CLIMBING BAMBOO (*DINOCHLOA* SPP.) IN DERAMAKOT FOREST RESERVE, SABAH: BIOMECHANICAL CHARACTERISTICS, MODES OF ASCENT AND ABUNDANCE IN A LOGGED-OVER FOREST

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YAP, S.W., CHAK, C.V., MAJUAKIM, L., ANUAR, M. & PUTZ, F.E. 1995. Climbing bamboo (*Dinochloa* spp.) in Deramakot Forest Reserve, Sabah: biomechanical characteristics, modes of ascent and abundance in a logged-over forest. Climbing bamboos are extremely abundant in Deramakot Forest Reserve, a lowland dipterocarp forest in central Sabah that was subjected to uncontrolled selective logging in 1975. In 1993, 53% of the trees > 10 cm dbh (diameter at 1.4 m) were bamboo infested and an additional 23% carried vines other than bamboo. The likelihood that a tree supported bamboo in its crown, however, decreased with tree diameter; bamboos were not observed ascending trunks of trees > 41.2 cm dbh (*Dinochloa scabrida*) or 39.1 cm dbh (*D. trichogona*). The angle of ascent of twining bamboo stems also decreased with increasing tree diameter, suggesting a biomechanical explanation for their distribution among potential host trees. Most bamboos reached the crowns of trees > 30 cm dbh by climbing previously established canopy vines or by climbing over from neighbouring trees. Free-standing culms attained heights of up to 3.45 m (*D. scabrida*) and 2.95 m (*D. trichogona*); unsupported culms of *D. scabrida* that twined around one another grew up to 4.68 m tall before toppling over. A partial explanation for the capacity of climbing bamboos to dominate logged-over forests is that they can climb where other vines fail in the absence of external support.

Key words: Biomechanics - climbing bamboo - *Dinochloa* - vines - forest weeds

YAP, S.W., CHAK, C.V., MAJUAKIM, L., ANUAR, M. & PUTZ, F.E. 1995. Buluh memanjat (*Dinochloa* spp.) di Hutan Simpan Deramakot, Sabah: ciri-ciri biomekanikal, cara-cara memanjat dan kepadatan di dalam hutan yang telah dibalak. Buluh-buluh memanjat terdapat dengan banyaknya di Hutan Simpan Deramakot, sebuah hutan

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dipterokarpa tanah pamah di bahagian tengah Sabah yang telah mengalami pembalakan terpilih tak terkawal pada 1975. Dalam 1993, 53% daripada pokok > 10 cm dbh (diameter 1.4 m) telah diserangi buluh dan tambahan 23% mempunyai tumbuhan memanjat selain daripada buluh. Akan tetapi, kemungkinan sesebatang pokok menyokong buluh pada silaranya berkurang dengan diameter pokok; buluh didapati tidak memanjat pokok-pokok yang berdiameter > 41.2 cm (*Dinochloa scabrida*) atau > 39.1 cm dbh (*D. trichogona*). Darjah menaik bagi batang buluh yang melilit juga berkurang dengan bertambahnya diameter pokok, mencadangkan satu penjelasan biomekanik untuk taburan buluh di antara pokok-pokok perumah yang berpotensi. Kebanyakan buluh mencapai silara pokok > 30 cm dbh dengan memanjat pepanjat yang tumbuh terdahulu atau dengan memanjat ke atas daripada pokok-pokok yang berhampiran. Batang-batang yang berdiri bebas mencapai ketinggian sehingga 3.45 m (*D. scabrida*) dan 2.95 m (*D. trichogana*); batang *D. scabrida* yang tidak disokong dan meliliti satu sama lain tumbuh sehingga ketinggian 4.68 m sebelum jatuh ke bawah. Sebahagian penjelasan untuk kapasiti buluh memanjat menerokai hutan yang telah dibalak ialah kebolehan mereka memanjat yang mana tumbuh-tumbuhan memanjat yang lain gagal dengan ketiadaan sokongan luar.

