



Ecological features of titica vine (*Heteropsis flexuosa* (Kunth) GS Bunting) in Rondônia State, Northwest Brazilian Amazon

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ABSTRACT

The aim of this study was to characterize the forest structure with *H. flexuosa* in Rondônia State, as a first step in developing sustainable harvest and conservation guidelines for the species. Crown attributes, total height (m) and diameter at breast height ≥ 10 (cm) of trees and palms with *H. flexuosa* were evaluated in three permanent plots (100 m x 150 m each) randomized in 219 ha. A total of 22 botanical families hosted *H. flexuosa*. It was not observed any specific preference for the species standing up itself. Nevertheless it was frequently associated to Burseraceae, Leguminosae, Sapotaceae, Annonaceae, Chrysobalanaceae, Apocynaceae, Moraceae and Myristicaceae and species with thick bark like *Schweilera coriacea*, *Protium* sp. and *Licania membranacea*. The species was less frequent with taller and broader trees and tended to develop in understory light condition. Trunks or branches were the main position for the attaching of *H. flexuosa* (90.83%) and a low frequency of other lianas was observed on the same host trees. These highlight the need to promote appropriate management practices for root harvesting and species conservation in order to maintain the species in open ombrophylus forest habitat.

Key words: non-timber forest product, ecology, plant fibers, habitat preference, multiple-use forest management

INTRODUCTION

The magnitude and importance of the natural resources in the Amazon tropics have not been properly appreciated to date. Misinformation and disinformation on many patterns and processes involving the diversity and distribution of Amazonian organisms are main factors that cause threats to the wilderness, biodiversity and local people. The open ombrophylus forest in Rondonia State, which encompasses a main biological repository in the Northwestern Brazilian Amazon,

covering up to 50% of upland forest ecosystems in the region, is a current area under threat due to the accelerated development since the 1980's.

Among the ecosystem functions and products that many species and their populations of tropical biodiversity may offer, vegetal fibers may constitute a real opportunity for new markets and incomes for rural communities who rely on fiber extraction and processing. It may in turn contribute to the promotion and development of sustainable non-wood-based regional economies (Shanley et al. 2002).

Some plant fibers such as carauá (*Ananas erectifolius*), babaçu (*Orbignya* spp.), buriti (*Mauritia*

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flexuosa), carnauba (*Copernicia prunifera*), and piaçava (*Attalea funifera*) feature in the non-timber economy of many Brazilian rural communities (IBGE 2005). In addition to that, recent studies have demonstrated the potential of these non-wood species for numerous applications (Monteiro et al. 2006a, b, Marques et al. 2007, Zambrana et al. 2007). Still, in the Amazon, little scientific information on major species that could high-value agricultural products is available to develop technical guidelines for sustainable management.

Multi-use approaches to tropical forests invite a great number of possibilities to generate forest goods and services (Fearnside 2008). Nevertheless non-timber forest products (NTFPs) are still far from having clear guidelines on sustainable multiple-use management (Summers et al. 2004, Guariguata et al. 2010).

Beyond encouraging the extraction of the raw material itself in order to expand the use of vegetable fibers in the Amazon, it is necessary to investigate the natural species behavior (Balcázar-Vargas and van Andel 2005, Balcázar-Vargas et al. 2011) to allow improvement in the current harvesting method of non-wood species (Leoni and Marques 2008), for which there are few protective laws or regulations in most of the Brazilian Amazon states.

From a biophysical standpoint, it is important to know more about the mechanisms and patterns by which these species establish themselves in their natural environment. It will contribute in filling the lack of scientific information to support management recommendations regarding the conservation of species of important biological and economic value.

The main concerns regarding non-wood forest species management relates to inadequate removal practices, which can compromise the mechanisms of resilience through the continued removal of their populations. This is the case of titica vine (*Heteropsis flexuosa* (HBK) GS Bunting), one of the eight natural fibers used in the regional markets of natural products in Rondônia State (Diário... 2010).

