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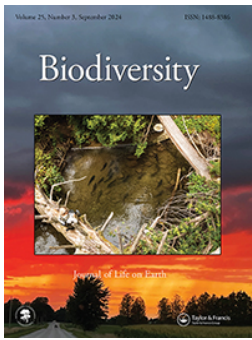
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## Status of ramin (*Gonystylus* spp.) in eastern Kalimantan, Indonesia

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### ABSTRACT

Peat swamp forests in Indonesia have been heavily logged in recent years, with *Gonystylus bancanus*, locally known as the ramin tree, being one of the main species of timber harvested. The potential for other *Gonystylus* species as timber trees is not known, as we have a poorer understanding of their distribution and regeneration patterns. In this study, the team explored the *Gonystylus* species diversity and distribution at five locations in East and North Kalimantan (Indonesia) in 2009. In total, we found six *Gonystylus* species – *G. affinis*, *G. brunnescens*, *G. consanguineus*, *G. forbesii*, *G. keithii* and *G. velutinus* – in primary forest with flat to hilly topography up to 500 m a.s.l. on typical ultisol soils. *Gonystylus brunnescens* was the most abundant species and had the best natural regeneration, whilst the populations of the other five species were much smaller, with fewer than five individuals at each location, and their regeneration was poor. We present information on the autecology of these *Gonystylus* species and recommend further studies on their physiology and ecology, with the support of governments and concessionaires, in order to conserve ramin populations.

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Diversity; *Gonystylus*;  
Kalimantan; soil; timber

## Introduction

There are 32 species of ramin trees (*Gonystylus* spp.; Thymelaeaceae) which are native to the wet forests of Southeast Asia from the Nicobar Islands to Fiji (Airy Shaw 1953, 1972). Borneo (an island shared between Brunei, Indonesian Kalimantan, and Malaysian Sabah and Sarawak) is the centre of diversity, with 30 of the 32 species recorded of which 18 are endemic to the island; 20 species are recorded from Indonesian Kalimantan, with Sidiyasa et al. (2010) providing an identification key to these. Northwestern Borneo appears to be the richest area for ramin tree species diversity (Airy Shaw 1953, 1972) but we have less information on their distribution in Kalimantan. Ramin trees have been heavily exploited as their pale timber has a pleasing texture for light construction and furniture as well as for various decorative items (Mohd-Jamil and Lau 2024; Soerianegara and Lemmons 1993). *Gonystylus bancanus* (Miq.) Kurz is the most well-known species, and is largely confined to peat swamp forests (Hamzah et al. 2010; Samsuri, Lastini, and Purnama 2018). In 1991–1992, the

production of ramin timber, mostly *G. bancanus*, in Indonesia totalled 900,000 m<sup>3</sup> year<sup>-1</sup>, the majority of which was from Central Kalimantan amounting to 550,000 m<sup>3</sup> year<sup>-1</sup> (Soerianegara and Lemmons 1993). Since then, production of this export commodity has decreased by about 90% and the genus is now becoming increasingly uncommon as populations are declining, and 19 of the known species are on the International Union for Conservation of Nature (IUCN) Red List as threatened taxa. This loss of trees can be attributed to various factors, such as illegal logging and conversion of forest to other land uses. The ramin sawn timber export ban through the former Indonesian Ministry of Forestry (1613-KPTS-IV/2001) was an attempt to prevent over-exploitation and, in 2004, the species entered Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix II.

