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MORPHOLOGICAL SPECIALIZATION AND ATTACHMENT SUCCESS IN TWO TWINING LIANAS[1]

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ABSTRACT

The success rates of attachment of two twining lianas, *Ipomoea phillomega* (Vell.) House (Convolvulaceae) and *Marsdenia laxiflora* Donn. Sm. (Asclepiadaceae), were compared. *Ipomoea phillomega*, a liana with relatively unspecialized shoot architecture, was found to have a lower success rate than *M. laxiflora*, a liana with specialized photosynthetic and twining shoots. The relatively lower success rate of *I. phillomega* is due to its reduced ability to remain attached to very thin supports (<7 mm in diameter).

CLIMBING PLANTS employ a wide range of devices to secure attachment to a support. These devices constitute the "prehensile mechanism" of a vine (appareil préhenseur, Baillaud, 1962a) and include adhesive roots, tendrils, and nutating shoots which twine upon touching a potential support. The morphological nature of prehensile mechanisms is well understood (Troll, 1937, 1939), and laboratory experiments have been conducted to investigate the behavior of tendrils and twining shoots (Baillaud, 1962a, b). Research on the physiology of tendrils has been reviewed by Jaffe and Galston (1968). Twining shoots are morphologically the simplest of prehensile mechanisms. Vines climbing by this technique produce shoots which characteristically have long internodes and reduced leaves. These shoots nutate as they elongate, and any structure within the trajectory of nutation can serve as a potential support. Attachment of the shoot by twining around the support represents a continuation of nutation with a reduced radius (Baillaud, 1962b).

In the field, a twining vine will encounter a variety of potential supports. Although it seems obvious that some of these will prove too weak to support the weight of the shoot while others will be too thick for the shoot to develop and that only successful attachments will lead to further growth of the vine canopy, there is apparently no published information on the dynamics of support "selection" by a particular kind of prehensile mechanism, or on the success rate of attachment events under field conditions.

In the course of an investigation of the shoot dynamics and vegetative spread of tropical lianas, I monitored the attachment attempts of nutating shoots in two dissimilar lianas, *Ipomoea phillomega* (Vell.) House (Convolvulaceae) and *Marsdenia laxiflora* Donn. Sm. (Asclepiadaceae) (Fig. 1, 2). In *I. phillomega*, twining shoots have leaves which gradually expand as the shoot nutates. The twining shoots of *M. laxiflora* never produce functional leaves, since the leaf primordia are abscised soon after displacement from the apical bud. In this species, the only foliage leaves are those borne on non-twining short-shoots.

MATERIALS AND METHODS—This work was conducted during 1973 and 1974 in a tropical rainforest on the lands of the Estación de Biología Tropical "Los Tuxtlas" (a facility of the Universidad Nacional Autónoma de México) in the Sierra de Los Tuxtlas, Veracruz, México.

I obtained an estimate of the distribution of diameters of potential supports by establishing a grid of random points on the forest floor, extending strings along random azimuths from stakes 1.5 m above the random points, and measuring with a vernier caliper the diameters of all potential supports touched by the strings. The height of 1.5 m was chosen for convenience in measuring diameters. The area sampled comprised about 2 ha and included undisturbed primary forest and natural clearnings caused by tree-falls. A total of 500 potential supports was located and measured by this technique. I followed 470 attachment attempts for each of the species. For each attempt the diameter of the support was measured and the attempt was monitored until it could be recorded as a success or failure. Shoots which remained on the support long enough to continue exploration or to branch were scored as

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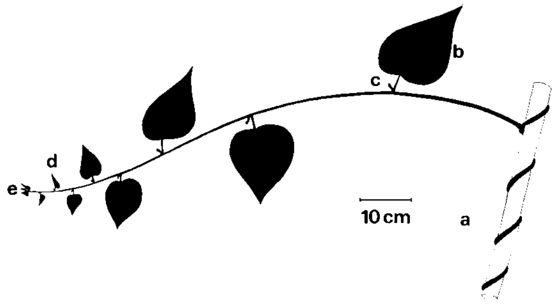

Fig. 1. Shoot architecture of *Ipomoea phillomega*, showing parent shoot attached to support (a), fully expanded leaf (b), axillary bud (c), unexpanded adaxiably folded leaf (d) and shoot tip (e). The distal one-third of this shoot circumnutates and can attach to a support.

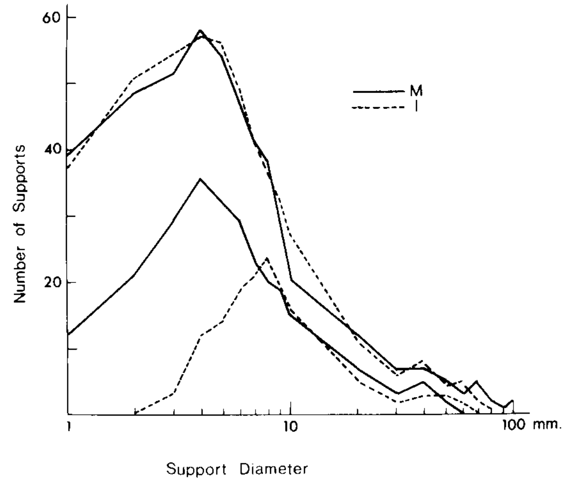

Fig. 3. Frequency distribution of diameters of attempted and successful supports for *Marsdenia laxiflora* ("M") and *Ipomoea phillomega* ("I"). The upper two curves show frequency distribution of diameters of attempted supports and are statistically indistinguishable from each other (Kolmogorov-Smirnov statistic, $P > 0.10$). The lower two curves show frequency distribution of successful attachments and differ significantly in location (Kolmogorov-Smirnov statistic, $P < 0.001$). The graphs show that both species attempt attachment to the same population of support diameters, but that *Ipomoea phillomega* is less able to remain attached to thin supports.

