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SHORT COMMUNICATION

Lianas and their supporting plants in the understorey at Los Tuxtlas, Mexico

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Lianas are woody climbing plants that begin their life cycles as seedlings rooted in the ground, but eventually rely on other plants for physical support in order to reach the top of the forest canopy (Holbrook & Putz 1996, Putz & Holbrook 1991). Lianas can negatively affect plants they climb by competing with them for common resources such as light, water and nutrients, and by causing them direct physical damage (Dillenburg *et al*. 1995, Pérez-Salicrup & Barker 2000, Stevens 1987, Whigham 1984). Yet, there is little documentation about the size at which liana individuals of different species begin to climb on other plants in nature. This information is important because the size at which a liana begins to climb on other plants will determine when lianas potentially start physically affecting their supporting plants. Furthermore, although the growth of liana seedlings might be determined by light (Sanches & Válio 2002), the availability of support will also largely influence the rate of growth of liana stems (Peñalosa 1982, 1983, 1985). Thus, information about the size at which liana species find support in the forest understorey will be useful in understanding future growth of liana individuals.

Lianas show a variety of adaptations for attaching themselves to their host and climbing towards the forest canopy. These adaptations include stem twining; the use of tendrils, thorns, and spines; and adhesive, adventitious roots (Hegarty 1991, Putz & Holbrook 1991). Some liana seedlings climb on other plants, including tree seedlings, in the forest understorey (Pérez-Salicrup *pers. obs*.). However there are no studies that have evaluated the direct physical effect of lianas on other plants in the forest understorey. By negatively affecting their supporting tree seedlings, liana seedlings may affect tree regeneration.

This study has two main objectives. The first objective is to assess the size at which seven abundant liana species in a tropical rain forest of south-east Mexico start relying on other plants for support. The second objective is to evaluate how frequently lianas climb tree seedlings and other understorey plants.

Field work was conducted at Los Tuxtlas research station of the National Autonomous University of Mexico in March–April of 2003. The 700-ha reserve is located between 150–700 m above sea level in the state of Veracruz, Mexico, at 18°34′N and 95°04′W. The reserve is adjacent to the 3500-ha Los Tuxtlas Biosphere Reserve. The climate is warm and humid with an annual average precipitation of 4725 mm and annual mean temperature of 23.2 °C. Precipitation is fairly constant throughout the year, but a drier period with less rain and higher temperatures exists between March and May (Soto & Gama 1997). Vegetation at the research station consists of old-growth tropical rain forest with secondary vegetation near roads and buildings (Ibarra-Manríquez *et al*. 1997). In the past 20 y, forests around the station have been extensively cleared for cattle farming and agriculture (Dirzo & García 1992, Guevara *et al*, 1997).

We selected the seven most abundant liana species at Los Tuxtlas (Table 1), according to a seedling database (Martínez-Ramos 1991), and from written reports (González *et al*. 1997). For each of these species we measured at least 20 individuals (Table 1), roughly half of which were not climbing, and half of which appeared to have just begun to climb, i.e. they had only one coil or one fixed tendril on their support, and depended on this support to keep upright. The seven most abundant liana species at Los Tuxtlas were either tendril-climbing ($n = 3$) or stem-twining species ($n = 4$). Liana individuals were sampled randomly, by walking along the network of paths within the station. At every 20 m we looked for

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Table 1. Family, climbing method, sample size (N), median basal diameter, median stem length, and median distance from the base of the liana to the base of its support for non-climbing and climbing individuals of seven abundant liana species at Los Tuxtlas, Veracruz, Mexico. NC = non-climbing, C = climbing.

Species	Family	Climbing method	*N*		Basal diameter (mm)		Stem length (m)		Distance to support (m)
			NC	C	NC	C	NC	C	
Forsteronia viridescens S. F. Blake	Apocynaceae	Stem twiner	12	11	2.4	2.9	1.31	1.16	0.50
Salacia megistophylla Standl.	Hippocrateaceae	Stem twiner	14	10	26.8	36.2	2.20	6.15	2.50
Urera eggersii Hieron.	Urticaceae	Stem twiner	12	10	4.1	4.5	0.56	1.64	0.40
Ipomoea phillomega (Vell) House	Convolvulaceae	Stem twiner	15	12	3.6	3.7	0.48	1.13	0.34
Cissus gossypiifolia Standl.	Vitaceae	Tendril climber	14	14	2.9	4.0	0.36	1.21	0.24
Paullinia clavigera Schltdl.	Sapindaceae	Tendril climber	19	11	6.2	8.7	0.60	1.92	0.64
Strychnos tabascana Sprague & Sandwith	Loganiaceae	Tendril climber	17	14	5.1	7.9	0.62	2.20	1.30

