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Lectotypification of Two Bamboo Species

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ABSTRACT

Two species of woody bamboos, *Athroostachys capitata* and *Chusquea spencei*, are lectotypified based on observations made from specimens deposited in the herbaria at Kew and the British Museum.

RESUMEN

Se propone lectotipos para dos especies de bambues leñosos, *Athroostachys capitata* y *Chusquea spencei*, basado en observaciones hechas de muestras depositadas en los herbarios de Kew y el Museo Británico

A recent visit to the herbaria at Kew and the British Museum made it possible to verify the status of the type specimens for two species of bamboo, *Athroostachys capitata* (Hook.) Benth. and *Chusquea spencei* Ernst. In the case of *A. capitata*, two specimens (syntypes) were cited in the original description, but only one can serve as the nomenclatural type (Greuter et al. 1994). Clark (1989) designated a neotype for *C. spencei*, believing that the original specimen upon which this species was based was no longer extant, but a specimen that is arguably type material is preserved at the British Museum.

Athroostachys capitata (Hook.) Benth., Gen.

Pl. 3: 1209. 1883. *Merostachys ? capitata* Hook., Ic. Pl. 3: pl. 273–274. 1840. TYPE: BRAZIL. Rio de Janeiro: common in low woods around Rio, 1837 (fl), G. Gardner 136 (lectotype, here designated: K!, 2 sheets; isolectotype: BM!).

Chusquea fimbriata Steud., Syn. Pl. Glumac. 1: 338. 1854. TYPE: BRAZIL. Rio de Janeiro, no date, L. Riedel s.n. (holotype: P n.v.; isotype: US n.v.).

Chusquea glomerata Munro, Trans. Linn. Soc. London 26(1): 50. 1868. Nom. inval., as synonym of *Merostachys capitata*

var. *angustifolia* Döll, Fl. Bras. 2(3): 217. 1880. TYPE: Brasilia, L. Riedel s.n. (holotype: LE?). *Merostachys capitata* Hook. var. *capitata*.

Hooker (1840) originally described this species as *Merostachys ? capitata*, based on two collections, one by Gardner from Rio de Janeiro and the other by Tweedie in South Brazil. Gardner 136 is represented by two sheets in the collection at Kew, and a third sheet at Kew appears to be from the same gathering although it is not labeled with any collection number. The specimen on the three sheets consists of several flowering branches. Tweedie 1324 consists of a single flowering branch mounted on the same sheet as one of the Gardner collections. According to McClure (1973), both of these collections are deposited at the British Museum, but I was able to locate only a single sheet of Gardner 136 there. Gardner 136 is the better material and should clearly be designated as the lectotype for this species.

Chusquea spencei Ernst, J. Bot. 10: 262. 1872. TYPE: VENEZUELA. Mountains of Caracas, summit of Naiguatá, c. 1871, J. M. Spence s.n. (lectotype, here designated: BM!).

Ernst (1872) listed 32 species of lichens and plants based on "[a] small collection of alpine plants from the summit, brought down rather as a *souvenir*,..." by Mr. James A. Spence and several other gentlemen upon their ascent to the peak of Naiguatá on 23 April 1872. He described one of these plants, *Chusquea spencei*, as a new species, providing a Latin description and a key to differentiate this species from the others of this genus known to him. Although there are several species of bamboo native to the coastal mountain range above Caracas, the description clearly refers to the sticky exudate characteristic of the culms of *C. spencei*, as well as its erect branches and narrow foliage leaf blades, and therefore the identity of the species is not in doubt.

Adolf Ernst was a German botanist who settled in Venezuela in 1861, and his herbarium and types are deposited at K, with other material at AMES, C, E, KIEL and VEN, although the specimens at VEN were mostly destroyed (Stafleu and Cowan 1976). Until this year, I was unable to locate any collection of *C. spencei* by Spence at K or the other herbaria, and therefore designated Tillett et al. 41, collected from the summit of Naiguatá, as the neotype for this species (Clark 1989).

