

Milks, J.R., J. Hibbard and T. P. Rooney. Exfoliating Bark Does Not Protect *Platanus occidentalis* L. From Lianas

1 **Exfoliating Bark Does Not Protect *Platanus occidentalis* L. From Root-Climbing**

2 **Lianas**

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4

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6

7 **Abstract** - Lianas are structural parasites that depress growth, fertility and survival rates
8 of their hosts, but the magnitude to which they alter these rates differ among host
9 species. We tested the hypothesis that sycamore (*Platanus occidentalis* L.) would have
10 fewer adventitious root-climbing lianas. We reasoned that because *P. occidentalis*
11 possesses exfoliating bark, it would periodically shed newly-established lianas from the
12 trunk. We investigated the distribution of lianas on the trunks of trees ≥ 10 cm DBH in
13 floodplains in southwestern Ohio. Contrary to predictions, *P. occidentalis* trees had
14 significantly more root-climbing lianas than expected at three of five sites, and
15 significantly fewer than expected at one site. In contrast, members of the *Acer* genus
16 (boxelder (*A. negundo* L.), sugar maple (*A. saccharum* L.) and silver maple (*A.*
17 *saccharinum* L.) had less than half of the root-climbing lianas as expected. We find no
18 support for our hypothesis that bark exfoliation protects *P. occidentalis* trees from root-
19 climbing lianas in our study, and suggest possible mechanisms that might protect *Acer*
20 species from adventitious root-climbing lianas.

21 **Introduction**

22 Lianas are structural parasites that depress growth, fertility and survival rates of their
23 hosts, but the magnitude to which they alter these rates differs among host species

Milks, J.R., J. Hibbard and T. P. Rooney. Exfoliating Bark Does Not Protect *Platanus occidentalis* From Lianas

24 (Givnish 1992, 1995, Stevens 1987, Ladwig and Meiners 2009, van der Heijden and
25 Phillips 2009, Ingwell et al. 2010). Different tree species exhibit different mechanisms to
26 decrease the number of lianas successfully establishing. Proposed mechanisms
27 include: compound leaves, fragile spines, and ant guards, flexible trunks, long leaves
28 and high relative growth rates (Putz 1980, 1984, Givnish 1995).

29 Few studies have examined the role of bark shedding as a defense against lianas
30 (e.g. Talley et al. 1996a; Carsten et al. 2002) and these have been confined to species
31 in the tropics. Bark shedding would be expected to protect against liana infestation, as
32 lianas would be expected to be shed along with pieces of bark. This should be
33 especially effective against root-climbing lianas, as species with this growth form attach
34 to bark to climb. Talley et al. (1996a) noted that bark shedding reduced lianas in two
35 species of Australian rainforest trees. Carsten et al. (2002) found a more complex
36 pattern, as liana densities increased at intermediate levels of bark shedding but
37 decreased at higher levels of shedding.

38 Temperate floodplains in the eastern United States are well suited for studying
39 liana/host relationships. Floodplain forests are subject to several factors that increase
40 liana abundance, including disturbance through periodic flooding (van der Heijden and
41 Philips 2008) and forest fragmentation (Londré and Schnitzer 2006). Floodplains are
42 also the primary habitat of *Platanus occidentalis* L., a bark-shedding deciduous tree in
43 the eastern United States (Burns and Honkala 1990). While bark-shedding has been
44 hypothesized to protect *P. occidentalis* L. from lianas (Givnish 1992, 1995), no previous
45 studies to our knowledge have tested this hypothesis.

Milks, J.R., J. Hibbard and T. P. Rooney. Exfoliating Bark Does Not Protect *Platanus occidentalis* L. From Lianas

46 Here, we tested the hypothesis that a temperate zone bark-shedding tree, *P.*
47 *occidentalis* L., would have fewer root-climbing lianas than co-occurring species that do
48 not shed bark. We counted the number of root-climbing lianas on tree trunks in five
49 floodplain forests in southwestern Ohio. We predicted that *Platanus occidentalis* L.
50 would have fewer lianas than expected compared to non bark-shedding species.