It is now recognized that ramin trees are quite hard to find under natural conditions. Improved survey and inventory of these trees in production forests and conservation areas was one of the nine

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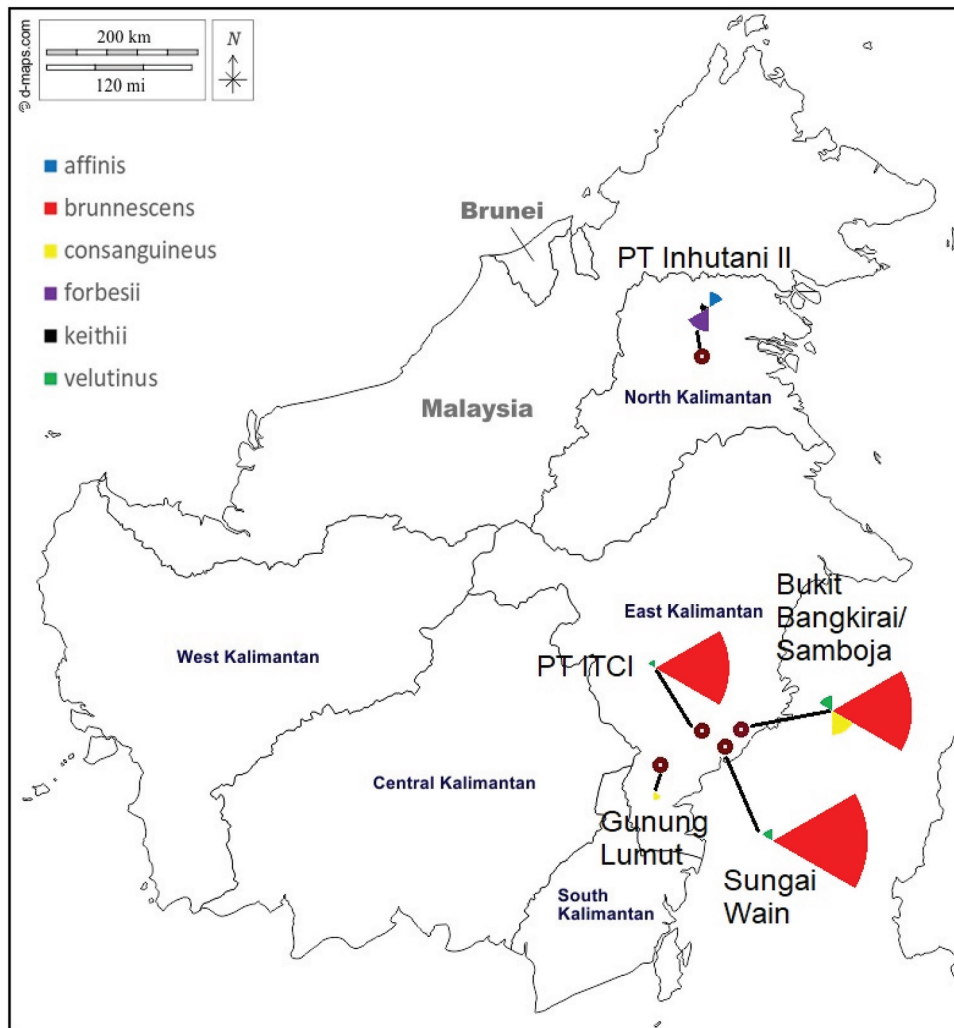
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recommendations of the Indonesian national workshop for the formulation of ramin management (Komar 2006). Whilst *G. bancanus* has been well studied, other species in this genus have received little attention. Therefore, our research fills the gap in the inventory of species diversity, abundance and distribution of *Gonystylus* species in eastern Kalimantan, namely at: PT Inhutani II (Malinau) concession, Sungai Wain, Bukit Bangkirai/Samboja, PT ITCI concession and Gunung Lumut.

## Materials and methods

The field study was conducted at five locations selected with reference to previous unpublished reports (i): the Production Forest of PT Inhutani II forest concession area around Center for International Forestry Research's (CIFOR) camp Seturan (Malinau Regency) in June 2009; (ii) Sungai Wain Protected Forest (Balikpapan Regency)