On a recent visit to the herbarium at the British Museum (BM), I found a specimen, singed from fire damage and remounted, with a typed label reading "Venezuela: mountains of Caracas, summit of Naiguatá, c. 1871, James M. Spence s.n." The specimen is vegetative, as the original collection evidently was, judging from the lack of any reference to reproductive structures in the protologue, and is clearly *C. spencei*. Considering the fire damage on the specimen, and the fact that many specimens at the British Museum were damaged or destroyed during World War II, it seems likely that this is indeed from the original gathering, and that the erroneous date was probably introduced when this label was prepared from what was left of the original. Ernst (1872) specifically noted that Linden had made a partial ascent 25 years earlier, but the first successful ascent to the summit of Naiguatá by a traveler was made by Spence and his companions on 23 April 1872, and therefore the c. 1871 date

must be an approximation by the person who prepared the label.

Judziewicz et al. (2000) and the TROPICOS nomenclatural database of the Missouri Botanical Garden (<http://mobot.mobot.org/Pick/Search/pick.html>) both give the type of *C. spencei* as *James M. Spence 13*, with the neotype as *Tillett et al. 41*. *Chusquea spencei* is the thirteenth species in the list by Ernst, but given the casual nature of the collections by Spence and the others, this enumeration likely did not refer to actual collection numbers by Spence but rather was simply a numbered list of species.

In light of these facts, I argue that this specimen represents part of the original collection of the species. It is impossible to know whether this is actually the holotype, however, and therefore I designate it as the lectotype. This relegates *Tillett et al. 41* to the status of a topotype.

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***Chusquea costaricensis*, A New Species of *Chusquea* sect. *Swallenochloa* (Poaceae: Bambusoideae)**

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ABSTRACT

Chusquea costaricensis is described and illustrated as a new species of *Chusquea* sect. *Swallenochloa* from the high montane forest/subpáramo ecotone of the Cordillera de Talamanca in Costa Rica and adjacent Panama. *Chusquea costaricensis* is most similar to *C. tonduzii*, *C. vulcanalis*, *C. talamancensis*, and *C. amistadensis*, with which it is compared and contrasted. A revised key to the species of *Chusquea* sect. *Swallenochloa* in Costa Rica is included.

RESUMEN

Se describe e ilustra *Chusquea costaricensis*, una especie nueva de *Chusquea* sección *Swallenochloa*. La especie nueva ocurre en el ecotono del bosque alto montano/subpáramo de la Cordillera de Talamanca en Costa Rica y en la zona adyacente en Panamá. *Chusquea costaricensis* es más afín a *C. tonduzii*, *C. vulcanalis*, *C. talamancensis* y *C. amistadensis*, con las cuales se compara. Se incluye una clave revisada de las especies de *Chusquea* sección *Swallenochloa* en Costa Rica.

The Cordillera de Talamanca of Costa Rica and Panama is home to 24 known species of woody bamboos, of which nine are found nowhere else. At higher elevations, these bamboos, particularly species of *Chusquea*, are a characteristic component of the upper montane forest and subpáramo vegetation of the cordillera (Widmer 1997; Judziewicz et al. 1999). It is possible to observe 14 of these bamboo species while driving along the Interamerican Highway from Cartago to San Isidro del General, although some may be difficult to find due to their small stature or habitat disturbance from landslides or human activities.

Chusquea sect. *Swallenochloa*, a group of 28 more or less shrubby species found in high altitude grasslands throughout the range of the genus, is represented in the Cordillera de Talamanca by eight species, of which five are endemic (*): **C. amistadensis* L. G. Clark, Davidse & Ellis, **C. costaricensis* L. G. Clark & R. March, *C. longiligulata* (Soderstr. & C. Calderón) L. G. Clark, **C. paludicola* L. G. Clark, **C. subtessellata* Hitchc.

**C. talamancensis* Widmer & L. G. Clark, *C. tonduzii* Hack., and *C. vulcanalis* (Soderstr. & C. Calderón) L. G. Clark. Only southeastern Brazil, with seven species of sect. *Swallenochloa* and six species of the *C. heterophylla* and *C. nudiramea* groups (Clark 1992), exceeds the Cordillera de Talamanca as a center of diversity for the shrubby chusqueas.