51

52

Field-site Description

53 This study was conducted in mature floodplain forests at five different parks in the
54 southwestern Ohio (39°30' N, 84°0' W): Germantown, Huffman Dam, Sugarcreek and
55 Taylorsville Metroparks in Montgomery County, and The Narrows Preserve in Greene
56 County. Montgomery County Parks within the Great Miami River Watershed, while The
57 Narrows Preserve lies within the Little Miami River Watershed. Land use in both
58 watersheds is predominantly cultivated cropland. Forest cover, pasture, and urban
59 development are also present. Both watersheds are located within the Till Plains region
60 of Ohio. This glaciated landscape contains rolling hills, moraines, and outwash plains
61 (Zimmerman and Runkle 2010).

62 Floodplain forests are comprised of mature deciduous species. *Platanus occidentalis*
63 L., *Acer negundo* L., *Celtis occidentalis* L., and *Populus deltoides* W. Bartram ex
64 Marshall were the dominant species at our study sites. The invasive shrub *Lonicera*
65 *maackii* (Rupr.) Herder is common in the forest shrub layer (Hutchinson and Vankat
66 1998).

67

68

Methods

Milks, J.R., J. Hibbard and T. P. Rooney. Exfoliating Bark Does Not Protect *Platanus occidentalis* From Lianas

69 We recorded the diameter at breast height (DBH) and species of each tree ≥ 10 cm
70 DBH in a single 10 m x 300 m belt transects (total 0.3 ha) in mature floodplain forests at
71 five different parks. Each park was considered a separate site. Transects were
72 randomly placed within the forests but in most cases, transects were within 50 meters of
73 forest edges due to the narrow dimensions and fragmented nature of the floodplain
74 forests in this region.

75 We tallied the number of adventitious root-climbing lianas present on the trunk of
76 each tree at 1.6 m above ground level at the same time as the DBH measurements.
77 Adventitious root-climbing lianas were chosen as they should be susceptible to being
78 shed by trees with exfoliating bark. Data was collected in the spring over two field
79 seasons (2007-2008).

80 We generated mean (\pm SE) lianas per tree, importance values and expected
81 numbers of lianas per tree species for each site. For the purposes of our analyses, we
82 combined *Fraxinus americana* and *Fraxinus pennsylvanica* into *Fraxinus* sp., as the two
83 species are virtually indistinguishable in the field in our area. Importance values for each
84 tree species were calculated by adding relative DBH and relative densities for each
85 species, then dividing by 2 and multiplying by 100. We calculated relative DBH by
86 dividing the total DBH for each species by the total DBH for all trees at the site.
87 Relative density was calculated totaling all individual stems per species and dividing by
88 the total individual stems per site. Relative DBH was used as we expected larger trees
89 to host more lianas than smaller trees due to increased age and having more surface
90 area to which lianas could attach (Talley et al. 1996a, Buron et al. 1998, Carsten et al.
91 2002, Reddy and Parthasarathy 2006, Leicht-Young, et al. 2010). To test if this pattern

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92 held for our sites, we analyzed the number of lianas per tree versus DBH with a hurdle
93 model for zero-inflated poisson distributions, using the `pscl` package for R (Zeileis et al.
94 2008, Jackson 2011, R Development Core Team 2011).

95 After finding a significant relationship between number of lianas and DBH, we
96 examined differences in number of lianas per cm DBH per tree species and site using a
97 two-way ANOVA with a post-hoc Tukey Honestly Significant Difference test. Finding a
98 significant interaction term between site and species, we then analyzed differences
99 between observed and expected lianas per tree species with replicated goodness of fit
100 (G) tests, with each site as a replicate. We obtained expected numbers of lianas for
101 each site and for each tree species by multiplying importance value for each tree
102 species by the total number of lianas counted at each site.

103

104

Results

105 We measured 1541 trees comprising 18 species and counted 1967 root-climbing
106 lianas (mostly *Toxicodendron radicans* (L.) Kuntze and a few *Parthenocissus*
107 *quinquefolia* (L.) Planch.) in a total of 1.5 ha (Table 1). Of those 18 tree species, *P.*
108 *occidentalis* L. and *Acer negundo* L. had the highest importance values at 32.3 and
109 23.2, respectively. Larger trees were significantly more likely to have at least one liana
110 than smaller trees ($\beta_1 = 0.025 \pm 0.003$ SE, $P < 0.0001$, Fig. 1a) and the number of
111 lianas per tree also increased with DBH ($\beta_1 = 0.018 \pm 0.001$ SE, $P < 0.0001$, Fig. 1b).
112 Sites differed greatly in liana abundance, from a low of 0.0042 ± 0.008 SE lianas per cm
113 DBH per tree at Germantown to a high of 0.059 ± 0.004 SE lianas per cm DBH per tree
114 at Huffman ($F = 36.3$, $P < 0.0001$, Table 2, Fig. 2). There was a significant interaction

Milks, J.R., J. Hibbard and T. P. Rooney. Exfoliating Bark Does Not Protect *Platanus occidentalis* From Lianas

115 term between site and species ($F = 4.91$, $P < 0.0001$, Table 2), which was then
116 examined using G-tests.

