PHENOLOGY OF *GONYSTYLUS BANCANUS* IN PAHANG, PENINSULAR MALAYSIA

P Ismail[1,] *, MS Nizam[2], A Latiff[2], I Faridah Hanum[3] & I Shamsudin[1]

[1]*Forest Research Institute Malaysia, 52109 Kepong, Selangor Darul Ehsan, Malaysia*
[2]*School of Environmental and Natural Resource Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor Darul Ehsan, Malaysia*
[3]*Faculty of Forestry, Universiti Putra Malaysia, 43400 Serdang, Selangor Darul Ehsan, Malaysia*

Received March 2010

ISMAIL P, NIZAM MS, LATIFF A, FARIDAH HANUM I & SHAMSUDIN I. 2011. Phenology of *Gonystylus bancanus* in Pahang, Peninsular Malaysia. A study on the phenology of *Gonystylus bancanus* (ramin melawis) was conducted in Pekan Forest Reserve, Pahang, Peninsular Malaysia, which covers areas of virgin and logged-over forests. Observations revealed that the flowering of *G. bancanus* was supra-annual. The smallest *G. bancanus* tree to flower was 29 cm in diameter at breast height (dbh) and was located in a logged-over site. Most trees that flowered had larger dbh of more than 40 cm and were found in logged-over and virgin forests. A total of 71–86 days was recorded for full development from the budding stage to mature fruit formation. The budding phase was quite long, extending for more than a month. However, it took only about two weeks for the flowers to become fruits. The flowers of *G. bancanus* were pollinated by thrips (*Heterothripts* sp.) and stingless bees (*Trigona canifrons* and *T. laeviceps*), while aphids (*Aphis* sp.), Prevost's squirrels (*Callosciurus prevostii*) and plantain squirrels (*C. notatus*) were identified as predators of *G. bancanus* flowers and fruits. *Gonystylus bancanus* seeds were mainly dispersed by gravity but the Malayan flying fox (*Pteropus vampyrus*) was also observed to disperse the fruits. Other fruit bats, namely, *Cynopterus sphinx*, *Megaerops ecaudatus* and *Penthetor lucasi* were also identified as potential seed dispersal agents of *G. bancanus*.

Keywords: Pekan Forest Reserve, flowering, fruiting, pollinators, predators

ISMAIL P, NIZAM MS, LATIFF A, FARIDAH HANUM I & SHAMSUDIN I. 2011. Fenologi *Gonystylus bancanus* di Pahang, Semenanjung Malaysia. Kajian fenologi *Gonystylus bancanus (*ramin melawis) dijalankan di Hutan Simpan Pekan, Pahang, Semenanjung Malaysia yang merangkumi kawasan hutan dara dan hutan yang telah dibalak. Pemerhatian menunjukkan yang pembungaan *G. bancanus* adalah supratahunan. Pokok *G. bancanus* terkecil yang berbunga berdiameter 29 cm pada aras dada (dbh) dan dijumpai di kawasan yang telah dibalak. Kebanyakan pokok yang berbunga mempunyai diameter yang besar iaitu melebihi 40 cm dbh dan terdapat di hutan yang telah dibalak dan hutan dara. Sejumlah 71 hari hingga 86 hari telah direkodkan bagi pertumbuhan penuh dari fasa putik hingga fasa buah matang. Fasa putik mengambil masa agak lama iaitu lebih daripada satu bulan manakala fasa bunga menjadi buah mengambil masa lebih kurang dua minggu. Bunga *G. bancanus* didebunga oleh kutu trip (*Heterothripts* sp.) dan kelulut (*Trigona canifrons* dan *T. laeviceps*), manakala afid (*Aphis* sp.), tupai (*Callosciurus prevostii* dan *C. notatus*) dikenal pasti sebagai pemakan bunga dan buah *G. bancanus*. Biji benih *G. bancanus* sebahagian besarnya disebarkan secara graviti tetapi keluang (*Pteropus vampyrus*) didapati turut membantu dalam penyebaran buah. Spesies kelawar yang lain iaitu *Cynopterus sphinx, Megaerops ecaudatus* dan *Penthetor lucasi* juga dikenal pasti sebagai agen penyebaran berpotensi bagi biji benih *G. bancanus*.