one climbing and one non-climbing liana individual of the focal species (Table 1) at least 3 m from either side of paths. We did not always find individuals that appeared to just have begun to climb, so the number of non-climbing individuals was slightly higher for most species (Table 1). All individuals measured were rooted in the ground and were apparently not connected to other stems, so they apparently emerged as seedlings, and are not sprouts from other stems. The type of support on which lianas were climbing was categorized as palm, tree, liana or understorey plant $\leq$ 50 cm tall. For each individual we measured length of the stem and basal diameter. For climbing individuals, we also measured the distance from the base of the climbing liana to the base of the support. We conducted a logistic regression to evaluate the climbing status of liana individuals as a function of stem length and basal diameter for each species. We compared the distance from the base of the liana to the base of its support between stem-twining and tendril-climbing species with a nested ANOVA, in which species were nested within climbing mechanism, after log-transforming data so they would conform to normality. Finally, we evaluated whether the support type was independent of liana species or climbing method with chi-square independence tests.

Median distance from rooting position to support in climbing individuals ranged from 1.2–6.1 m (Table 1). Length was a significant variable in the logistic regression model for five of the seven species (Table 2). For all these species, individuals were significantly longer when climbing than when not climbing (Table 1). Climbing for individuals of these species seems to be size dependent. Length was not a significant variable in the logistic regression model for *Forsteronia viridescens* and *Urera eggersii* (Table 2). Climbing for individuals of these species could be limited by the availability of the appropriate supports, and not by the length of the individual, although additional studies should be conducted to prove this notion. Basal diameter was not a significant variable in the logistic regression model for any species.

Table 2. Parameters for the Constant, the variables Length, and Diameter, and McFadden's Rho^2 in Log linear models to evaluate whether individuals of seven abundant liana species at Los Tuxtlas, Veracruz, Mexico, were climbing or not climbing.

Species	Constant	Length	Diameter	McFadden's Rho^2
Forsteronia viridescens	−1.14	−0.002	1.5	0.012
Salacia megistophylla	−2.54	0.009*	0.6	0.375
Urera eggersii	3.44	0.039	−18.0	0.439
Ipomoea phillomega	−3.09	0.026*	1.5	0.214
Cissus gossypiifolia	−5.12*	0.054**	2.8	0.563
Paullinia clavigera	−6.59*	0.025*	3.9	0.522
Strychnos tabascana	−3.43	0.022*	0.2	0.430

* $P \leq 0.05$, ** $P \leq 0.01$.

The distance from the base of lianas to their support was larger for individuals of stem-twining species than for individuals of tendril-climbing species, and differed between species within climbing mechanism (climbing mechanism, df = 1, F = 18.5, $P < 0.001$; Species within climbing mechanism, df = 5, F = 4.9, $P < 0.001$). This suggests that stem-twining lianas generally use supports that are further from the base of their stem than tendril-climber species, but that for a particular climbing type, species differ in how far they forage for a support.

The type of support climbed was independent of liana species and climbing method. Apparently, lianas that have just begun to climb rely on any support available. Interestingly, this includes palms, which have been observed to carry fewer lianas than trees in other tropical forests (Pérez-Salicrup *et al.* 2001). It is possible that liana shedding occurs at later stages of palm growth (Pérez-Salicrup *et al.* 2001, Putz 1984).