117 We found that the number of root-climbing lianas growing on *P. occidentalis* was
118 significantly greater than expected at three of five sites, significantly less at one site and
119 did not differ from expected abundance at the remaining site (Table 3). When data
120 were pooled across sites, *P. occidentalis* had 30% more root-climbing lianas than
121 expected (pooled $G = 73.6$, d.f. = 1, $P < 0.001$). In contrast, *A. negundo* had significantly
122 fewer lianas than expected at three sites and did not differ from expected abundance at
123 two sites (Table 3). When data were pooled across sites, *A. negundo* had 59% fewer
124 root-climbing lianas than expected (pooled $G = 222.2$, d.f. = 1, $P < 0.0001$). *Acer*
125 *saccharinum* had 76.5% fewer lianas at all three sites where individuals of this species
126 occurred (pooled $G = 32.8$, d.f. = 1, $P < 0.0001$; Table 3). A third maple species, *Acer*
127 *saccharum*, had 83% fewer lianas than expected at the one site we found it ($G = 45.8$,
128 d.f. = 1, $P < 0.0001$). Other species exhibited idiosyncratic relationships between site
129 and liana abundance. *Fraxinus* spp. had significantly more lianas than expected at one
130 site ($G = 45.3$, d.f. = 1, $P < 0.0001$) but fewer than expected at two other sites ($G = 31.8$,
131 d.f. = 1, $P < 0.0001$ and $G = 13.7$, d.f. = 1, $P < 0.0002$; Table 3). When combined
132 across all sites, there was no significant relationship (pooled $G = 0.38$, d.f. = 1, $P =$
133 0.54). A fifth species (*Celtis occidentalis* L.) had significantly more lianas than expected
134 at two sites ($G = 131.50$, d.f. = 1, $P < 0.0001$ and $G = 33.96$, d.f. = 1, $P < 0.0001$),
135 significantly fewer than expected at two sites ($G = 5.81$, d.f. = 1, $P = 0.016$ and $G =$
136 10.4 , d.f. = 1, $P = 0.0013$), and no significant difference at the fifth ($G = 3.00$, d.f. = 1, P

Milks, J.R., J. Hibbard and T. P. Rooney. Exfoliating Bark Does Not Protect *Platanus occidentalis* L. From Lianas

137 = 0.083, Table 3). When combined across sites, *C. occidentalis* had 61% more vines
138 than expected (pooled $G = 114.7$, d.f. = 1, $P < 0.0001$).

139

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Discussion

141 We find no support from our data for the hypothesis that bark shedding protects *P.*
142 *occidentalis* from root-climbing lianas. *P. occidentalis* had either the same as or more
143 than the expected number of lianas at four sites out of five sites whereas we predicted
144 that *P. occidentalis* should have fewer than expected lianas. This contrasts with Talley
145 et al. (1996a) who found that bark-shedding trees in Queensland tropical forests had
146 fewer than expected root-climbing lianas. Carsten et al. (2002) found that root-climbing
147 lianas increased on trees with intermediate bark roughness and levels of bark-shedding
148 and decreased at high levels of shedding and on trees with smooth bark. It is possible
149 that *P. occidentalis* would be fall within the intermediate range of the bark texture scale
150 of Carsten et al. (2002). One possible test would be to compare individual *P.*
151 *occidentalis* for differences in bark shedding levels and liana load as individual *P.*
152 *occidentalis* vary in levels of bark shedding with some trees shedding nearly all bark
153 and others shedding very little (Milks, personal observation).