INTRODUCTION

Gonystylus bancanus (Thymelaeaceae), locally known as ramin melawis, is not the only main species of *Gonystylus* (Soerianegara & Lemmens 1994) but also the major timber species of peat swamp forests (PSFs) (Soerianegara & Lemmens 1994, Ng & Shamsudin 2001). This species is one of the main commercial timbers logged from the forests of Malaysia and Indonesia (Soerianegara & Lemmens 1994, Abdullah et al. 2004, MTIB 2004). During the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) meeting in October 2004 in Bangkok, Thailand, all parties agreed to the uplifting of *Gonystylus* spp. to Appendix II for better management and conservation of the species via trade regulation (Jumat 2004). Even though in general *G. bancanus* has received more attention through research compared with other

**E-mail: ismailp@frim.gov.my*

Gonystylus species, information is still insufficient. As recommended by ITTO (2007), the present project was aimed at studying the phenology of *G. bancanus* in order to obtain more information on the species.

Detailed study of the phenological development of *G. bancanus* in PSF of Peninsular Malaysia is lacking. However, the works of Shamsudin and Ng (1995), Shamsudin (1996) and Nurul Huda (2003) described some of the phenological characteristics of *G. bancanus*. All these studies reported the timing of flowering and fruit fall of *G. bancanus*. However, other aspects of phenological development, pollinators and seed dispersal agents were not investigated. Therefore, the main objective of this study was to determine several important phenological aspects of *G. bancanus* such as development of buds, flowering and fruiting, pollinators, predators and seed dispersal agents.

MATERIALS AND METHODS

Study site

This study was conducted in Pekan Forest Reserve (FR) in the South-East Pahang Peat Swamp Forest (SEPPSF), Peninsular Malaysia (Figure 1). The SEPPSF has four forest reserves, namely, Pekan, Kedondong, Nenasi and Resak with a total area of about 85 000 ha (UNDP/GEF 2007). Pekan FR is the largest of the four forest reserves, covering an area of about 50 000 ha. Eight sites were selected across areas in the north, south, middle, east and west of the Pekan FR for observation. The selected areas included both logged-over and virgin forests (Table 1).

The selection of the sites was influenced by accessibility to the areas via forest roads and rivers/canals. Accessibility to the interior of the Pekan FR was generally poor due to unstable soil condition and limited forest roads.

