VINE INFESTATION OF LARGE REMNANT TREES IN LOGGED FOREST IN SABAH, MALAYSIA: BIOMECHANICAL FACILITATION IN VINE SUCCESSION

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PINARD, M. A. & PUTZ, F.E. 1994. Vine infestation of large remnant trees in logged forest in Sabah, Malaysia: Biomechemical facilitation in vine succession. Seventy-nine percent of trees larger than 20 *cm* DBH remaining after logging in the Ulu Segama Forest Reserve carried vines in their crowns 13 -14 years later. On 62% of the vine-infested trees, the vines grew over from neighboring trees; on the remaining trees, vines climbed up their stems from the ground. Isolated trees with diameters exceeding the maximum support diameters used by the common vines often were infested with twining and tendril-climbing vines that climbed up root and branch twiners. This biomechanical dependence of some types of climbers on others results in a successional sequence of vine colonization of isolated remnant trees.

Key words: Climbers - Sabah - *Merremia* - *Ficus* - logged forest - remnant trees - vines - lianas - climbing mechanisms - facilitation - succession

PINARD, M. A. & PUTZ, F.E. 1994. Infestasi pepanjat pada saki-baki pokok-pokok besar di hutan yang dibalak di Sabah, Malaysia: Kemudahan biomekanikal dalam pawarisan pepanjat. Tujuh puluh sembilan peratus daripada pokok-pokok yang mempunyai DBH melebihi 20 *cm*, yang ditinggal selepas pembalakan di Hutan Simpan Ulu Segama, mempunyai tumbuhan pepanjat pada bahagian silaranya, 13 - 14 tahun kemudian. Pada 62% pokok yang diserangi tumbuhan pepanjat, didapati bahawa pepanjat ini menjalar dari pokok-pokok yang berhampiran. Pada pokok yang selainnya, pepanjat ini memanjat batang pokok dari tanah. Pokok-pokok terasing, yang mempunyai diameter yang melebihi diameter sokongan maksimum yang diperalatkan oleh pepanjat, selalunya diserangi oleh pepanjat sulur paut dan pepanjat melilit yang memanjat akar dan pelilit dahan. Beberapa jenis pepanjat bergantung dari segi biomekanikal kepada tumbuhan pepanjat yang lain yang menghasilkan warisan penjajahan pepanjat yang berturut-turut pada saki-baki pokok-pokok yang terasing.

Introduction

Climbing plants are an important component of tropical forests, but they can be a problem for forest managers because after natural or anthropogenic disturbance, vines can impede tree regeneration and growth (Putz 1984, Hegarty 1991). The negative effects of vines on trees are particularly apparent in logged forests in

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Sabah where silviculturalists are concerned about how to avoid vine infestations and how to regenerate forests where vine infestations are severe (Fox 1968, Liew 1973). Even in natural mixed dipterocarp forest in Sabah, vines seem more abundant than in many other tropical lowland forests. In 8 *ha* of primary forest in the Danum Valley Conservation Area in southeastern Sabah, for example, Campbell and Newbery (1993) found 57% of the trees > 9.5 *cm* DBH to be vine infested. After logging, the proportion of vine infested trees appears to be even higher.

Vine climbing mechanisms

Vines can grow extremely rapidly in length, but their access to the canopy is limited by the availability of supports, or trellises, to which they can attach (Putz 1984, Putz & Holbrook 1991). A vine's climbing mechanism determines its maximum support diameter. Vines that climb with the aid of tendrils are limited to small diameter supports; twiners, vines that coil around supports, can ascend stems up to about 30 *cm* in diameter; vines with branches that grow out and surround tree stems can climb up trees larger yet; and root and adhesive-tendril climbers attach to the sides of trees with glandular secretions or by growing into cracks in the host's trees bark and can climb trees of all diameters (Putz 1984, Putz & Chai 1987, Hegarty 1991).