successes, while shoots which were unable to remain attached to the support were scored as failures. In order to quantify the morphological differences between the twining shoots of *I. phillomega* and *M. laxiflora,* I selected a sample of 100 shoots of each and measured the diameters of the nutating portion of the shoots. Statistical analyses follow Sokal and Rohlf (1969).

RESULTS—The visually obvious morphological differences between the shoot systems of *I. phillomega* and *M. laxiflora* were verified by the measurements of stem diameter. The nutating stems of *I. phillomega* are relatively thick ($\bar{x}$ = 1.8 mm) while those of *M. laxiflora* ($\bar{x}$ = 0.8 mm) are relatively thin. The difference in sample means is statistically significant ($t = 45.4$, $P < 0.001$).

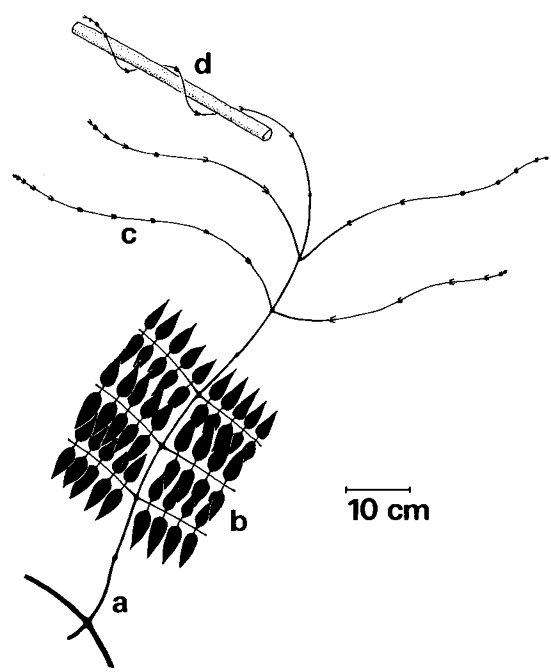

Fig. 2. Shoot architecture of *Marsdenia laxiflora*, showing a parent long-shoot (a), three pairs of short-shoots, each with expanded leaves (b), an "exploring" long-shoot with unexpanded leaves (c), successful attachment of a long-shoot to a support (d).

Figure 3 compares the frequency distributions of diameters of "attempted" and "successful" supports. Not shown is the distribution of potential supports (those located by the "stretched string" technique), since this distribution is statistically indistinguishable from each of the two upper curves ("attempts") of the figure (Kolmogorov-Smirnov statistic, $P > 0.10$). Similarly, the two "attempts" curves for each of the species cannot be distinguished from each other statistically (Kolmogorov-Smirnov statistic, $P > 0.10$). The close similarity among the three frequency distributions (potential supports, *I. phillomega* "attempts" and *M. laxiflora* "attempts") shows that the nutating shoots of these species attempt attachment to supports of different diameter in proportion to the relative frequency of the diameters encountered.

A more interesting relationship is revealed by the two lower curves ("successes") in Fig.

3. The number of successful attempts for each species is proportional to the area under the respective "success" curve. Of 470 attempts monitored by each of the species, 247 (53%) in *M. laxiflora* were successful, but only 143 (30%) in *I. phillomega* were successful. The difference between these percentages is significant (angular transformation of proportions, $t = 3.5, P < 0.001$). The shift to the right (toward thicker supports) of the *I. phillomega* "success" curve is statistically significant (Kolmogorov-Smirnov statistic, $P < 0.001$) and shows that the shoots of that species are less able to remain attached to supports thinner than about 7 mm diameter. In some cases, the thick, relatively inflexible shoots of *I. phillomega* were unable to clasp firmly the thin supports and in other cases the thinner supports gave way under the weight of the shoot. Most of the supports, potential and utilized, are very thin. Despite the fact that this study was conducted in a forest, my random sample of 500 potential supports failed to include any structure greater than 10 cm in diameter. The most frequently encountered supports were petioles of leaves of young trees and the aerial roots of Araceae.

DISCUSSION—The results of this investigation provide an opportunity for comparing the utility of basically similar prehensile apparatuses which differ in their degree of morphological specialization. In *I. phillomega,* all young shoots are leafy and twine but in *M. laxiflora* there is a morphological specialization between leafy short-shoots and functionally leafless long-shoots (twiners). In this case, specialization for thin, flexible, leafless nutating shoots has resulted in greater success in attaching to a support and allowing upward growth of the liana toward the forest canopy.

Since not all twining climbers have developed this degree of specialization, it is possible that there are energetic "costs" associated with the *M. laxiflora* strategy. The cost may lie in the production and maintenance of leafless shoots which do not contribute directly to carbon assimilation

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