To evaluate the frequency of liana seedling infestation on other plants in the forest understorey, we measured basal diameter and height of all understorey plants $\leq$ 50 cm in height in 100 1-m^2 square plots. For each

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plant we recorded whether they were climbed by lianas or not. Plots were established randomly at 7 m from either side of the station paths with a distance between plots of ≥ 20 m. Liana seedlings were considered as climbing when they appeared to be resting on other understorey plant and not being able to grow upright without support. Understorey plants were not identified to species, but were categorized as herbs, ferns, herbaceous vines, palms, trees and lianas. We evaluated whether the proportion of seedlings climbed by lianas was independent of support type with a chi-square independence test. We also classified understorey plants in three basal diameter categories (0.5–3.0, 3.1–5.0 and < 5.1 mm) and into three height categories (i.e. < 20.0, 20.1–30.0, 30.1–50.0 cm) and evaluated whether lianas climbed on seedlings depending on basal diameter or height categories with a chi-square independence test.

A total of 1758 understorey plants were recorded, 45 of which were climbed by lianas. Thus only 2.6% of all plants in the understorey are climbed by liana seedlings. The tropical rain forest of Los Tuxtlas is an old-growth forest with a high disturbance rate, mainly caused by fragmentation and edge effects (Dirzo & García 1992, Guevara *et al.* 1997). Disturbed forests usually have higher liana densities than undisturbed sites (DeWalt *et al.* 2000, Hegarty 1991, Schnitzer & Bongers 2002). Liana densities and the proportion of trees that carry lianas at Los Tuxtlas is high (Pérez-Salicrup & de Meijere 2005). Yet, the proportion of understorey plants ≤ 50 cm in height that were infested with liana seedlings was very low. Therefore, it is likely that the proportion of understorey plants climbed by liana seedlings in the forest floor of other non-disturbed tropical forests might be lower than the results reported here. Hence, even if liana seedlings affect the survival and growth of their supporting plant, liana seedlings climbing directly on other seedlings would have only a marginal effect on seedling dynamics in the forest understorey.

One explanation for the low number of seedlings carrying lianas in the forest floor is the small size of plants in the understorey. Most of the liana individuals studied in the first part of this study were > 50 cm in length when climbing (Table 1), so apparently seedlings ≤ 50 cm in height are not very likely to be used as supports. Putz & Holbrook (1991) experimented on diameter classes of support types on which lianas climb. They concluded that most liana individuals of stem-twining and tendril-climbing species need supports ≥ 4 cm in diameter. Hence, the low proportion of seedlings in the understorey climbed by liana seedlings may also reflect the fact that seedlings are too thin to act as support for many liana species.

The type of support climbed was independent of support type, but larger support categories in terms of basal diameter ($\chi^2 = 16.7$, df = 2, $P < 0.001$) and height ($\chi^2 = 37.3$, df = 2, $P < 0.001$) showed a higher proportion of individuals supporting lianas than supports of smaller categories. Apparently, larger seedlings are more likely to become adequate support for liana seedlings, both because of their increased size, and presumably because of longer time to potential exposure to liana infestation.

In summary, the size at which lianas start relying on other plants seems to vary widely between species, and for some liana species the event of climbing is not affected by the length or basal diameter of individuals. The event of lianas climbing on tree seedlings or other plants in the forest understorey was infrequent in the study site, thus it is unlikely that at Los Tuxtlas lianas might affect tree regeneration by affecting tree seedlings.

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LITERATURE CITED

DEWALT, S. J., SCHNITZER, S. A. & DENSLOW, J. S. 2000. Density and diversity of lianas along a chronosequence in a central Panamanian lowland forest. *Journal of Tropical Ecology* 16:1–9.

DILLENBURG, L. R., TERAMURA, A. H., FORSETH, I. N. & WHIGHAM, D. F. 1995. Photosynthetic and biomass allocation responses of *Liquidambar styraciflua* (Hamamelidaeae) to vine competition. *American Journal of Botany* 82:454–561.

DIRZO, R. & GARCÍA, M. C. 1992. Rates of deforestation in Los Tuxtlas, a Neotropical area in Southeast Mexico. *Conservation Biology* 6:84–90.

GONZÁLEZ, S. E., DIRZO, R. & VOGHT, R. C. (eds). 1997. *Historia Natural de Los Tuxtlas*. Instituto de Biología e Instituto de Ecología, Universidad Nacional Autónoma de México, México D.F. 647 pp.

GUEVARA, S., LABORDE, J., LIESENFELD, D. & BARRERA, O. 1997. Potreros y Ganadería. Pp. 43–54 in González, S. E., Dirzo, R. & Voght, R. C. (eds). 1997. *Historia Natural de Los Tuxtlas*. Instituto de Biología e Instituto de Ecología, Universidad Nacional Autónoma de México, México D.F.