Extraction of the species is regulated only in the Brazilian states of Amapá and Amazonas (Amapá 2001, Amazonas 2008); while in the other states 100% of *Heteropsis* spp. roots are removed, causing severe damages or death to the mother plant of the vine. Amapá State, actually, is the main producer of *Heteropsis* sp. in the Amazon Region, with an average monthly production of 45 tons of raw fiber—followed by the states of Pará, Amazonas and Rondônia (IBGE 2005).

The genus *Heteropsis* encompasses 17 species (Morais 2008) and is described by Plowden et al. (2003) as a hemi-epiphytic root of natural occurrence in most of the Amazon Basin forests. In Rondônia State, at least two species of titica vine are commonly found in the main forest type formation (*Heteropsis flexuosa* (Kunth) GS Bunting and *Heteropsis spruceana* Schott). Although the economic use of the fiber may be low in contrast to agricultural income, *Heteropsis* spp. roots are widely appreciated by their resistance for baskets, furniture and other manual handcrafts, therefore a source of additional income for local communities.

The objective of this study was to characterize the forest structure with *H. flexuosa* in open ombrophylus “terra firme” forest in Rondônia State as a basis for future sustainable harvest and conservation guidelines of the species.

MATERIALS AND METHODS

STUDY SPECIES

Titica vine (*Heteropsis* spp.), Araceae, is found in a variety of Central American (Costa Rica, Nicaragua) and particularly South American (Colombia, Venezuela, Ecuador, Guyana, Perú, Brazil) habitats. In Brazil it ranges from the Amazon to the Atlantic forest (Morais 2008).

The species differs from true epiphytes by germinating in soil. After germination, it commonly uses adventitious root to climb a plant, usually trees, and reach a point where it can growth and receive

light and nutrients for development. The trees that stand the liana are known as host trees. The vine reaches the juvenile phase when it produces its first large leaf and a vegetative elongation, forming what is commonly called as the vine's "mother plant". To survive, the mother plant sends down an absorbent root, allowing a connection to the ground to transport water and nutrients (Plowden et al. 2003).

The vine usually grows attached to the trunk of the host tree and it is possible to find inflorescences of *H. flexuosa* from 7 m upwards, with most inflorescences at heights of > 10 m (Balcázar-Vargas et al. 2011). In addition, when it develops a root with downward growth it may be susceptible to damage by herbivores. When the meristem is damaged, a node can be observed together with the appearance of new roots which will keep on growing until they reach the soil (Plowden et al. 2003, Morais 2008). For commercial purposes, good quality roots should show few nodes and no sign of weevil infestation (Balcázar-Vargas and van Andel 2005). In rural Brazilian communities, the absence of nodes is a main indicator for resistance and durability to the local production (Almeida 2010).

STUDY SITE, SAMPLE DESIGN AND FIELD MEASUREMENTS

Fieldwork was conducted during the dry season, in October 2006, at the research station of Embrapa in the municipality of Machadinho do Oeste, Northwestern of Rondônia State (61°47' and 63°00'

WGr, 9°19' and 10°00' S). The climate in this area is *A_m* – tropical monsoon according to Köppen Climatic Classification and it presents an average annual precipitation of nearly 2,400 mm, with dry season from June to August and rainy season from December to March, where peaks of 1,300 mm are registered. The annual temperature average is 26.2°C and the relative humidity annual mean is 85%. The topography of the study area, with low hills, reaches at maximum 180 m above sea level with predominance of Yellow Latosol (Table I).

Open ombrophylus forest is the dominant vegetation type in the region (Projeto... 1978). The survey was carried out in undisturbed upland forest locally known as “terra firme” in three permanent vegetation plots, randomized in an area of 219 ha, each measuring 1,5 ha. Each plot was 100 m x 150 m, subdivided into 30 subplots of 20 m x 25 m (0.05 ha). Total height (m) and diameter at breast height (dbh) ≥ 10 cm of trees and palms that hosted *H. flexuosa* were evaluated, accordingly to the Amazon non-timber forest products network of EMBRAPA (Kamukaia).