Vines readily climb other vines, so a tree with one vine is likely to become infested with many more (Putz 1984, Campbell & Newbery 1993). Vines can also get into the crowns of larger trees by growing over from neighbors, most commonly by ascending a series of successively taller trees until reaching the canopy where there are abundant potential trellises in the form of branches small enough in diameter to be climbed.

Vines are profuse after logging in the Ulu Segama Forest Reserve in eastern Sabah; climber towers, *i.e.*, trees completely covered with vines, are particularly prevalent (Figure 1A). Even large, isolated and formerly vine-free trees often seem to become vine-infested in logged-over forests. We sampled 13 - 15 - year - old logged forests to estimate density of vine-infested remnant trees and studied the mechanisms that allow vines to climb the boles of large isolated trees in heavily disturbed forest.

Study site description and methods

Study site

The study site was in the Ulu Segama Forest Reserve in eastern Sabah, Malaysia (9782 km^2, state commercial forest, latitude 5^0 0'N, longitude 117^0 30'E, *ca* 200 *m* elevation). Natural forest in the area is mixed dipterocarp forest of *Parashorea malaanonon* Bl.type (Fox 1967) typical of the east coast of Sabah (see Newbery *et al.* 1992, Campbell & Newbery 1993, for a more complete description). Soils are varied, but primarily are derived from uplifted alluvial, tertiary sediments (Leong 1974).

The climate is tropical with the wettest period between November and March and one dry period, usually in April, when mean monthly precipitation is only 104 *mm*. Mean annual rainfall for 1986 through 1992 was 2766 *mm*, mean daily temperature was 26.7^0 C (unpublished Danum Valley Field Center records).

We worked in two secondary forest areas that had been logged 13 and 14 years prior to our study. The average timber volumes removed from the 1978 and 1977 coupes were 110 m^3 ha^{-1} and 118 m^3 ha^{-1} respectively (unpublished records from Pacific Hardwoods Sdn. Bhd.); a ground fire burned through the 1977 logging area in 1983. In January 1992 the logged areas were dominated by *Macaranga hypoleuca*, *M. gigantea* and other pioneer trees. Tangles of vines (mostly *Merremia* spp., *Caesalpinia* spp. and *Uncaria* spp.) and climbing bamboo (*Dinochloa* spp.) were also common.

Sampling methods

To estimate the stocking (*i.e.*, density and basal area) of trees > 20 *cm* DBH (diameter at 1.3 *m* or above buttresses) that remained after logging and the proportion of these trees that were vine infested, we conducted point-quarter sampling in the two areas. Twenty point-quarter samples were taken in each area; points were randomly located along transects, with a minimum distance between points of 50 *m*. We did not sample light-demanding trees that we assumed had established after logging (*e.g.*, *Macaranga* spp., *Neolamarkia cadamba*, *Endospermum peltatum*). We recorded the DBH of the nearest remnant tree > 20 *cm* DBH in each quadrant, whether or not the tree had vines on its trunk or in its crown, and, for vine-infested trees, whether the vines grew from neighbours or apparently climbed up the trunk. We also noted whether the tree was a *Koompasia excelsa* (a species seldom felled because of its unsuitable wood properties) or a dipterocarp, and whether the tree bole was obviously defective (*i.e.*, bent, broken or hollow).

To describe mechanisms used by vines to climb large, isolated, remnant trees, we randomly selected 50 trees > 20 *cm* DBH within 30 *m* of logging roads through areas felled during 1985 - 1991 with vines growing upwards but not yet reaching the lowermost branches. More recently felled areas were selected so as to maximize the availability of trees with vines growing up the stem that had not yet reached the crown. For each tree we recorded DBH, vine species present and the sequence with which the vines ascended the bole. We also determined how the most common vine species climb (*e.g.*, tendril climber, twiner, branch twiner, root climber), the largest diameter support to which they attach and the maximum distance they span between supports.