Introduction

Climbing bamboos (*Dinochloa* spp.) are extremely abundant and persistent in many logged-over forests in Sabah. Although there are potential uses for the slender stems of climbing bamboos (Billington 1991), they are generally perceived as a silvicultural nuisance and are thus targeted for eradication by slashing and herbiciding (Liew 1973). Although Wong (1985) contributed substantially to our understanding of the growth habits of climbing bamboo and Dransfield (1992) outlined their taxonomy, much remains to be learned about these silviculturally problematic plants. We initiated this study in the belief that progress towards developing inexpensive, effective, and environmentally benign methods for avoiding or controlling climbing bamboo infestations will be facilitated by increased understanding of their biology.

The slender culms of climbing bamboos can ascend to the canopy only where suitable supports are available. If climbing bamboos resemble other types of twiners (e.g. Hegarty 1991, Putz & Holbrook 1991), they can utilize only small-diameter and closely-spaced supports. We anticipated that this biomechanical constraint influences the distribution of climbing bamboos within forests. In particular, we predicted that the likelihood of climbing bamboo infestation decreases with increasing tree size and where small-diameter potential supports (e.g. other vines) are lacking. To further elucidate how biomechanical characteristics might influence climbing bamboo distribution and abundance, we also investigated the growth habits of two species that are abundant in central Sabah (*Dinochloa scabrida* and *D. trichogona*).

Materials and methods

Site and species descriptions

This study was conducted in lowland dipterocarp forest in Deramakot Forest Reserve (5° 20' N, 117° 30' E) in areas that were selectively logged in 1975 (Compartments 37 and 48). At the time of our study (1993), the uncontrolled nature of the logging was evidenced by low stocking of potential crop trees, eroded skid trails, extensive vine tangles, and abundance of damaged and hollow trees.

Dinochloa scabrida S. Dransf. and *D. trichogona* S. Dransf. are clump-forming, solid-culmed bamboos that branch above as well as below ground (Wong 1985). In addition to reproducing from seed at long and irregular intervals, both species spread vegetatively through rhizomatous expansion and by rooting of fallen culms. Climbing bamboos often proliferate after logging and fire, presumably in response to canopy opening.

Methods

To estimate the proportion of trees infested by climbing bamboos and other vines and to determine how infestation varies with tree size, the closest tree in each of 3 size classes (10-20, 20-40, 40-80 cm dbh) was selected from 25 randomly-located points. The mode of ascent was described for climbing bamboos growing on another set of randomly located trees (N=156) of 4 size classes (20-30, 30-40, 40-60, and > 60 cm dbh). The modes of ascent were categorised as follows: directly up the host tree's stem; over from neighbouring tree crowns; in a tangle of other bamboo stems; or, up other vines.

To examine the biomechanical limitations to climbing, observations on the relationship between angle of ascent (deviation from vertical) and tree diameter were made on a randomly-selected sample of 20 trees for each climbing bamboo species; only trees around which the bamboo culms had twined at least twice were sampled. Culm diameter at the centre of the internode nearest to 1.4 m above ground, length of the same internode, and tree dbh were recorded. The direction of twining (clockwise or anti-clockwise) was also recorded.

The heights that randomly-selected bamboo culms attained without external support were determined in both open (< 50% canopy cover) and more shaded areas. Additional observations of free-standing heights of bamboo culms twining around each other in a tripod-like fashion but without any other support were made.

Results and discussion

Of the 75 trees > 10 cm dbh censused, 76% were infested with either climbing bamboos or other vines. The proportion of trees supporting climbing plants declined with tree size and there was a positive association between bamboos and other types of climbers (Table 1). A mechanistic explanation for this association is suggested by data on modes of canopy ascent based on an independent sample of 156 trees (Figure 1). The stems of trees < 30 cm dbh were often directly ascended by twining bamboo culms but larger trees generally were climbed indirectly. Although access to the forest canopy by climbing bamboos is facilitated by prior colonization by other climbing plants, the association is probably also due to some trees being particularly susceptible to climber infestations due to the presence of nearby intermediate supports or low branches. Campbell and Newbery (1993) working in unlogged dipterocarp forest in eastern Sabah also suggested that tree branching patterns might influence vine susceptibility. In a nearby forest, Pinard and Putz (1994) described how vines that climb with the aid of adventitious roots or adhesive tendrils mechanically facilitate crown access of other vines by providing small-diameter trellises.