The life-cycle stage of the individuals in this study was categorized as adults, following Balcázar-Vargas et al. (2011), as having upper height ≥ 10 m. All the adult plants of *H. flexuosa* were identified in the entire plot and tagged for future management test purposes. The trees of the entire forest community had already been tagged for monitoring growth (Vieira et al. 2002).

TABLE I
Edafoclimatic conditions of site with naturally occurrence of *H. flexuosa* in Rondônia State, Brazilian Amazon (Source: Rondônia 2005, Miranda et al. 2002).

- Localization:	61°47' and 63°00' WGr 9°19' and 10°00' S	- Rainfall (mm):	2,390 - annual mean
- Study area:	219 ha - primary forest	- Dry season:	June to August
- Climate ¹ :	<i>A_m</i> – tropical monsoon	- Rainy season:	December to March (1300mm)
- Temperature:	26.2 °C - annual mean	- Soil:	Yellow Latosol
- Relative humidity:	85% - annual mean	- Altitude/Relief:	180 m above sea level/Smooth

¹Köppen Climatic Classification

For each *H. flexuosa* host tree the upper height was taken with a measuring tape and climbing techniques were used to reach the plant when needed. The dbh ≥ 10 cm of host trees was also taken. Furthermore, the crown attributes of each host tree were evaluated following Synnott (1979) for crown form (perfect, good, tolerable, poor, and very poor) with adaptations for crown position (dominant, co-dominant, intermediate, and suppressed). The presence of adult *H. flexuosa* in the stem, crown, or crown and stem, and the current stage of infestation by other lianas (without liana, presence up to 25%, up to 75%, above 75%) were also considered.

The botanical identification of the species in this study was done in a first moment based on the experience of a field assistant ("mateiro"), and later by comparison with exsiccates deposited at the herbarium of Embrapa Amazônia Oriental (CPATU), in Pará State.

STATISTICAL ANALYSIS

Descriptive statistics (Brower and Zar 1984) with significance level at 99% were used to test differences among the assessed variables. The biodiversity measure among botanical families that host *H. flexuosa* was obtained following Odum (1983):

i) Shannon-Weaver Diversity Index, which takes into account the number and the relative abundance of the species,

$$H' = - \sum_{i=1}^S p_i \ln p_i; p_i = \frac{n_i}{N},$$

where: p_i = relative abundance of the i-th species; N = total of individuals of the n-th species; and S = total of species.

ii) Uniformity of Pielou Index, which measures the uniformity defined by the distribution of the species,

$$e = \frac{H'}{\ln S},$$

where: H' = Shannon-Weaver Diversity Index; and S' = number of families.

An extensive inventory of the entire forest community was carried out in 2000 at the research station used in the current study (Embrapa in Machadinho do Oeste). The object of the survey was to study the phytosociology, to assess marketable species, and to monitor forest dynamics (Vieira et al. 2002). For comparison of the diversity and uniformity between host trees and the entire forest community the Hutchinson t-test (Zar 1996) was used:

$$t = \frac{H'_1 + H'_2}{\sqrt{\hat{\sigma}_{H_1}^2 + \hat{\sigma}_{H_2}^2}}$$

The estimator for the variance (a) and the degrees of freedom (b) of the Hutchison t-test is defined by:

$$\hat{\sigma}_H^2 = \frac{\sum p_i (\ln p_i)^2 + [(\sum p_i (\ln p_i))^2 / N]}{N^2} \text{ (a) and}$$

$$gl = \frac{(\hat{\sigma}_{H_1}^2 + \hat{\sigma}_{H_2}^2)^2}{\frac{(\hat{\sigma}_{H_1}^2)^2}{N_1} + \frac{(\hat{\sigma}_{H_2}^2)^2}{N_2}} \text{ (b),}$$

where N_1 and N_2 are the number of observations used to obtain the estimative of N'_1 and N'_2 .

As for comparison of tree size (dbh) means between host trees and the entire forest community in the survey, F-test (Callegari-Jacques 2003) was used:

$$z_{calc} = \frac{\bar{x} - u}{\sigma(\bar{x})},$$

where \bar{x} is the sample mean, u is the population mean, and σ is the standard deviation of the population mean.