Results and discussion

Condition of the logged forest

In the 1978 logging area, there were 43.4 trees per *ha* (> 20 *cm* DBH) that remained after logging with a total estimated basal area of 5.2 m^2 ha^{-1}, of which

1.0 m^2 consisted of *Koompassia excelsa* trees. In the 1977 logging area, there were 36.3 remnant trees per *ha* (> 20 *cm* DBH) with a total estimated basal area of 8.8 m^2 ha^{-1} (2.5 m^2 ha^{-1} *K. excelsa*). The 1977 logging area may have fewer remnant trees per *ha* than the 1978 logging area due to fire-related mortality.

Of the 160 remnant trees included in the two sampling areas, 60% had defective trunks. Incidence of stem damage was slightly higher in the burned area, 65% (1977 logging area) compared with 55% in the 1978 logging area. Vine infested trees may have been more heavily damaged by the fire, the lianas presumably providing additional fuel and access to tree crowns.

Seventy-five percent of the remnant trees sampled were vine infested. Fifty-eight percent were colonized by vines growing into their crowns from neighbours and 45%, including 21 trees > 40 *cm* DBH, had vines growing up their stem. While the incidence of vine infestation was similar in the two areas sampled, climbers in the burned area had gained access to tree crowns more often by climbing up stems (on 57% of trees - 1977, 32% - 1978) than by growing over from the crowns of neighbouring trees (on 48% of trees - 1977, 68% - 1978).

Dipterocarps in the logged forest we sampled were sparse (9.8 and 9.5 ha^{-1}) and were slightly less likely to carry vines than other common tree species; 25 of the 39 Dipterocarpaceae in our samples were vine-infested in contrast to 96 of the 121 trees in other families ($G = 3.54$, $p < 0.1$, d.f. = 1). This result is similar to that reported by Campbell and Newbery (1993) for unlogged forest in the Danum Valley Conservation Area, although in the primary forest the percentage of vine-free dipterocarps was higher. In the 8 *ha* of primary forest they sampled, 58.5% of the trees (> 10 *cm* GBH) were vine-free; only 30% of the remnant trees (> 20 *cm* DBH) in the logged forest we sampled were vine-free.