154 In contrast to *P. occidentalis*, *A. negundo*, *A. saccharum*, and *A. saccharinum* had
155 either the expected number of lianas or significantly fewer lianas than expected on all
156 sites where those species occurred. Other studies have also noted fewer than
157 expected lianas on *A. saccharum*. Both Talley et al. (1996b) and Leicht-Young et al.
158 (2010) found fewer than expected *T. radicans* lianas on *A. saccharum* in forests in
159 Alabama, Indiana and Michigan. However, our finding of fewer than expected lianas on

Milks, J.R., J. Hibbard and T. P. Rooney. Exfoliating Bark Does Not Protect *Platanus occidentalis* From Lianas

160 *A. saccharinum* contrasts with Leicht-Young et al.'s (2010) finding. Only 2.3% of *A.*
161 *saccharinum* in our study were infested with lianas whereas Leicht-Young et al. found
162 an infestation rate of 28.6%. The reasons for this difference likely lie in differences in
163 our methods, as we focused on root-climbing lianas whereas Leicht-Young et al. (2010)
164 included all lianas, regardless of climbing mode. Another possible reason may be due
165 to differences in the dominant liana species. Our dominant root-climbing species was *T.*
166 *radicans* whereas *P. quinquefolia* dominated the liana community in Leicht-Young et
167 al.'s (2010) study.

168 Other tree species in our study (like *Fraxinus* sp. and *C. occidentalis*) showed no
169 consistent trend between site and liana abundance, with some sites having more than
170 expected lianas, others having fewer than expected. Site differences are apparent in
171 our data, especially between Germantown and the other sites (Fig. 1). The reasons for
172 those large differences in liana abundance between sites are not clear and may simply
173 represent spatial heterogeneity.

174 Possible reasons for the differences between liana abundance between *P.*
175 *occidentalis* and *A. negundo*, *A. saccharum* and *A. saccharinum* include leaf size, bark
176 morphology and bark chemistry. Putz (1984) found that larger leaf size protected trees
177 from lianas on Barro Colorado Island. However, in our area, *P. occidentalis* generally
178 has larger leaves than any of the *Acer* species, making leaf size an unlikely mechanism
179 in eastern temperate floodplain forests.

180 Bark morphology (smooth versus furrowed) is also unlikely to be an important
181 mechanism, as this has been tested in other forest types with mixed results (Boom and
182 Mori 1982, Carsten et al. 2002). In our study, *A. saccharum* and *A. negundo* had

Milks, J.R., J. Hibbard and T. P. Rooney. Exfoliating Bark Does Not Protect *Platanus occidentalis* L. From Lianas

183 slightly furrowed bark whereas *A. saccharinum* had rough, furrowed bark. None of
184 these three had many lianas, as only 14.1% of *A. negundo*, 13.3% of *A. saccharum* and
185 2.3% of *A. saccharinum* had lianas (Table 1). Bark morphology by itself is unlikely to
186 explain our results, although it warrants further study.

187 One unexplored possibility is that allelopathic chemicals in the bark of some maple
188 species may protect them from root-climbing lianas. Talley et al. (1996b) found
189 allelopathic chemicals in *A. saccharum* bark (as well as chemicals in the bark of other
190 tree species) could inhibit liana seedling germination and growth in the southern US,
191 with differences in the presence of allelopathic chemicals influencing liana distributions
192 on host trees. Talley et al. (1996a) found similar patterns in Australia. It is possible that
193 bark chemistry may also protect *Acer* species from clinging lianas in our study region,
194 although our study did not investigate that possibility.

195 This study is, to our knowledge, the first study that demonstrates that bark shedding
196 in *P. occidentalis* does not protect that species from liana infestation. We also showed
197 that *A. negundo* has either the same or fewer than expected lianas, which is also a new
198 finding. Further research into the characteristics that decrease root-climbing liana
199 abundance on *A. negundo* is desirable. Future investigations could also examine host
200 preferences for different species of lianas in temperate floodplains, and whether
201 variability in bark shedding among individual *P. occidentalis* individuals affects liana
202 loads.

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Acknowledgements

Milks, J.R., J. Hibbard and T. P. Rooney. Exfoliating Bark Does Not Protect *Platanus occidentalis* From Lianas

205 The idea for this project was first suggested by T. Givnish in his class entitled The
206 Vegetation of Wisconsin.

207

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Milks, J.R., J. Hibbard and T. P. Rooney. Exfoliating Bark Does Not Protect *Platanus occidentalis* L. From Lianas

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262 Table Legend

263 **Table 1.** Species of trees, sites the species occurred at (sites), number of individual
264 trees (n), number of lianas found on each species of tree, percentage of trees with at
265 least one root-climbing liana clinging to them, and importance values per tree species
266 for all sites combined. Sites are as follows: G = Germantown, H = Huffman Dam, N =
267 The Narrows, S = Sugarcreek, and T = Taylorsville.