Table 1. Presence of climbing bamboos and other types of vines in tree crowns by stem diameter class

Tree dbh (cm)	No. of trees					
	With bamboo	Without bamboo	With vines	Without vines	With vines and bamboo	Without vines or bamboo
10-20	17	8	11	14	5	4
20-40	17	8	14	11	4	5
40-80	6	19	3	22	2	9

The test of association (Chi-squared) between climbing bamboo and other vines was significant ($p<0.05$).

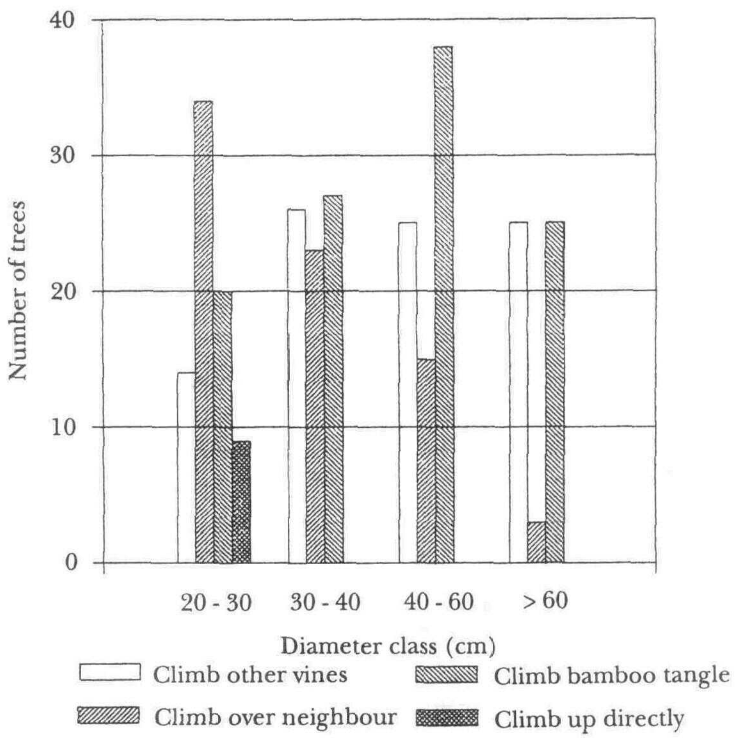

Figure 1. Association between mode of canopy ascent with tree diameter for *D. scabrida* and *D. trichogona*

Climbing bamboo, like other twiners, ascends at an increasing angle from vertical with increasing tree diameter (Figure 2). However, there were no correlations between bamboo culm diameter or internode length with angle of ascent. Billington's (1991) failure to detect a relationship between culm strength and diameter in *D. scabrida* and *D. trichogona* is consistent with this finding. The trees around which climbing bamboo culms successfully twined had maximum diameters of 41.2 cm and 39.1 cm dbh for *D. scabrida* and *D. trichogona* respectively. Presumably, the combinations of culm rigidity and frictional interactions between culm and in trees of larger diameter bark are not sufficient to prevent the bamboo coils from slipping down. This suggestion is supported by the observation of coils of fallen bamboo stems wrapped around the bases of several large trees.