and (iii) Bukit Bangkirai and around Wanariset-Samboja (Kutai Kartanegara Regency) in August 2009; and (iv) PT ITCI forest concession area (Penajam Paser Utara Regency) and (v) around Gunung Lumut, Sepaku (Paser Regency) in December 2009 (Figure 1). We conducted surveys for *Gonystylus* species on an ad hoc basis and made notes on the tree families associated with the *Gonystylus* individuals, along with broad environmental parameters such as elevation, topography and soil type. Additionally, we recorded individuals in permanent monitoring plots established earlier at Sungai Wain (Sidiyasa 2009) where six individuals of *G. brunnescens* whose diameter had been measured in 1999 were remeasured. GPS coordinates of each tree as well as their stem diameter and height were recorded; they were grouped as 'trees' (> 10 cm dbh), 'saplings' (2 to 10 cm dbh) and 'seedlings' (< 2 cm dbh). Voucher specimens including flowers and fruit (if any) were taken and deposited in the Herbarium Bogoriense, Cibinong (BO).



**Figure 1.** Population and distribution of six *Gonystylus* species in eastern Kalimantan, Indonesia. The size of each pie chart 'slice' is the logarithmically scaled number of individuals of each of the six species recorded.



## Results

Six species of *Gonystylus* were found in the survey locations, namely *G. affinis* Radlk. var. *affinis*, *G. brunnescens* Airy Shaw, *G. consanguineus* Airy Shaw, *G. forbesii* Gilg, *G. keithii* Airy Shaw and *G. velutinus* Airy Shaw (illustrated in Figure 2). Among them, two species are endemic to Borneo: *G. consanguineus* and *G. keithii* (Airy Shaw 1953, 1972; Sidiyasa et al. 2010). The distribution and abundance of each species are shown in Figure 1 and Table 1. In general, all six species were found growing in lowland evergreen forest dominated by members of the Dipterocarpaceae and commonly associated with other

species in the families Euphorbiaceae, Leguminosae, Malvaceae, Myristicaceae, Phyllanthaceae and Sapotaceae. The topography ranged from flat to rolling and hilly, with slopes between 10° and 70° and the elevation ranging from 20 m to 500 m a.s.l. Soils were typically sandy clay ultisols although sometimes quite rocky.

### *Gonystylus affinis* Radlk. var. *affinis*

*Gonystylus affinis* was only found in the PT Inhutani II Malinau forest concession, with just two trees in a hilly area between 200 and 235 m a.s.l.



**Figure 2.** *Gonystylus* species found in eastern Kalimantan, Indonesia, in this study: (a) *G. affinis*, (b) *G. brunnescens*, (c) the first author with *G. consanguineus*, (d) *G. forbesii*, (e) *G. keithii* and (f) *G. velutinus*.

**Table 1.** List of *Gonystylus* species and their distribution in eastern Kalimantan, Indonesia. Numbers in each cell represent adults/saplings/seedlings, respectively, with a dash (-) indicating that particular life stage was not found at the given location.

|                      | Location       |             |                             |            |              | Total      |
|----------------------|----------------|-------------|-----------------------------|------------|--------------|------------|
|                      | PT Inhutani II | Sungai Wain | Bukit Bangkirai/<br>Samboja | PT ITCI    | Gunung Lumut |            |
| <i>affinis</i>       | 2/-            | -           | -                           | -          | -            | 2          |
| <i>brunnescens</i>   | -              | 47/75/61    | 10/20/116                   | 114*       | -            | 443        |
| <i>consanguineus</i> | -              | -           | 1/-/3                       | -          | 1/-/-        | 5          |
| <i>forbesii</i>      | 4/-/-          | -           | -                           | -          | -            | 4          |
| <i>keithii</i>       | 1/-/-          | -           | -                           | -          | -            | 1          |
| <i>velutinus</i>     | -              | 1/1/-       | 2/-/-                       | 1/-/-      | -            | 5          |
| <b>Total</b>         | <b>7</b>       | <b>185</b>  | <b>152</b>                  | <b>115</b> | <b>1</b>     | <b>460</b> |

\*Data was not split into life stages at this location.