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Milks, J.R., J. Hibbard and T. P. Rooney. Exfoliating Bark Does Not Protect *Platanus occidentalis* From Lianas

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Species	Sites	n	No. root-climbing lianas	Percent of trees Infested	Importance Value
<i>Acer negundo</i>	G, H, N, S, T	432	169	14.1	23.2
<i>Acer saccharum</i>	N	30	4	13.3	1.4
<i>Acer saccharinum</i>	G, H, T	88	10	2.3	5.8
<i>Aesculus glabra</i>	G, H, N, S, T	88	67	37.5	4.7
<i>Celtis occidentalis</i>	G, H, N, S, T	163	482	71.8	10.1
<i>Crataegus sp.</i>	H	2	2	100	0.1
<i>Fraxinus sp.</i>	H, N, S, T	65	85	21.5	3.7
<i>Juglans nigra</i>	G, H, N, S, T	25	51	36.0	1.9
<i>Liriodendron tulipifera</i>	S	26	11	23.1	1.5
<i>Maclura pomifera</i>	H, T	28	56	64.3	1.8
<i>Morus alba</i>	H	2	0	0	0.1
<i>Platanus occidentalis</i>	G, H, N, S, T	405	735	42.2	32.3
<i>Populus deltoides</i>	H, T	71	167	39.4	7.1
<i>Prunus serotina</i>	S	8	13	37.5	0.4
<i>Robinia psuedoacacia</i>	T	2	8	100	0.1
<i>Tilia americana</i>	H	4	0	0	0.3
<i>Ulmus americana</i>	G, H, N	60	43	30.0	3.1
<i>Ulmus rubra</i>	H, T	42	64	42.9	2.3
Total		1541	1967	32.8	99.9

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Milks, J.R., J. Hibbard and T. P. Rooney. Exfoliating Bark Does Not Protect *Platanus occidentalis* L. From Lianas

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272 Table Legend

273 **Table 2.** Variation in the number of lianas per cm DBH attributable to tree species, site

274 and their interaction.

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Milks, J.R., J. Hibbard and T. P. Rooney. Exfoliating Bark Does Not Protect *Platanus occidentalis* From Lianas

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Variable	d.f.	Sum Sq	Mean Sq	F	P
Site	4	0.6932	0.1733	36.2827	<0.0001
Species	17	0.7233	0.0425	8.9079	<0.0001
Site*Species	26	0.6097	0.0235	4.9100	<0.0001
Residuals	1493	7.1307	0.0048		

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Milks, J.R., J. Hibbard and T. P. Rooney. Exfoliating Bark Does Not Protect *Platanus occidentalis* L. From Lianas

278 Table Legend

279 **Table 3.** Number of stems, importance values per species per site, observed lianas
280 abundance, expected liana abundance, and p-values for the five species of trees with
281 overall importance values > 0.05 and which were found in three or more sites. N/A =
282 species not recorded at that site. Bold P-value indicates statistical significance.

Milks, J.R., J. Hibbard and T. P. Rooney. Exfoliating Bark Does Not Protect *Platanus occidentalis* From Lianas

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Species	Site	No. stems	Importance value per site	Lianas Obs.	Lianas Exp.	P-value
<i>Acer negundo</i>	Germantown	120	58.4	11	13.43	0.3078
	Huffman	142	22.9	59	244.46	<0.0001
	Narrows	88	24.7	75	110.98	<0.0001
	Sugarcreek	6	4.4	0	8.36	<0.0001
	Taylorville	76	14.3	24	36.51	0.0181
<i>Acer saccharinum</i>	Germantown	26	15.12	0	3.49	0.0059
	Huffman	2	0.4	0	4.72	0.0021
	Narrows	0	0.0	N/A	N/A	N/A
	Sugarcreek	0	0.0	N/A	N/A	N/A
	Taylorville	60	13.4	10	34.28	<0.0001
<i>Celtis occidentalis</i>	Germantown	4	1.9	2	0.45	0.0831
	Huffman	137	26.3	454	280.57	<0.0001
	Narrows	6	1.7	2	7.52	0.0159
	Sugarcreek	4	3.0	0	5.12	0.0013
	Taylorville	12	2.2	24	5.67	<0.0001
<i>Fraxinus sp.</i>	Germantown	0	N/A	N/A	N/A	N/A
	Huffman	5	1.1	42	12.15	<0.0001
	Narrows	29	9.2	39	41.47	0.6850
	Sugarcreek	19	1.3	4	19.16	<0.0001
	Taylorville	12	2.7	0	6.78	0.0002
<i>Platanus occidentalis</i>	Germantown	24	18.3	5	4.21	0.6779
	Huffman	72	20.8	286	221.71	<0.0001
	Narrows	105	39.9	269	179.31	<0.0001
	Sugarcreek	50	48.8	166	82.89	<0.0001
	Taylorville	154	41.8	48	106.87	<0.0001