RESULTS

Based on the survey of the three permanent vegetation plots, 403 trees were found (268.66 individuals.ha⁻¹) distributed into 24 botanical families hosting *H. flexuosa* alive. Established, adults of *H. flexuosa* were mostly found on the trunk, branches or canopies of natural endemic families such as Lecythydaceae, Burseraceae, Leguminosae, Sapotaceae, Annonaceae,

Chrysobalanaceae, Apocynaceae, Moraceae, Myristicaceae, and Myrtaceae. Lecythidaceae and Leguminosae constituted 38.05% of all botanical families surveyed in the study area

(Table II). The species belonging to the main botanical families were: *Schweilera coriacea*, *Protium* sp., *Licania membranacea*, *Rollinia exsucca* and *Pouteria pachycarpa*.

TABLE II
Frequency of the host botanical families of *H. flexuosa* in open ombrophylus forest in Machadinho do Oeste, Rondônia.

#	Botanical Family	HTC (n)	FC (n)	HTC (%)	FC (%)
1.	Lecythidaceae	115	515	28.54	19.17
2.	Burseraceae	61	217	15.14	8.08
3.	Leguminosae	45	507	11.17	18.88
4.	Sapotaceae	34	241	8.44	8.97
5.	Annonaceae	27	255	6.70	9.49
6.	Chrysobalanaceae	27	94	6.70	3.50
7.	Apocynaceae	21	199	5.21	7.41
8.	Moraceae	18	223	4.47	8.30
9.	Myristicaceae	13	93	3.23	3.46
10.	Myrtaceae	9	71	2.23	2.64
...	Others	33	271	8.19	10.08
Total of individuals (n)		403	2,686	100	100
Botanical family (n)/tree community		22	24		
H'		2.34 ^{ns}	2.41 ^{ns}		
e		0.757	0.760		
r (HTC/FC)		0.88			

^{ns} – not significant by Hutchinson t- test of Shannon-Weaver estimative ($p < 0.001$).
 HTC – host tree community; FC – entire forest community; n – number of individuals.
 H' – Shannon-Weaver Diversity Index; e – Pielou Equability Index; and r – Simple correlation coefficient.

The mean height of hosts was 20.40 m (SD ± 6.4 m) and only 29.78% of *H. flexuosa* were found above the mean height; still, in this forest type the vines were found on a wide range of heights (0.8 to 33.0 m height), with 7.2 m of mean height, independently of the maturity of plants. The canopy in this stratum performs light attenuation to the forest soil. The diameter distribution of host trees of *H. flexuosa* did not differ from that of the entire forest community > 10 cm dbh (z-test_{0,01} = 1.96), with mean dbh of 19.55 cm ± 13.64 cm, with 53% of the adults of *H. flexuosa* climbing up the smallest diameter category of hosts (10.19 to 91.35

cm dbh), and in both the research sample and the forest community the size distribution showed an inverse J shape (Fig. 1).

Over all crown categories, only 26.05% of host tree crowns were considered as perfect and good crown (complete or incomplete circle); and tolerable and poor crowns (half-crown or less than half-crown) together were over 63% amongst the host tree community, while few host trees showed crowns with any degree due natural damages (Table III).

Regarding position of establishment, 90.82% of *H. flexuosa* were observed attached to trunks or branches of the hosts. *H. flexuosa* was less