### *Gonystylus brunnescens* Airy Shaw

*Gonystylus brunnescens* was the most abundant species but found at only three of the locations – Sungai Wain, Bukit Bangkirai/Samboja and PT ITCI forest concession – with a total of 443 individuals divided among trees, sapling and seedlings. At Sungai Wain and Bukit Bangkirai/Samboja, this species was found up to around 110 m a.s.l. where the topography was generally flat, while in the PT ITCI forest concession area it was found up to 500 m a.s.l. on ridges. The mean ( $\pm$  standard deviation) diameter growth rate of six trees at Sungai Wain recorded after 10 years was  $1.8 \pm 1.1$  mm year<sup>-1</sup>. *Gonystylus brunnescens* showed good regeneration, with many seedlings and saplings around the parent trees, and at Bukit Bangkirai, we found clustered patterns of juvenile trees (Brearley, Mansur, and Eichhorn 2023). In August, many trees of *G. brunnescens* were flowering in Sungai Wain Protected Forest.

### *Gonystylus consanguineus* Airy Shaw

*Gonystylus consanguineus* was found in only two locations, namely Wanariset Samboja with one tree and three seedlings in a valley at 80 m a.s.l., and in the Gunung Lumut area with a single tree at 260 m a.s.l.; no seedlings or saplings were found here. This species seems to have a broad edaphic preference (e.g. calcareous, clayey or rocky soil).

### *Gonystylus forbesii* Gilg

*Gonystylus forbesii* was only found in the PT Inhutani II Malinau forest concession area. During a survey of 24 ha of permanent plots established by CIFOR in 1998 (Kartawinata et al. 2006a, 2006b), just four trees were found broadly distributed across the area and growing between 190 and 240 m a.s.l. This species is also found in peat swamp forest together with *G. bancanus* in West Kalimantan (Mansur 2009).

### *Gonystylus keithii* Airy Shaw

A single individual of *G. keithii* was found only in the Malinau forest concession area at 150 m a.s.l. where the topography was flat. We did not find any seedlings or saplings around this single tree.

### *Gonystylus velutinus* Airy Shaw

*Gonystylus velutinus* was found in three locations, namely Sungai Wain (two trees), Bukit Bangkirai (two trees) and the PT. ITCI forest concession area (one tree)

on rolling land in sandy or rocky clay soil at altitudes between 80 and 350 m a.s.l. This species was in flower in August in the Sungai Wain Protected Forest.

## Discussion

From the six species of *Gonystylus* found in eastern Kalimantan, three species have timber trade potential, namely *G. affinis*, *G. forbesii* and *G. velutinus* (Soerianegara and Lemmons 1993). Excepting *G. brunnescens*, the other five species were hard to find with just a few individuals in each location. In general, *Gonystylus* is a genus characterized by slow regeneration, as we observed, and as also observed by Wardani and Heriyanto (2021) in Sumatra, Muin and Astiani (2018) in Kalimantan, and Shamsudin (1996) in Peninsular Malaysia. Besides their mast-fruiting characteristics (Brearley et al. 2007; Corlett 1990), ramin seeds are recalcitrant (Partomihardjo, Prajadinata, and Hidayat 2008), decay rapidly (Utami, Witjaksono, and Hoesen 2006) and have a high rate of pest/pathogen attack (Shamsudin 1996; Ismail et al. 2011) with such conditions limiting the success of germination and seedling growth (Utami, Witjaksono, and Hoesen 2006), thereby affecting populations in their natural habitats.

Throughout the range of the genus, the richest area for *Gonystylus* species diversity is northwestern Borneo (Airy Shaw 1953, 1972) and whilst 20 species are known from Kalimantan generally, 15 are recorded from East and North Kalimantan (Sidiyasa et al. 2010). In addition to the six species we noted, these other species are *G. acuminatus* Airy Shaw, *G. areolatus* Domke ex Airy Shaw, *G. borneensis* (Tiegh.) Gilg, *G. confusus* Airy Shaw, *G. glaucescens* Airy Shaw, *G. macrophyllus* (Miq.) Airy Shaw, *G. micranthus* Airy Shaw, *G. reticulatus* Merr. and *G. xylocarpus* Airy Shaw. They have only been recorded from a few locations (Triono et al. 2009) and we did not find these other species at our study locations. Of course, many of these collections are from some years ago (i.e. the Dutch colonial period); since then, much forest has been lost in eastern Kalimantan and it is quite likely that *G. glaucescens*, for example, that had only been recorded from its type locality, is now extinct. One individual of *G. brunnescens* was recorded by Kartawinata et al. (2006b) in the PT Inhutani II concession in Malinau but not found there again by us, and, indeed, since our 2009 survey, more than half of the *Gonystylus* trees recorded in permanent plots at Malinau have been killed by anthropogenic disturbances (L. Qie, pers. comm.).