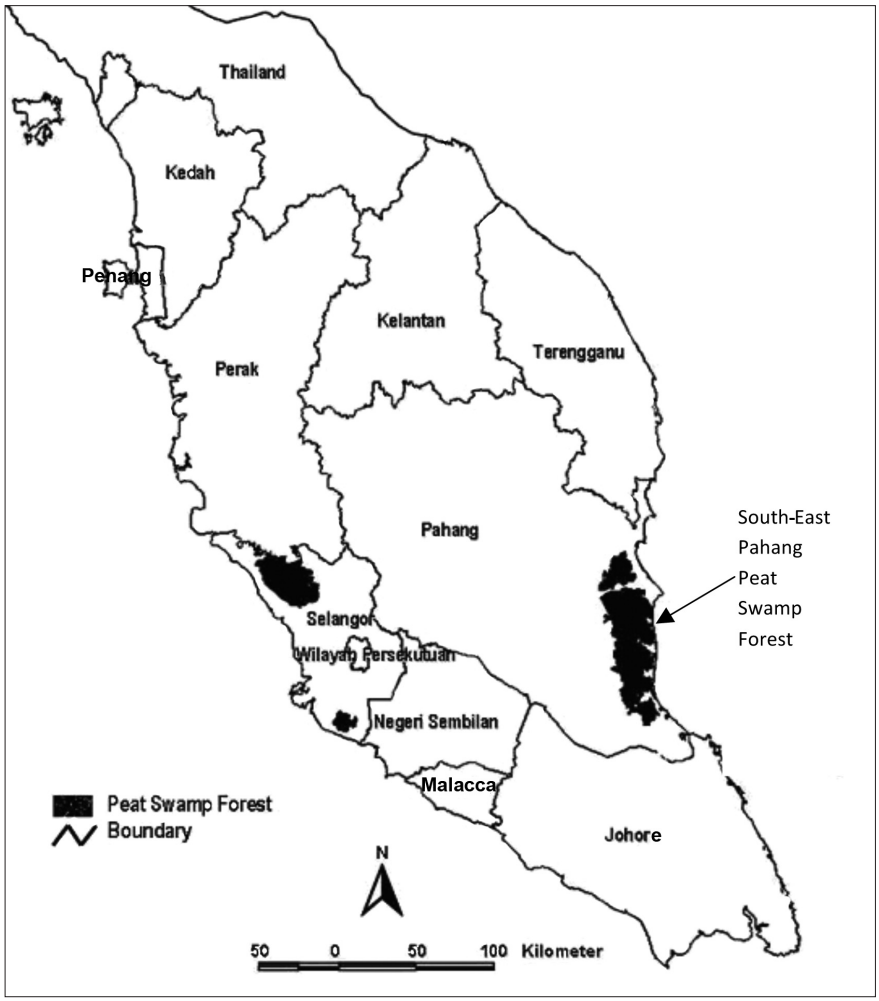

Figure 1 Location of the South-East Pahang Peat Swamp Forest, Peninsular Malaysia

Table 1 Summary of selected study sites for phenological observations of *Gonystylus bancanus* at Pekan FR, Pahang

Site	Location in Pekan FR	Latitude (N)	Longitude (E)	Compartment	Forest status	Number of trees observed
1	North	3° 29' 40"	103° 18' 45"	7	Logged-over	6
2	East	3° 22' 35"	103° 25' 00"	156	Virgin	10
3	East	3° 26' 32"	103° 21' 22"	42	Logged-over	1
4	East	3° 25' 38"	103° 21' 21"	75	Logged-over	4
5	Middle	3° 25' 59"	103° 21' 21"	70	Logged-over	12
6	Middle	3° 25' 46"	103° 19' 42"	77	Virgin	7
7	West	3° 23' 26"	103° 09' 47"	139	Logged-over	10
8	South	3° 17' 08"	103° 13' 58"	200	Virgin	3

Selected trees

Fifty-three *G. bancanus* trees, that were generally in good condition with a range of diameter sizes, were selected from the major accessible areas in the logged-over and virgin forests of the Pekan FR. The smallest tree was 21.9 cm while the biggest was 90.7 cm in diameter at breast height (dbh). Relatively small-sized trees were included in this study to determine whether smaller-sized trees had the ability to produce flowers and fruits. The number of small-sized trees was limited because they were less abundant than the bigger-sized trees.

Observation

Observations were conducted from 2005 till 2007. Based on the first author's observations and work by Shamsudin and Ng (1995) as well as Nurul Huda (2003), the species was found to start bearing fruit early in the year. Hence, field observations were carried out once a month, except for the beginning of the year (January–March) when observations were made fortnightly. Field observations began in October 2005. No flowering was recorded in 2005 and 2006. However, budding was observed in February 2007. Therefore, observations were made every fortnight until May 2007 when all mature fruits fell. Observations were made using binoculars (Marzalina et al. 1995).

To monitor phenological stages, a tree of about 28 m high and 67 cm in dbh was fitted with an observation tower. Construction scaffolding was attached to the tree with aluminium poles. The tree was selected as it had good round bole, healthy appearance and suitable height of first branches of about 21 m. Daily observations were made on the tree using the tower starting from bud formation until the fall of mature fruits. Chi-squared test was used to compare the flowering behaviour in terms of location, site and tree size.

Pollinator sampling

Insect pollinators were sampled over three days (72 hours) during the flowering phase using a net. Netting was done from the top of the observation tower. The times when the insects were sampled were recorded. The main reason for conducting insect sampling over 72 hours was that the pollinators may be pollinating *G. bancanus* during the early hours to avoid predators (Appanah 1982).

Predators and fruit dispersal agents

Predators of *G. bancanus* fruits were caught using trap baited with the fruits. Observations were made to identify animals that consumed and dispersed the fruits. It was done during the fruiting stage from early morning till late evening.

RESULTS AND DISCUSSION

Flowering and fruiting

No flowering was recorded in 2005 and 2006. During that period, flushing/production of new

leaves occurred. It was apparent that while several trees were flushing, others showed no changes. Sometimes, all trees were flushing with new leaves and sometimes none were flushing.