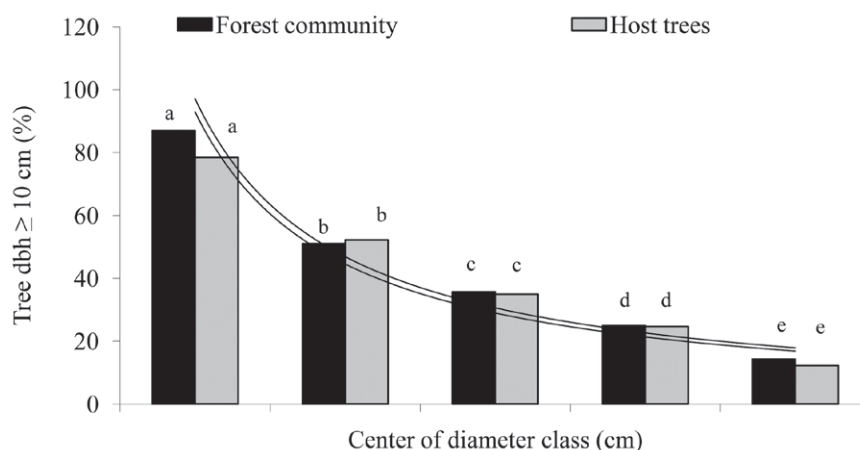


Figure 1 - Tree size (dbh) of open ombrophylus forest with *H. flexuosa* in Machadinho do Oeste, Rondônia. Common letters indicate means that are not significantly different from one another by Z Test ($p < 0.001$). Source: research data.

observed only in the trunk (6.15%) or only in the canopy positions (3.03%) and the majority of the vines were growing at a mean height of 10.2 m of the host trees. Only 23.57% of crowns were found dominant or co-dominant amongst the host tree community; thus, 41.44% of hosts presented suppressed crowns; followed by intermediate crowns (36.72%). Moreover, low frequency of other lianas species (21.87%) was found in the same host trees of *H. flexuosa* (Table III).

TABLE III
Crown position and form of host tree community (HTC) of *H. flexuosa* in open ombrophylus forest in Machadinho do Oeste, Rondônia.

Crow position	Individuals (n)	Crown form	Individuals (n)
1	19.00 b	1	8.66 b
2	12.33 b	2	26.00 ab
3	49.00 a	3	45.66 a
4	53.33 a	4	39.66 a
		5	13.66 b

Common letters indicate means that are not significantly different from one another by Tukey Test ($p < 0.001$).

Crow position (illumination): 1 – dominant, 2 – co-dominant, 3 – intermediate and 4 – suppressed. Crown form: 1 – perfect, 2 – good, 3 – tolerable, 4 – poor, and 5 – very poor.

Estimates of host tree family diversity and uniformity by information content are given in Table III. These estimates refer to the sample of 22 families and 403 trees and they were close to that found in the entire forest community of 24 families and 2,686 trees, corroborating that host trees of *H. flexuosa* are important species in the forest type studied.

DISCUSSION

The majority of *H. flexuosa* adults had climbed up small to medium size host trees in the forest studied, and no specific preference to specific botanical families was found across all the observed forest area. However, the vines were frequently found on the trunk, branches or canopies of natural endemic families such as Lecythidaceae, Burseraceae, Leguminosae, Sapotaceae, Annonaceae, Chrysobalanaceae, Apocynaceae, Moraceae, Myristicaceae, and Myrtaceae. This finding is consistent with the results of other studies on host tree characteristics of *Heteropsis* genus along the areas of East and Central Amazon (Plowden et al. 2003, Morais 2008) that showed Lecythidaceae, Chrysobalanaceae and Burseraceae as the main families associated with *Heteropsis* spp. The authors suggested that this fact

may be explained as *Heteropsis* spp. could colonize a variety of tree species in ombrophylus forests, mainly those trees with thick and deep longitudinal fissured barks (Morais 2008), as occurred in Machadinho do Oeste.

Most of the adults of *H. flexuosa* in the area tended to be less frequent in taller host trees. In fact, adult *H. flexuosa* in Machadinho do Oeste occurred on a lower range of hosts between 20.0 - 95.0 cm dbh and on a higher range of trees and palms with 10.0 - 20.0 cm dbh. These results are similar to those of Plowden et al. (2003), which observed most *H. flexuosa* in host trees from 10.5 m and above in Brazil; and they differ from those in Balcázar-Vargas et al. (2011) and Knab-Vispo et al. (2003) that found *Heteropsis* spp. in large trees with dbh > 20 cm in “terra firme” forest in Colombia and Venezuela, respectively. However, indicates, as in Knab-Vispo et al. (2003), that the species has a preference for abiotic characteristics of the forest type rather than the density of preferred host tree species or sizes.