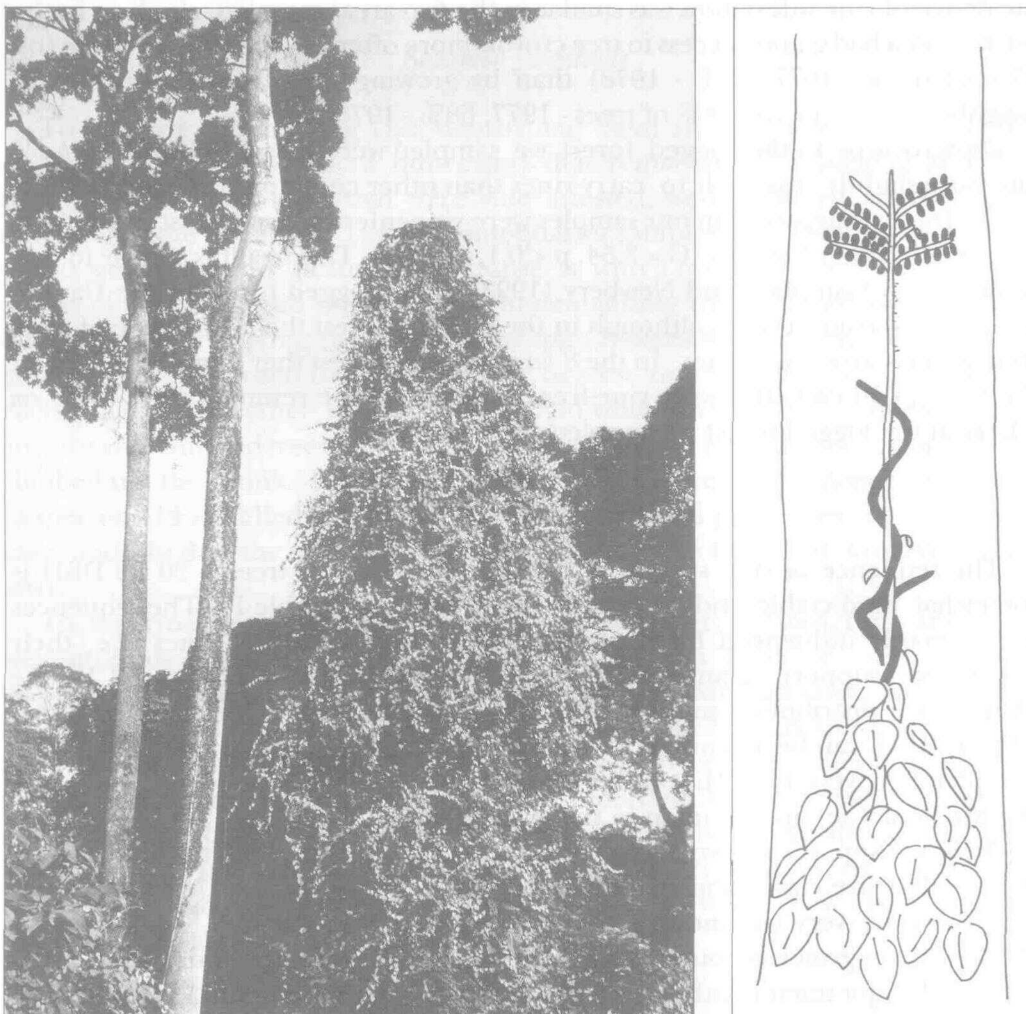
Vines on remnant trees

The sequence of vine species ascending the trunks of trees > 20 *cm* DBH is somewhat predictable and changes with tree diameter (Table 1). The sequences are primarily influenced by biomechanical limitations of the vines (*i.e.*, their maximum support diameters) but are undoubtedly also influenced by the abundance, distribution and growth rates of the different vines species. Trees < 20 *cm* DBH can be ascended by a multitude of species; for example, small trees completely covered by *Mikania scandens* (Compositae) or *Jacquemontia tomentella*. (Convolvulaceae) are common in the study area.

Merremia spp. (Convolvulaceae) were most often the first vines to climb trees in the smallest size class sampled (20 - 30 *cm* DBH). Two species (*M. bornensis* and *M. gracilis*) are very common in disturbed areas within the Ulu Segama Forest Reserve. They grow vigorously along the ground, blanketing roadsides, log yarding areas and major tractor paths within 6 *mth* to 1 *y* of abandonment. *Merremia* climb by twining, can ascend supports < 35 *cm* in diameter, and were the leading vines on several trees sampled in the second size class (30 - 40 *cm* DBH) as well.

The climbing bamboo, *Dinochloa trichogona* and spiny *Caesalpinia latisiliqua* (Fabaceae) were the first climbers on two trees 20 - 30 *cm* DBH. *Dinochloa trichogona* produces stiff leader shoots that are self-supporting to 2.8 *m*. These shoots scramble across any available supports and also twine around stems < 20 *cm* diameter. Uneven growth of nodal intercalary meristems and twisting of internodes in the climbing culms produce zig-zag stem growth that increases the security of attachment (Wong 1986). *Caesalpinia latisiliqua* climbs with the aid of branches that grow more-or-less perpendicularly to the stem and coil around the host tree. Recurved spines on the branches and petioles increase attachment security. The stem grows straight up the side of trees less than approximately 40 *cm* DBH and can span gaps up to 1.5 *m* between supports.