Because it dominates the subpáramo vegetation on Cerro de la Muerte, *Chusquea subtessellata* is the most conspicuous member of sect. *Swallenochloa* along the Interamerican Highway in the Cordillera de Talamanca. Yet careful observation has revealed the presence of six of the other Talamancan species of sect. *Swallenochloa* in close proximity to Cerro de la Muerte along this highway (*C. amistadensis* is restricted to the southeastern portion of the Cordillera de Talamanca). Some of these species intergrade morphologically, perhaps an indication of hybridization, which has been documented in two instances (Clark et al. 1989), and/or relative recency of origin.

Clark (1989: 118) segregated several vegetative specimens collected just below the Cerro de la Muerte as a probable new species. This species is similar vegetatively to both *C. tonduzii* and *C. vulcanalis*, but can be distinguished from them and the other sympatric species of sect. *Swallenochloa* by a combination of characters. Although this area has been observed annually or nearly so by R. W. Pohl,

L. G. Clark, Y. Widmer, U. Stein and others since approximately 1965, no flowering of this putative new species has been recorded. The lack of flowering material notwithstanding, this entity is distinct enough to warrant formal recognition as a species. We therefore describe this new species as *C. costaricensis*, and provide a revised key to the species of sect. *Swallenochloa* in Costa Rica.

TAXONOMIC TREATMENT

Key to the Species of *Chusquea* sect. *Swallenochloa* in Costa Rica
(based on vegetative characters; modified from Widmer & Clark 1991)

1. Foliage leaf blades 0.4–0.6 cm wide. *C. paludicola*
1. Foliage leaf blades 0.7–2.7 (3.2) cm wide.
 2. Inner ligule of foliage leaves 10–70 mm long, tapering.
 3. Culm leaf blades adaxially glabrous; foliage leaf sheaths farinose. *C. amistadensis*
 3. Culm leaf blades adaxially densely pubescent or scabrid; foliage leaf sheaths glabrous.
 4. Culm leaf blades adaxially scabrid; foliage leaf blades lax, outer ligule ciliate. *C. costaricensis*
 4. Culm leaf blades adaxially densely pubescent; foliage leaf blades more or less erect to erect, outer ligule glabrous.
 5. Foliage leaves 3–4 per complement, inner ligules 10–70 mm long; internodes flattened to shallowly sulcate for nearly the full length above the central bud; 1500–2060 m. *C. longiligula*
 5. Foliage leaves 5–9 per complement, inner ligules (2) 3–15 mm long; internodes more or less terete; 2400–3350 m. *C. tonduzii*
 2. Inner ligule of foliage leaves 0.5–4 (15) mm long, truncate to tapering.
 6. Foliage leaf blades 3–14.5 cm long; culm leaf blades 0.35–1.5 cm long, the sheaths (7) 12–27 times as long as the blades. *C. subtessellata*
 6. Foliage leaf blades (5.5) 10–29 cm long; culm leaf blades 1–6.5 cm long, the sheaths (1.5) 2–11 times as long as the blades.
 7. Foliage leaf blades with L: W = 7–12 (17), the base rounded to rounded–truncate. *C. vulcanalis*
 7. Foliage leaf blades with L: W = (7) 10–20 (24), the base rounded to attenuate.
 8. Inner ligules of foliage leaves 1–2.5 mm long, truncate to rounded; foliage leaf sheaths often farinose, especially when young; culm leaf blades adaxially scabrid. *C. talamancensis*
 8. Inner ligules of foliage leaves (2) 3–15 mm long, usually tapering; foliage leaf sheaths not farinose; culm leaf blades adaxially pubescent. *C. tonduzii*

Chusquea costaricensis L. G. Clark & R. March, sp. nov. TYPE: COSTA RICA. Cartago: Interamerican Highway, 69 km from Cartago on the road to San Isidro del General, less than 1 km from the turnoff to Cerro Buenavista in the direction of La Georgina, E side of road, 3100 m, 83° 46' W, 9° 35' N, 22 Jan 1998, L. G. Clark, G. Reiners & X. Londoño 1565 (holotype, CR; isotypes, INB, ISC, MO, US, USJ). Figure 1.