The ecology and physiology of *Gonystylus* species other than *G. bancanus* is very poorly known. Despite being an understorey genus and slow-growing, ramin produces light hardwood. The diameter growth rate of *G. bancanus* averages 5 mm year<sup>-1</sup> (Partomihardjo 2005)

but Brearley (unpubl. data) found *G. affinis* at Barito Ulu, Central Kalimantan, to be very slow growing at less than 1 mm year<sup>-1</sup> and E. Suzuki (unpubl. data) found *G. brunnescens* to grow at a similar rate at Serimbu in West Kalimantan. Understorey seedlings of *G. forbesii* grew about 4.3 cm in height per year (Mukhtar and Koike 2009) and it was shown that *G. affinis* grew better in shaded conditions than in larger gaps where seedlings suffered photoinhibition of photosynthesis (Kenzo et al. 2011).

*Gonystylus* species, including two of the species noted here, *G. affinis* (Brearley et al. 2007) and *G. forbesii* (Sakai et al. 1999), show supra-annual flowering activity seeming to be restricted to mast-fruited events. However, it is not known if they are reproductively active outside these events, as seen for *G. bancanus* (Ismail et al. 2011; Shamsudin 1996), or what the environmental cues for reproductive activity are. Therefore, improved phenological research is also important to ensure that the collection of seeds can be conducted in a timely fashion (Kettle et al. 2010). Additionally, further studies on seed germination (e.g. Utami, Witjaksono, and Hoesen 2006), which is reported to be poor (Grippin et al. 2018), would be valuable, as well as an improved understanding of inter- and intra-specific genetic variation (Ng et al. 2016).

Considering the slow growth rates, small population sizes and reduction of forest area due to forest fires, illegal logging and conversion of forest to other uses, the threats to these species are clear. Therefore, cultivation from seeds, stem cuttings, or tissue culture presents a way to support the existence of ramin trees. Integrated studies on biogeography, physiology, soil science and ecology need to be done with the active support of governments and the concessionaires in order to conserve ramin populations into the future.

## Conclusions

In our 2009 survey of *Gonystylus* in eastern Kalimantan's lowland dipterocarp forest we found limited individuals of six species (*G. affinis*, *G. brunnescens*, *G. consanguineus*, *G. forbesii*, *G. keithii* and *G. velutinus*). Populations of *G. brunnescens* in the Sungai Wain Protected Forest, the area of Bukit Bangkirai and the PT ITCI forest concession were abundant and showed good regeneration, while other species were rarer. Their rarity is likely due to a combination of infrequent reproduction, seed pests and predators, human harvesting and slow growth rates. We note that all of these species are threatened, with loss of individuals since our survey, and that further research is needed for future understanding and protection of *Gonystylus* trees.

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## Disclosure statement

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## Notes on contributors

**Muhammad Mansur** is a plant ecologist with an interest in the composition, population structure and ecophysiology of Indonesian tropical forest plants and trees.

**Kade Sidiyasa** (deceased) was a devoted botanist and expert on the trees of Kalimantan. In commemoration of his dedication, an ex-situ conservation area has been created in Samboja called the "Sidiyasa Ulin Conservation Area".

**Francis Q. Brearley** is a tropical ecologist with an interest in the functional importance of plant-soil interactions for ecosystem processes. He has a particular focus on the forests and ecosystems of Southeast Asia.

**Teguh Triono** is a plant taxonomist with research interests in biodiversity, ecology, evolution and systematics of Indonesian plants.

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