There were flowering and fruiting in 2007. Some of the trees started producing buds in early February 2007. Of the 53 trees, 34 trees (64%) of various sizes and locations flowered (Table 2). Based on χ^2 test, there was significant difference ($p < 0.05$) in flowering and non-flowering occurrences between the logged-over and virgin forests ($\chi^2_{computed} = 3.8725$, $\chi^2_{table} = 3.84$, df = 1, p = 0.04908). Mast flowering was observed as nearly all branches had flowers. The smallest tree that flowered was 29.0 cm and the biggest, 90.7 cm in dbh. Both trees were located in logged-over forest.

Flowering episodes

Based on current and previous observations, there were three flowering episodes for *G. bancanus* from 2000 till 2007. Flowering occurred in 2000 (Nurul Huda 2003), 2004 (H Khali Aziz, personal communication) and 2007 (current study). From the results, it was apparent that there was no other flowering occurrence in between these years. The flowering episodes indicated sporadic flowering in 2000 (Nurul Huda 2003) and mast flowering in 2004 (H Khali Aziz, personal communication) and 2007.

Based on this behaviour, the flowering of *G. bancanus* can be categorised as supra-annual. This means that *G. bancanus* does not necessarily flower every year. The previous and current

Table 2 Summary of trees that flowered based on diameter size, location and site status

Dbh group	Location	Site status	Number of trees flowered
1	West	Logged-over	1
		Subtotal	1
2	West	Logged-over	1
2	Middle	Logged-over	2
2	East	Virgin forest	1
2	North	Logged-over	1
2	East	Logged-over	2
		Subtotal	7
3	West	Logged-over	1
3	Middle	Logged-over	5
3	East	Logged-over	1
3	Middle	Virgin forest	3
		Subtotal	10
4	West	Logged-over	1
4	South	Virgin forest	1
4	Middle	Logged-over	5
4	Middle	Virgin forest	3
4	East	Virgin forest	1
4	North	Logged-over	3
4	East	Logged-over	2
		Subtotal	16
		Grand total	34

Group 1: 20.0–29.9 cm dbh, Group 2: 30.0–39.9 cm dbh, Group 3: 40.0–49.9 cm dbh, Group 4: ≥ 50.0 cm dbh

observations confirmed this scenario whereby the species flowered three times in eight years. Supra-annual behaviour is relatively common as Sakai et al. (2005) reported that about 20% of tree species in Lambir Hills National Park, Sarawak and more than 50% in La Selva, Costa Rica were supra-annual species, which, on average, flowered once in two or more years.

Fruit production

Despite the mast budding and flowering, fruits of *G. bancanus* did not seem to be abundant during the fruiting episode. A comparison of fruit production between the 2007 fruiting season (current study) and the fruiting season in 2004 (H Khali Aziz, personal communication) indicated that the fruiting season of 2007 could be regarded as less successful. During the 2004 fruiting season, mature fruits were found abundantly on the trees. Fallen fruits were also abundant on the forest floor. At that time, the Pahang Forestry Department staff and local nursery operators collected thousands of mature fruits/seeds while the fruits were still attached to the trees.

Close observations from the phenological tower provided some important information on the phenological developments (Table 3). Table 3 shows that the species took about 71–86 days for full development from budding to the falling of mature fruits. About 36–46 days were needed for the development from bud to flower with about 30% of the buds turning into flowers. The development of flowers in an inflorescence to the early stage of fruit formation (petal closure) took about 10 to 15 days. Pollination is critical during this period as it is important for the flower to become fruit. The period of about two weeks was fairly short and, therefore, pollination was assumed to be very intense. From the recorded observations, about 26% of the flowers fully developed into fruits. Many of the flowers were aborted due to predation and turned brownish in colour. It took about 25 to 38 days for the fruits to develop to maturity at which time they would start to fall. It was observed that about 21% of the fruits successfully developed to maturity. However, it should be noted that the study was carried out during a relatively unsuccessful fruiting season. Thus, the percentage is expected to be higher in a more successful fruiting season. Based on this result, it is interesting to note that by simple calculation, if 1000 buds develop, only about 16.4 mature fruits are estimated to be produced (see Table 3).