Culmi 1–1.5 cm diam., 3–6 m alti. Folia culmorum (8) 11–15 cm longa; vaginae (6.4) 8.5–12.5 cm longae, 3.4–5.2 plo longiores quam laminae, abaxiales glabrae; laminae 1.7–2.5 cm longae, erectae, adaxiales scaberulae, abaxiales glabrae. Ramificatio intravaginalis. Laminae foliorum 13–30 cm longae, 1.5–2.7 (3.2) cm latae, longitudo versus latitudo = 7.5–11 (12.5), glabrae, tessellatae, laxae; ligulae interiorae 10–15 (25) mm longae, glabrae; ligulae exteriorae 1.0–2.5 mm longae, ciliatae. Synflorescentia ignota.

Culms 1–1.5 cm diameter, 3–6 m tall, erect at base but arching over or leaning above; internodes 12.5–28 cm long, sulcate for the entire length, waxy. Culm leaves (8) 11–15 cm long, juncture of the sheath and blade a shallow to deep, inverted V-shaped line; sheaths (6.4) 8.5–12.5 cm long, triangular, loosely wrapped around the culm, abaxially glabrous, 3.4–5.2 times as long as the blade, shoulders broadly rounded, margins ciliate near apex; blades 1.7–2.5 cm long, erect, persistent, triangular, narrower than the sheath apex, abaxially glabrous, adaxially scabrous; girdle 1–3 mm wide, glabrous; inner ligule 1–3 mm long, stiff, glabrous. Nodes with the dominant triangular central bud not developing, subtended or less commonly flanked by (6) 9–11 subsidiary buds proliferating from the base; supranodal ridge prominent; sheath scar more or less horizontal, dipping slightly below the branch complement. Branching at least initially intravaginal, culm leaf sheath often splitting; subsidiary branches 9–15 per mature complement, 21–35 (65) cm long, rebranching basally. Foliage leaves 6–9 per complement; sheaths glabrous with variably ciliate margins; blades 13–30 cm long, 1.5–2.7 (3.2) cm wide, L: W = 7.5–11 (12.5), adaxially and abaxially glabrous,

adaxially and abaxially tessellate, lax, margins scabrous and cartilaginous, the apex setose, the base rounded–truncate, asymmetrical; pseudopetiole 2–4 mm long; outer ligule 1–2.5 mm long, margin densely ciliate; inner ligule 10–15 (25) mm long, glabrous, chartaceous. Synflorescence unknown.

Distribution. *Chusquea costaricensis* is known only from the Cordillera de Talamanca of Costa Rica and extreme northwestern Panama; 2900–3270 m. There are two clusters of occurrence: one in the Cerro de la Muerte area at the northwest end of the Cordillera de Talamanca and the other where the Costa Rica–Panama border crosses the Cordillera de Talamanca.

Chusquea costaricensis is distinguished from other species of sect. *Swallenochloa* by the combination of internodes sulcate for the full length, lax foliage leaf blades, a ciliate outer ligule, and foliage leaf blades 1.5–2.7 (3.2) cm wide. Some specimens placed here in *Chusquea costaricensis* were previously annotated as *C. vulcanalis* and *C. tonduzii*, and one specimen (*Horn 106*) was cited in the description of *C. tonduzii* (Clark, 1989). *Chusquea costaricensis* is distinguished from sympatric species of sect. *Swallenochloa* in Table 1.

A *Chusquea* specimen collected in the southeastern region of the known domain of *C. costaricensis* (COSTA RICA. Puntarenas: Cordillera de Talamanca, Cerro Pittier, 82° 56' W, 9° 04' N, 2860–2900 m, 18 Sep 1996, *Morales 5809*, INB) may represent the flowering phase of this species. As with many flowering specimens of bamboos, the vegetative material of this specimen is limited, making it difficult to determine some of the character states. This specimen does, however, have a ciliate outer ligule, non-farinose leaf sheaths and a long (1.4 cm) inner ligule like *Chusquea costaricensis*, but the leaf blades are narrower (1.1 cm) unlike *C. costaricensis*. We therefore do not assign this *Chusquea* specimen at this time, but remain watchful for plants known to be *C. costaricensis* to bloom.