HEGARTY, E. E. 1991. Vine-host interactions. Pp. 357–375 in Putz, F. E. & Mooney, H. A. (eds). *The biology of vines*. Cambridge University Press, Cambridge.

HOLBROOK, N. M. & PUTZ, F. E. 1996. Physiology of tropical vines and hemiepiphytes: plants that climb up and plants that climb down. Pp. 363–394 in Mulkey, S. S., Chazdon, R. L. & Smith, A. P. (eds). *Tropical forest plant ecophysiology*. Chapman & Hall, New York.

https://doi.org/10.1017/S0266467405002531 Published online by Cambridge University Press

IBARRA-MANRIQUEZ, G. I., MARTÍNEZ-RAMOS, M., DIRZO, R. & NÚÑEZ-FARFÁN, J. 1997. Pp. 61–85 in González, S. E., Dirzo, R. & Voght, R. C. (eds). *Historia Natural de Los Tuxtlas*. Instituto de Biología e Instituto de Ecología, Universidad Nacional Autónoma de México, México D.F.

MARTÍNEZ-RAMOS, M. 1991. *Patrones, procesos y mecanismos en la comunidad de plántulas de una selva húmeda neotropical*. Ph.D. dissertation. Universidad Nacional Autónoma de México. México D.F.

PEÑALOSA, J. 1982. Morphological specialization and attachment success in two twining lianas. *American Journal of Botany* 69:1043–1045.

PEÑALOSA, J. 1983. Shoot dynamics and adaptive morphology of *Ipomoea phillomega* (Vell) House (Convolvulaceae), a tropical rainforest liana. *Annals of Botany* 52:737–754.

PEÑALOSA, J. 1985. Dinámica de crecimiento de lianas. Pp. 147–169 in Gómez-Pompa, A. & Del Amo, S. (eds). *Investigaciones sobre la regeneración de selvas altas en Veracruz, México*. Vol. II. Instituto Nacional de Investigaciones Sobre Recursos Bioticos-Alhambra Mexicana, México.

PÉREZ-SALICRUP, D. R. & BARKER, M. 2000. Effect of liana cutting on water potential and growth of adult *Senna multijuga* (Caesalpinioideae) trees in a Bolivian tropical forest. *Oecologia* 124:469–475.

PÉREZ-SALICRUP, D. R., & DE MEIJERE, W. 2005. Number of lianas per tree and number of trees climbed by lianas at Los Tuxtlas, a tropical rainforest in Veracruz, Mexico. Biotropica 37:153–156.

PÉREZ-SALICRUP, D. R., SORK, V. L. & PUTZ, F. E. 2001. Lianas and trees in a liana forest of Amazonian Bolivia. *Biotropica* 33:34–47.

PUTZ, F. E. 1984. How trees avoid and shed lianas. *Biotropica* 16:19–23.

PUTZ, F. E. & HOLBROOK, M. N. 1991. Biomechanical studies of vines. Pp. 73–96 in Putz, F. E. & Mooney, H. A. (eds). *The biology of vines*. Cambridge University Press, Cambridge.

SANCHES, M. C. & VÁLIO, I. F. M. 2002. Seedling growth of climbing species from a southeast Brazilian tropical forest. *Plant Ecology* 154:51–59.

SCHNITZER, S. A. & BONGERS, F. 2002. The ecology of lianas and their role in forests. *Trends in Ecology and Evolution* 17:223–230.

SOTO, M. & GAMA, L. 1997. Climas. Pp. 7–23 in González, S. E., Dirzo, R. & Voght, R. C. (eds). 1997. *Historia Natural de Los Tuxtlas*. Instituto de Biología e Instituto de Ecología, Universidad Nacional Autónoma de México, México D.F.

STEVENS, G. C. 1987. Lianas as structural parasites: the *Bursera simaruba* example. *Ecology* 68:77–81.

WHIGHAM, D. 1984. The influence of vines on the growth of *Liquidambar styraciflua* L. (sweetgum). *Canadian Journal of Forest Research* 14:37–39.

https://doi.org/10.1017/S0266467405002531 Published online by Cambridge University Press