Location, site status and tree size

All locations and sites had trees that flowered (Table 2). Based on the χ^2 test, there was significant difference ($p < 0.05$) with regard to location for the flowering and non-flowering occurrences ($\chi^2_{computed} = 13.5144$, $\chi^2_{table} = 9.49$, df = 4, $p = 0.009018$). Thus, location plays a critical role in the flowering of *G. bancanus*. However, the occurrence of flowering based on site status (logged-over or virgin forest) was not significantly different at $p < 0.05$ ($\chi^2_{computed} = 6.1092$, $\chi^2_{table} = 9.49$, df = 4, $p = 0.1911$). The number of trees involved in this study was higher in the middle part, both for logged-over and virgin forests. Naturally, *G. bancanus* stocking was higher in the middle part of the Pekan FR (mainly in ramin–bintangor subtype) as reported by Blackett and Wollesen (2005). Therefore, more trees in this part were found flowering.

The smallest *G. bancanus* tree that flowered was 29.0 cm in dbh located in the west, while the biggest, 90.7 cm in dbh located in the middle part of the Pekan FR. Both trees were located in the logged-over forest. There was only one tree that flowered in dbh class of 20 – < 30 cm, followed by 7, 10 and 16 trees in dbh classes of 30 – <

Table 3 Development of phenological phases in the 2007 *G. bancanus* fruiting season in Pekan FR, Pahang

Phenology development	Duration (days)	Remark
Bud to flower	36–46	About 30% of buds became flowers
Flower to fruit	10–15	About 26% of the flowers became fruits
Fruit maturity and fall	25–38	About 21% of the fruits were matured
Total (days)	71–86	

40 cm, 40 – < 50 cm and ≥ 50 cm respectively (Table 2). It shows that bigger trees potentially have better chance of flowering, although small trees below 30 cm in dbh can also produce flowers. The χ^2 test also showed that there was no significant difference with respect to the dbh classes on the number of flowering trees at $p < 0.05$ ($\chi^2_{computed} = 5.2769$, $\chi^2_{table} = 7.81$, df = 3, p = 0.1526).

All locations and sites had flowering trees, but the numbers varied based on location and the number of overall trees observed in each area. The location is related to the natural distribution of *G. bancanus*, which were more abundant in the middle part of the Pekan FR (Blackett & Wollesen 2005). It is apparent that trees in the middle showed the highest number of flowering trees both in logged-over and virgin forests. However, in general, the number of flowering trees is higher in the logged-over forest compared with the virgin forest, although it is not significantly different (p = 0.1911). Appanah and Mohd. Rasol (1990) suggested that more trees fruited in logged-over forest due to less competition for light and nutrients compared with undisturbed sites. It was observed that larger *G. bancanus* trees would flower regardless of the location and site status. It shows that bigger-sized trees have more chances biologically and ecologically to produce flowers (Appanah and Mohd. Rasol 1990).

Pollinators

Based on the sampling that was conducted over three days, nine insect species visited the selected *G. bancanus* tree (Table 4). The family of all the insects were successfully determined. However, there were several specimens that could not be identified to the species level and thus vernacular names were used. Some species were potential pollinators of *G. bancanus*. Thrips (*Heterothripts* sp.) were among the main species that pollinate *G. bancanus* flowers. Two species of stingless bees, i.e. *Trigona canifrons* and *T. laeviceps* were observed to pollinate the flowers. In general, pollination occurred in the late morning and at night.

Although many insects visited the *G. bancanus* tree, only three species were observed to attend to the flowers and thus were involved in pollination. The low number of insects attending the *G. bancanus* flowers was presumably due to the characteristics of the flowers that were not attractive. The flowers are fairly small (about 4–6 mm in size), with fairly dull colour of light green and apparently lack smell. Hence, these features are perhaps less favourable to attract many types of insect pollinators. Moreover, during the flowering period of *G. bancanus*, several other PSF tree species in Pekan FR such as *Durio carinatus, Tetramerista glabra* and *Shorea platycarpa* were also flowering. Some of them have bigger flowers with attractive colours of bright yellow. In comparison with other similar works in dryland forests. Thrips (*Heterothripts* sp.) were important pollinators of *Shorea* species in Pasoh FR (Appanah & Chan 1981). Pollination of the species generally took place in the early morning (Appanah 1979).