The tree size (dbh) did not influence *H. flexuosa* colonization in the forest community and just like in Balcázar-Vargas et al. (2011), the diameter distributions showed clear inverse J shapes.

Crown form and position, which reflect the light conditions prevailing at a particular moment in the forest canopy (Synnott 1979), or the tree ability to access light resources (Kainer et al. 2007), are important to explain several ecological processes including variations in fruit production and photosynthesis. The findings for host tree attributes are consistent with the results of the study on growth and management of *H. flexuosa* in “terra firme” forest of Amapá State (Pereira and Guedes 2008), which have climbed host trees from 11.8 m \pm 0.8 m up to 14.3 m \pm 0.8 m of mean height.

Concerning the ability to compete for light, nutrients and water, the scarcity of other lianas species in the same host trees as *H. flexuosa* (21.87%) could indicate a minimum competitive niche, or that those other lianas were not adapted to

the abiotic traits at the mean height colonized by *H. flexuosa* (Table III). The diversity indexes followed the expected range in the region (Fotopoulos 2006, Silva and Bentes-Gama 2008), suggesting that *H. flexuosa* has a random preference pattern for its host trees, or, as in Knab-Vispo et al. (2003), that the simply distribution of preferred host tree sizes could not explain its distribution and density. These results highlight the importance of identifying which habitat type is suitable to support *H. flexuosa* populations, to recommend future sustainable harvest guidelines for the species in open ombrophylus forest in the Amazon.

CONCLUSION

- *H. flexuosa* did not present specific host preferences for developing the capacity to hold itself upright, but was frequently associated with botanical families (Burseraceae, Leguminosae, Sapotaceae, Annonaceae, Chrysobalanaceae, Apocynaceae, Moraceae and Myristicaceae) and species with thick bark (*Schweilera coriacea*, *Protium* sp. and *Licania membranaceae*) of common frequency in the study area.
- *H. flexuosa* was less frequent with taller and broader trees in the study community.
- Crown form and position were important explanatory variables in this study and indicated the species preference for developing under understory strata light condition.
- Trunks or branches of host trees were the preferred position for the attaching of *H. flexuosa* (90.83%).
- The low frequency of other lianas (21.87%) observed on host trees indicated that they could not be adapted to the abiotic characteristics at the mean height colonized by *H. flexuosa*.
- These results highlight the importance of identifying which habitat type is suitable to support *H. flexuosa* populations, to recommend future sustainable harvest guidelines for the species in open ombrophylus forest in the Amazon.

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RESUMO

O objetivo deste estudo foi caracterizar a estrutura florestal com *H. flexuosa* no Estado de Rondônia, como base para a coleta sustentável e diretrizes de conservação da espécie. Os atributos de copa, altura total (m) e o diâmetro a altura do peito ≥ 10 (cm) de árvores e palmeiras com *H. flexuosa* foram avaliados em três parcelas permanentes (100 m x 150 m cada), aleatorizadas em 219 ha. Um total de 22 famílias botânicas foram hospedeiras de *H. flexuosa*. Não foi observada preferência específica para desenvolver sua capacidade de sustentar a si mesma. Entretanto, a espécie esteve frequentemente associada às famílias Burseraceae, Leguminosae, Sapotaceae, Annonaceae, Chrysobalanaceae e espécies que apresentam a casca espessa, como *Schweilera coriacea*, *Protium* sp. e *Licania membranaceae*. A espécie ocorreu com menos frequência conforme o aumento das classes de altura e diâmetro e tendeu a desenvolver-se sob a condição de luminosidade de sub-bosque. Os troncos ou galhos foram o principal local de fixação de *H. flexuosa* (90.83%) e uma baixa frequência de outras espécies de cipós foi observada nas mesmas árvores hospedeiras. Estes resultados indicam a necessidade de promover práticas de manejo apropriadas para a coleta de raízes e a conservação da espécie em habitat de Floresta Ombrófila Aberta.

Palavras-chave: Brasil, ecologia, fibras vegetais, preferência de habitat, manejo florestal de uso-múltiplo.

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