Specimens examined. COSTA RICA. San José: Cerro Buenavista, km 90–91 of the Interamerican Highway, 83° 45–46' W, 9° 35' N, 3250 m, 31 May 1989, *Clark, Widmer &*

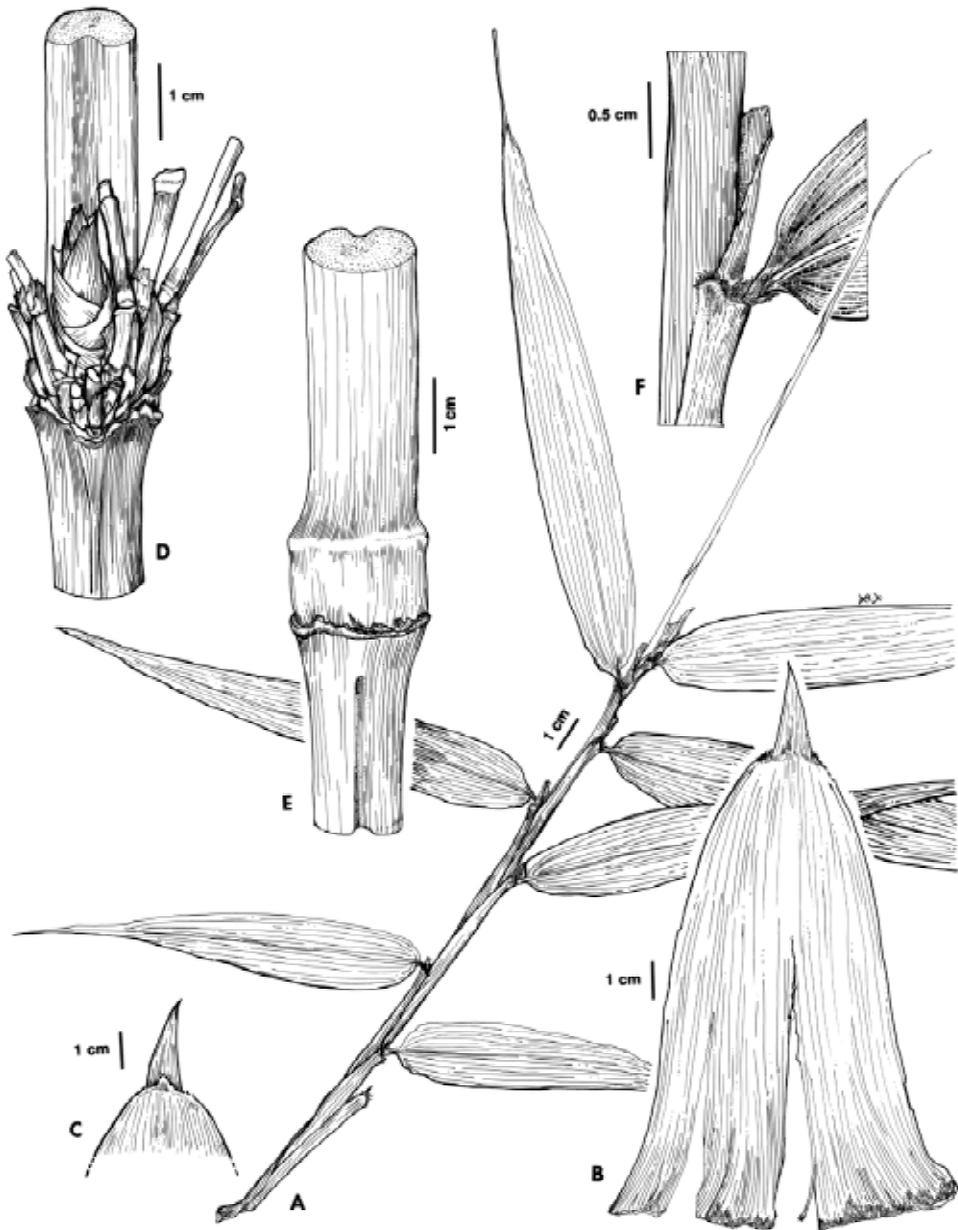


Figure 1. *Chusquea costaricensis*. A. Leafy subsidiary branch. B. Culm leaf, abaxial view. C. Culm leaf sheath apex and blade, adaxial view. D. Bud/branch complement. E. Node with supranodal ridge and sulcus extending nearly the length of the internode. F. Apex of foliage leaf sheath, showing inner and outer ligules and pseudopetiole. Based on Clark et al. 1565.