Predators

From the beginning of bud development, some predators and pests were observed. The presence of aphids was noticed throughout the period from bud development until fruit production. The effects of aphid predation on *G. bancanus* buds were particularly obvious during the bud development stage where many buds became brownish in colour, dried and subsequently died. Squirrel is another predator observed. Prevost's squirrel (*Callosciurus prevostii*) was found consuming the fruits as well as seeds of *G. bancanus*. Due to its big size, the species is able to consume large amounts of *G. bancanus* fruits. Hence, Prevost's squirrel could be regarded as one of the major predators of *G. bancanus*. The plantain squirrel (*C. notatus*) was also found eating the fruit of *G. bancanus*. These two species are commonly found and widely distributed across primary to secondary forests, gardens and plantations (Payne et al. 1985). These predator species are arboreal (tree dwellers), although they can sometimes be seen foraging close to the ground for fallen fruits (Norhayati 2000). In this study, no terrestrial (ground-based) small mammals such as rodents were captured or spotted consuming the fruits of *G. bancanus* even though they were reported as predator by Liam (2005) and Shamsudin (1996).

Fruit dispersal agent

It has been observed that the common fruit dispersal agent for *G. bancanus* is gravity. The fruit is considerably heavy and large in size (about 3 cm long) hindering it from being dispersed far from the tree. In addition, as the topography of PSF is relatively flat, the fallen fruits would only

disperse within a short range. Based on the works of Nurul Huda (2003) and Shamsudin (1996), the fruits could not disperse naturally beyond 20 m from the mother trees. We found that the Malayan flying fox (*Pteropus vampyrus*) with a wing span of up to one and half metres consumed the fruits of *G. bancanus*. Groups of *P. vampyrus* were spotted in the early evenings consuming fruits of *G. bancanus* during the fruiting season. However, *P. vampyrus* is not considered as a seed predator as it only consumes the flesh of the fruit leaving the seeds intact (Marshall 1985). We assume that seeds from the fruits consumed by *P. vampyrus* are still good for germination. *Pteropus vampyrus* is able to fly in the range of 70 km from its roosting site to search for food.

Table 4 List of insects that were found visiting *G. bancanus* flowers

No.	Order	Family	Species	Common name	Time sampled
1	Coleoptera	Histeridae	n.i.	Beetle	1.00–7.00 a.m.
2	Coleoptera	Tenebrionidae	n.i.	Beetle	7.00–9.00 a.m.
3	Coleoptera	Chrysomelidae	*Mimastra* sp.	Leaf beetle	7.00–9.00 a.m.
4	Coleoptera	Cerambycidae	n.i.	Longhorn beetle	7.00–9.00 a.m.
5	Coleoptera	Curculionidae, Stromboscerinae	n.i.	Snout beetle	9.30–11.30 a.m.
6	Diptera	Sarcophagidae	n.i.	Flesh fly	1.00–7.00 a.m.
7	Diptera	Tephritidae, Dacinae	*Dacus* sp.	Fruit fly	9.30–11.30 a.m.
8	Diptera	Cicadomyiidae	n.i.	Midge	7.00–12.00 p.m.
9	Diptera	Cecidomyiidae	n.i.	Midge	1.00–7.00 a.m.
10	Diptera	Culicidae	n.i.	Mosquito	1.00–7.00 a.m.
11	Diptera	Pipunculidae	n.i.	Parasitic fly	7.00–12.00 p.m.
12	Diptera	Drosophilidae	*Drosophila* sp.	Vinegar fly	7.00–12.00 p.m.
13	Diptera	Drosophilidae	*Drosophila* sp.	Vinegar fly	1.00–7.00 a.m.
14	Hemiptera	Miridae	n.i.	Bug	7.00–12.00 p.m.
15	Homoptera	Delphacidae	n.i.	Plant hopper	7.00–12.00 p.m.
16	Homoptera	Cicadellidae	n.i.	Plant hopper (brown)	7.00–12.00 p.m.
17	Hymenoptera	Formicidae	*Dolichoderus* sp.	Ant	9.30–11.30 a.m.
18	Hymenoptera	Formicidae	*Tetraponera* sp.	Ant	9.30–11.30 a.m.
19	Hymenoptera	Formicidae	*Camponotus* sp.	Ant	7.00–12.00 p.m.
20	Hymenoptera	Formicidae	*Tetraponera* sp.	Ant	1.00–7.00 a.m.
21	Hymenoptera	Braconidae	n.i.	Parasitic wasp	7.00–12.00 p.m.
22	Hymenoptera	Chalcididae	n.i.	Parasitic wasp	7.00–12.00 p.m.
23	Hymenoptera	Apidae	*Trigona canifrons*	Stingless bee*	9.30–11.30 a.m.
24	Hymenoptera	Apidae	*Trigona laeviceps*	Stingless bee*	9.30–11.30 a.m.
25	Hymenoptera	Apidae	*Trigona canifrons*	Stingless bee*	7.00–9.00 a.m.
26	Hymenoptera	Chalcidoidea, Agaonidae	n.i.	Wasp	1.00–7.00 a.m.
27	Lepidoptera	Noctuidae	n.i.	Moth	9.30 – 11.30 a.m.
28	Lepidoptera	Pyralidae	n.i.	Moth	7.00 – 9.00 a.m.
29	Lepidoptera	Noctuidae	n.i.	Moth	7.00 – 9.00 a.m.
30	Orthoptera	Gryllidae	n.i.	Cricket	7.00 – 9.00 a.m.
31	Thysanoptera	Heterothripidae	*Heterothripts* sp.	Thrip*	8.00 – 12.00 p.m.
32	Thysanoptera	Heterothripidae	*Heterothripts* sp.	Thrip*	7.00 – 9.00 a.m.