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286 Figure Legend

287 **Fig. 1. A.** Estimated probability of at least one liana growing on a tree versus diameter

288 at breast height along with the estimated logistic regression curve. **B.** Truncated

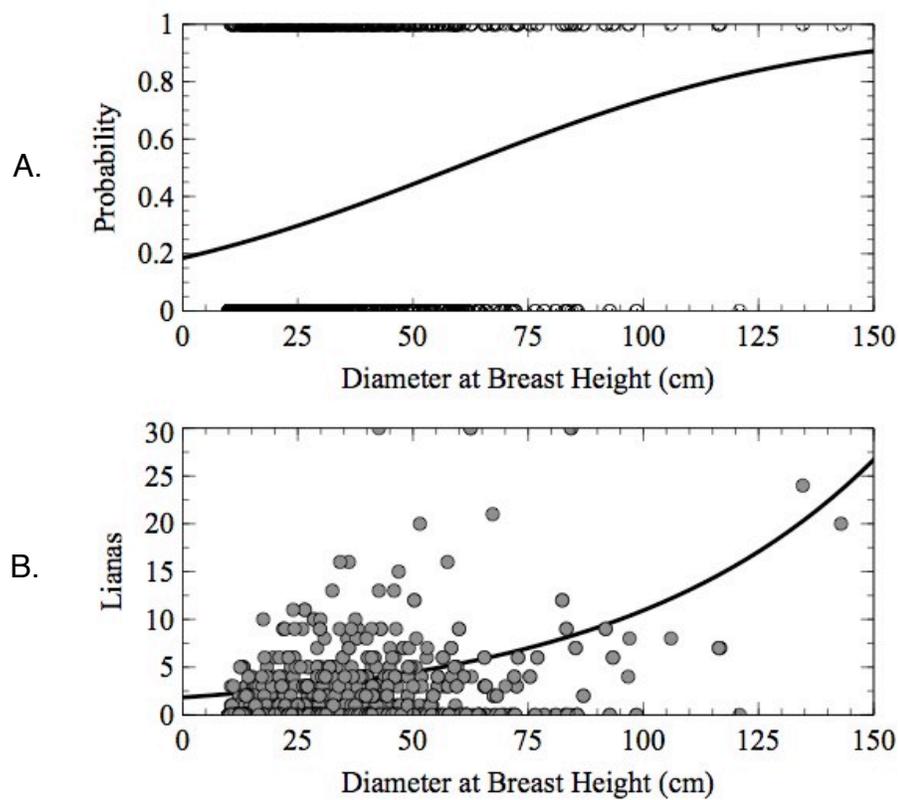
289 Poisson regression of the number of lianas growing on trees versus diameter at breast

290 height.

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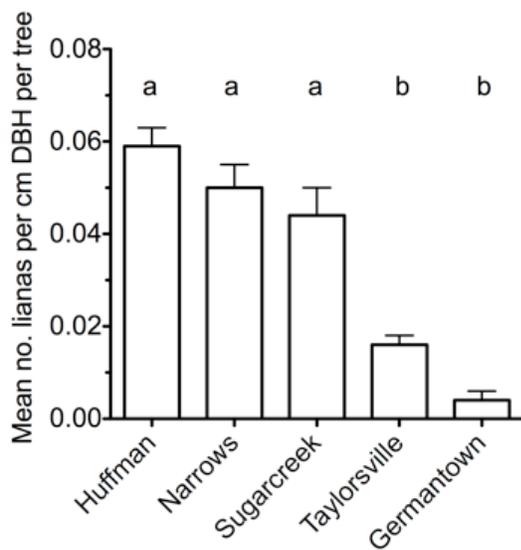
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294 Figure Legend

295 **Fig. 2.** Mean (\pm SE) lianas per cm DBH per tree for each site. Sites that with
296 significantly different means ($p \leq 0.05$) based on Tukey's HSD test are denoted with
297 different letters.

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