Smaller diameter twining vines (*e.g.*, *Mikania scandens* and *Jacquemontia tomentella*) were common on trees of all size classes. These two species, however, are restricted to twining around supports < 15 *cm* in diameter and are only able to climb isolated



(A) (B)

Figure 1. (A) A climber tower; (B) a small-leaved root climber being ascended by twining climbers

Table 1. For given host tree diameter class, counts are presented for the number of times a species or species group was observed as the first, second or third vine up the tree

	climbing mode	Tree diameter 20 - 30 cm			30 - 40 cm			> 40 cm		
Ficus spp.	root climbers				5^{1st}			11^{1st}		
Piper spp.	root climbers				2^{1st}			4^{1st}		
Caesalpinia latisiliqua	branch climber	1^{1st}	2^{2nd}		6^{1st}	2^{2nd}		1^{1st}	2^{2nd}	3^{3rd}
Merremia spp.	twiners	9^{1st}			4^{1st}	10^{2nd}	1^{3rd}	1^{1st}	16^{2nd}	2^{3rd}
Jacquemontia tomentella	twiner		1^{2nd}	1^{3rd}			5^{3rd}			2^{3rd}
Mikania scandens	twiner		1^{2nd}				1^{3rd}			1^{3rd}
Dinochloa spp.	scambler-twiners	1^{1st}	2^{2nd}			3^{2nd}	2^{3rd}		1^{2nd}	
Uncaria spp.	hook climbers		3^{2nd}	2^{3rd}	2^{1st}	4^{2nd}	1^{3rd}			3^{3rd}
hemiepiphytes	root climbers	1^{1st}						3^{1st}		1^{3rd}
Smilax sp.	tendril climber		1^{2nd}							

trees of larger diameters if other vines are already present to serve as a trellis. These species, when found on trees exceeding their maximum support diameters, were generally found climbing up stems of *Dinochloa, Merremia, Caesalpinia* or *Uncaria* species (Table 1, Figure 1A).

The trunks of trees > 40 *cm* DBH are not suitable trellises for the common twining, tendril climbing or hook climbing species but are readily ascended by species that climb with the aid of adventitious roots. The primary colonists of these large remnant trees were *Ficus* spp. and *Piper* spp; these species, however, were never observed to span the gaps between host trees. Access to the crowns of large isolated trees by twining and tendril climbing vines is facilitated by the presence of these root climbers (Figure 1B).

Merremia stems were frequently found secured to the lower trunks of large trees via *Ficus* and *Piper* stems; the convolvulaceous climbers had apparently ascended the tree by twining up the root climbers. Once a sufficient height was reached such that the host tree's diameter, due to tree taper, was below the vine's maximum support diameter, *Merremia* stems often continued to climb by twining around the host tree's stem. A similar facilitation of climbing by root climbers was observed in *C. latisiliqua.*

We found several *Merremia* spp. vines climbing boles of trees larger than their critical support diameter in spite of downward slippage of the stems. Dislodged stems piled in coils at tree bases built up increasingly tall foundations from which leader shoots twined upwards; even if they too slip downwards, height increments are attained. More efficient vine height growth (*i.e.*, steeper twining angles) can occur with increasing height due to the presence of tree branches or bark protuberances that prevent downwards vine slippage.

The phenomenon of twining and tendril climbing vines using root and adhesive-tendril climbing vines to ascend trees larger in diameter than their attachment modes allow is also common in primary forest in Sabah. In addition to several species of root climbing *Piper* and *Ficus* that provide trellises for other vines, we observed several species of Rubiaceae, Araceae and Apocynaceae facilitating canopy access for other vine species. We also observed species of *Passiflora* with adhesive tendrils being climbed by vines lacking the capacity to attach to large diameter trees.

Conclusion

Stocking of advanced regeneration larger than 20 *cm* DBH is sparse in the Ulu Segama Forest Reserve and many of the trees present are defective or vine-infested. The hitherto undescribed process of twining and tendril climbing vines ascending trees by using root climbers as trellises means that even large, isolated and previously vine-free trees are not safe from the onslaught of climbing plants. This biomechanical dependence of some vines on others is a clear example of early colonizers facilitating the growth of other species.

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