost, either in transit or during publication. An electronic version of the manuscript should be submitted upon acceptance of the paper for publication or when requested by the Chief Editor. Submission of a manuscript is held to imply that the article has not been published and is not being published elsewhere.

Manuscripts should be submitted to:

The Chief Editor
Sepilok Bulletin
Forest Research Centre, Sepilok
P.O. Box 1407
90715 Sandakan, Sabah
MALAYSIA
Tel: +(089) 531522
Fax: +(089) 531068
Email: Maria.Ajik@sabah.gov.my
or frcsabah@sabah.gov.my

PREPARATION OF MANUSCRIPTS

Manuscripts should be submitted in Microsoft Word in 12 point Times New Roman, with at least 30 mm margins. Pages should be numbered consecutively but in the text no reference should be made to page numbers.

Title Page: The title page should include the title, followed by the name(s) and affiliation(s) of author(s). The title should be brief giving a concise description of the content of the paper. For multi-authored papers, the author for correspondence should be indicated.

Abstract and Keywords: A manuscript should open with an abstract not exceeding 250 words. It should be an intelligible summary of the paper, without the use of reference. The abstract should be followed by a few keywords, identifying the matter for retrieval systems, and arranged in alphabetical order.

Main Text: The main text should be divided into suitable sections under short headings. For research papers, the main text should normally be organized as Introduction, Materials & Methods, Results, Discussion (Results and Discussion may be combined), and Conclusion. For notes and short articles, the authors may use appropriate section headings of their own choice.

Tables and figures (including drawings and photographs) should be numbered and given brief self-explanatory titles. They should not be inserted in the text but prepared on separate sheets.

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.

Acknowledgements: Acknowledgements may be included at the end of the main text preceding the references cited. It should be brief.

References: Citations in the text should be by author(s) and year of publication, e.g. Chan (1987); (Chan 1987). When several references are cited at one place in the text, they should be arranged chronologically. Citations for papers with two authors should be in the form "Tan & Hiew" while for three or more authors only the first author is given followed by "*et al.*" If several papers by the same author(s) in the same year are cited, they should be differentiated, e.g. 1981a, 1981b, etc.

In the list of references, the papers should be arranged alphabetically by authors' names, and chronologically per author, and conform to the following format. All citations in the text should be listed, and all papers listed should have been cited.

Burgess, P.F. (1966). *Timbers of Sabah*. Sabah Forest Record No. 6. Sabah Forest Department, Sandakan. 501 pp.

Chan, C.L., Lamb, A., Shim, P.S. & Wood, J.J. (1994). *Orchids of Borneo. Vol. 1. Introduction and a selection of species*. Sabah Society, Kota Kinabalu & Royal Botanic Gardens, Kew. 402 pp.

Holloway, J.D. (2001). Malaysian moth mysteries. *Malaysian Naturalist* 55(2): 48-51.

Ng, F.S.P. (1983). Ecological principles of tropical lowland rain forest conservation. (In) Sutton, S.L., Whitmore, T.C. & Chadwick, A.C. (eds.), *Tropical rain forest: ecology and management*. Special Publication No. 2 of the British Ecological Society. Blackwell, Oxford. Pp. 359-375.

REPRINTS

On publication, 25 reprints will be supplied free to the author(s).

DICETAK OLEH PENCETAK KERAJAAN,
POLITIN @ WENEN BIN MOBIJI, A.D.K., B.S.K., JABATAN CETAK KERAJAAN,
SABAH, MALAYSIA.
2017.

SEPILOK BULLETIN
Vols. 25 & 26 June 2017

CONTENTS

Front cover: A hyper-endemic species, *Nepenthes macrophylla*, in Mount Trus Madi. (Photo: Alviana Damit)