* = species identified as pollinators, n.i. = not identified at species level

They consume some of the food at site or carry some back to their roosting place.

Based on this finding, *P. vampyrus* perhaps assists in dispersing *G. bancanus* over a much wider range than it is possible through gravity. *Pteropus vampyrus* has also been reported to be commonly found in SEPPSF and is recommended as an indicator species for fauna conservation in the SEPPSF (Lim 2007). Lim (2007) listed seven bat species that were found in the SEPPSF including *Cynopterus sphinx* (short-nosed fruit bat), *Megaerops ecaudatus* (tailless fruit bat) and *Penthetor lucasi* (dusky fruit bat). However, none of these bat species were observed consuming *G. bancanus* fruits. This agrees with the findings of Marshall (1985) and Serafina Christine (2000) who did not include fruits of *Gonystylus* species as fruits that were consumed by bats in Malaysia. However, Shamsudin (1996) spotted unidentified bat species consuming fruits of *G. bancanus* in Pekan FR. Further, Sorianegara and Lemmens (1994) reported that in PSF of Sulawesi, Indonesia, seeds of *G. macrophyllus* were dispersed by bat species, namely, *Rousettus celebensis*.

CONCLUSIONS

Gonystylus bancanus in Pekan FR shows phenological traits which may be related to variability in environmental conditions and the behaviour of fauna species that interact with the trees. The flowering of *G. bancanus* was found to be supra-annual with a total of 71–86 days recorded from budding to mature fruit formation. Faunal species pollinated and predated *G. bancanus* flowers and fruits. Fruit dispersal was mainly by gravity and partially by animals.

ACKNOWLEDGEMENTS

The authors would like to express their sincere gratitude to the staff of the Forestry Department of Pahang and the Natural Forest Programme, Forest Research Institute Malaysia for assistance in plot establishment, data collection and analysis.

REFERENCES

Abdullah AL, Chua L, Ibrahim S, Soehartono T & Tawan C. 2004. *Inclusion of Ramin,* Gonystylus *spp. in Appendix II. Proponent: the Republic of Indonesia.* TRAFFIC, Singapore.

Appanah S. 1979. The ecology of insect pollination of some tropical rain forest trees. PhD thesis, Universiti Malaya, Kuala Lumpur.

Appanah S. 1982. Pollination of androdioecious *Xerospermum intermedium* Radlk. (Sapindaceae) in a rain forest. *Biological Journal of the Linnean Society* 18: 11–34.

Appanah S & Chan HT. 1981. Thrips: the pollinators of some dipterocarps. *Malaysian Forester* 44: 37–42.

Appanah S & Mohd Rasol AM. 1990. Smaller trees can fruit in logged dipterocarp forests. *Journal of Tropical Forest Science* 3: 80–87.