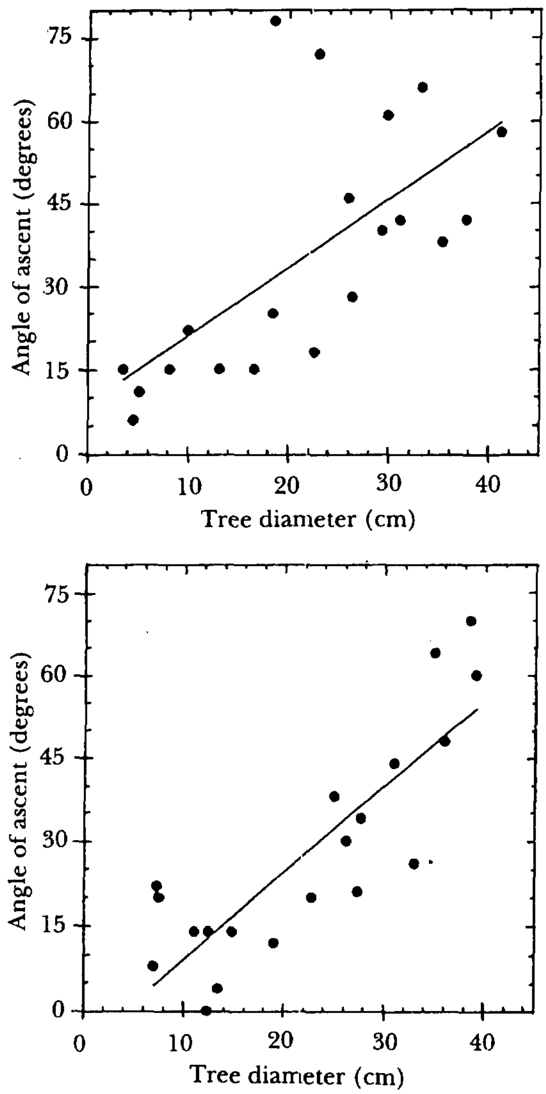

Figure 2. Relationship between angle of ascent (deviation from vertical) and tree diameter for (a) *D. scabrida* (angle of ascent = 3.17 + 1.29 tree diameter, std. dev. = 0.20, r = 0.85, $p < 0.05$) and (b) *D. trichogona* (angle of ascent = -6.18 + 1.57 tree diameter, std. dev. = 0.20, r = 0.86, $p < 0.05$)

Although they may experience the same general mechanical constraints to climbing as other vines, climbing bamboo stems successfully twine around tree stems much larger than can be climbed by other vines (Hegarty 1991). Billington's (1991) estimates of the apparent moduli of elasticity and permissible working stresses of *Dinochloa* spp. stems provide at least a partial explanation for this observation; stems of other vine species that have been tested were much more flexible (Putz & Holbrook 1991). As pointed out by Wong (1985), the rough hairs on the internodes of climbing bamboo may also help prevent the coils from slipping.

Anti-clockwise twining was slightly more common in both *D. scabrida* (34 out of 50 culms) and *D. trichogona* (29 out of 50 culms) than clockwise twining but stems emerging from the same rhizome twining in opposite directions were also observed. More surprisingly, perhaps, are the two instances of culms changing their direction of twining half-way up the stem of their supporting tree. Perhaps the twining direction is influenced by contact with rigid supports, i.e. it is a thigmomorphogenic process. This versatility may be advantageous in allowing braiding around the same tree by twining in opposite directions. Several twining bamboo culms were observed to support one another mechanically.

Climbing bamboos were self-supporting to greater heights than most vines that had been studied (Hegarty 1991). Single stems of *D. scabrida* reached 1.48 m (maximum = 1.95 m, N=10) in shaded areas and mean heights of 2.24 m (maximum = 3.45 m, N=20) in open canopy areas. Mean heights of unsupported *D. trichogona* were 1.88 m (maximum = 2.37 m, N=13) in shaded areas and 2.48 m (maximum = 2.95 m, N=13) in open areas. Where 3-5 otherwise unsupported *D. scabrida* stems coiled around one another, their mean height was 3.41 m (maximum = 4.68 m, N=10). This well developed capacity for self-support increases the likelihood of climbing bamboo culms reaching suitable trellises (e.g. low branches) before toppling over under their own weight.

Conclusions

Climbing bamboos have rigid stems that are self-supporting to substantial heights, can bridge large gaps between supports, and ascend relatively large-diameter trees. These biomechanical characteristics, coupled with a well-developed capacity for vegetative expansion contribute to the silvicultural menace of climbing bamboos. Considering the high costs and modest success in treating climbing bamboo tangles after they have developed, greater emphasis should be placed on reducing logging damage so as to avoid their proliferation.

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