Blackett H & Wollesen L. 2005. *Timber Resource Assessment and Forest Zoning of Pekan Forest Reserve.* DANIDA Peat Swamp Forest Project. Document No. 4. DANIDA, Kuantan. (Unpublished)

ITTO. 2007. *ITTO Expert Meeting on the Effective Implementation of Inclusion of Ramin (*Gonystylus *spp.) in Appendix II of CITES—Report of the Expert Meeting.* Forest Research Institute Malaysia, Kepong.

Jumat A. 2004. Implementation of Appendix II, CITES in Malaysia. Paper presented at MTC Lecture Series 2004. 24 November 2004, Kuala Lumpur.

Liam D. 2005. Phenology of *Gonystylus bancanus* in logged-over peat swamp forest in Sarawak. Pp 315–330 in Meer PJVD (Eds) *Ramin Technical Report—Joint Working Group Malaysia–The Netherlands: Sustainable Management of Peat Swamp Forests of Sarawak with Special Reference to Ramin.* Forest Department Sarawak and Sarawak Forestry Corporation, Kuching.

Lim BL. 2007. Report on fauna of SEPPSF—strategies for their survival and conservation. FRIM–UNDP/GEF Peat Swamp Forest Project. (Unpublished)

Marshall AG. 1985. Old world phytophagous bats *(Megachiroptera)* and their food plants: a survey. *Zoological Journal of the Linnean Society* 83: 351–369.

Marzalina M, Haris M, Ang KC & Baskaran K. 1995. *Panduan Pemerhatian Fenologi bagi Pokok-pokok Hutan Kawasan Hutan Hujan Tropika.* FRIM Technical Information Handbook No. 4. Forest Research Institute Malaysia, Kepong.

MTIB. 2004. Findings on *Gonystylus* sp. in Malaysia of the technical working group on ramin. Report prepared on task of ramin uplisting to Appendix II, CITES. (Unpublished)

Ng TP & Shamsudin I. 2001. *Common Trees of Peat Swamp Forests of Peninsular Malaysia.* Research Pamphlet No. 124. Forest Research Institute Malaysia, Kepong.

Norhayati A. 2000. Frugivores and fruit production in primary and logged tropical rain forests. PhD thesis, Universiti Kebangsaan Malaysia, Bangi.

Nurul Huda H. 2003. Kajian corak regenerasi lima spesies munculan di kawasan hutan paya gambut, Pahang. MSc thesis, Universiti Kebangsaan Malaysia, Bangi.

Payne J, Francis CM & Phillips K. 1985. *A Field Guide to the Mammals of Borneo.* World Wildlife Fund Malaysia, Kuala Lumpur.

Sakai S, Momose K, Yumoto T, Nagamitsu T, Nagamasu H, Abang AHK, Nakashizuka T & Inoue T. 2005. Plant reproductive phenology and general flowering in a mixed dipterocarp forest. Pp 35–50 in Roubik DW, Sakai S & Abang AHK (Eds) *Pollination Ecology and Rain Forests.* Springer, New York.

Serafina Christine DF. 2000. Roles of *Pteropodids* (fruit bats) as seed dispersers in Malaysian rain forests. Forest Research Institute Malaysia, Kepong. (Unpublished)

Shamsudin I. 1996. Observation on flowering, fruiting, germination and predation of *Gonystylus bancanus* in Peninsular Malaysia. *Journal of Tropical Forest Science* 8: 424–426.

Shamsudin I & Ng TP. 1995. Population and distribution patterns of *Gonystylus bancanus* in primary peat swamp forest at Pekan, Pahang. Pp 35–44 in Abdul Rashid AM et al. (Eds) *Proceedings of Third Conference of Forestry and Forest Products Research (Volume 1)*. Forest Research Institute Malaysia, Kepong.

Soerianegara I & Lemmens RHMJ (Eds). 1994. *Timber Tree: Major Commercial Timbers. Plant Resources of South-East Asia No. 5(1)*. Pudoc Scientific Publishers, Wageningen.

UNDP/GEF. 2007. *Integrated Management Plan of the South-East Pahang Peat Swamp Forest*. PSF Technical Series No. 9. FRIM–UNDP/GEF Peat Swamp Forest, Kepong.