Table 1. A morphological comparison of *C. costaricensis* and sympatric species of *Chusquea* sect. *Swallenochloa*

Character	<i>C. amittadensis</i>	<i>C. costaricensis</i>	<i>C. subhessellata</i>	– terete	– terete	
Internode	terete	sulcate for the full length	± terete			
Culm leaf sheath, abaxial	glabrous	glabrous	pubescent at juncture with girdle, otherwise scabrid, often scattered hairs at apex			
Culm leaf blade, adaxial	glabrous	scabrid	Glabrous			
Foliage leaf sheath	farinose	not farinose	not farinose			
Foliage leaf blade color	yellowish green	green (to slightly yellowish green)	yellowish green			
Foliage leaf blade orientation	erect	lax	erect		– erect	
Foliage leaf blade width (cm)	0.7–1.4 (1.6–1.8)	1.5–2.7 (3.2)	0.7–1.3			
Foliage leaf blade length:width	7–14.5 (16)	7.5–11 (12.5)	3.5–12 (16)			
Foliage leaf inner ligule length (mm)	10–44	10–15 (25)	0.5–1.5			
Foliage leaf outer ligule	ciliolate	ciliate	glabrous or ciliolate			

Stein 506 (CR, ISC, MO, US); 4.6 km northwest of La Georgina, 3270 m, 2 Jan 1975, Pohl & Lucas 13139 (CR, ISC, US); Cantón de Dota, Cordillera de Talamanca, Cerro de la Muerte, 83° 49' W, 9° 37' 10" N, 3250 m, 23 May 1995, *Kelchner & González 15* (INB). San José/Cartago: Cordillera de Talamanca, Cerro de la Muerte, lower north slope of Cerro Estaquero, 3185 m, 7 Mar 1985, *Horn 106* (CR, ISC); Cerro de la Muerte, about 1 km east of Asunción, 3245 m, 23 April 1985, *Horn 174* (CR, ISC). Cartago: Cerros Cuericí, 3220 m, 11 May 1988, *Widmer s.n.* (ISC); Cerro de la Muerte, behind La Georgina at Villa Mills, 2900 m, 8 Aug 1967, *Smith 2975* (US). PANAMA. Bocas del Toro: Cordillera de Talamanca, 2 km northwest of Cerro Fábrega, 82° 53' W, 9° 08' N, 3150–3200 m, 7–8 Mar 1984, *Davidse, Gómez, Herrera, Chacón & Chacón 25331* (MO).

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Bamboo uses for housing by the different tribes of Northeast India

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ABSTRACT

This paper describes, in tabular format, the different uses of several bamboo species in construction of houses by tribes in Northeast India. The uses for 25 species in 9 genera of bamboo are described.

Northeast India is comprised of the states of Arunchal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura. The region is located between 25° 57' and 28° 23' north latitude and between 89° 46' and 92° 25' east longitude. The region is inhabited by the Adi Gallong, Adi Minyong, Apatani, Assamese, Cachari, Dapla, Dimasha, Garo, Khasi, Manipuri, Mikir, Mizo, Naga, Nishi and Tripuri tribes.

Bamboo are perennial arborescent grasses (POACEAE: GRAMINEAE) with culms that arise from a rhizome. Both “clumping” and “running” species occur in the area. They are classified as minor forest products in North-east India. The expansive geographic area encompasses wide variation in altitude as well as climatic, edaphic and biotic factors that all contribute to the bamboo species diversity in the region. In general, bamboo in the area thrive best in the monsoon forests becoming undershrubs in more temperate areas and often resembling ordinary grasses at high altitudes. There are 58 species of bamboo in 16 genera in the region (Arora and Maurya 1988) of which 25 species in 9 genera are used in construction

of houses by the tribes inhabiting the area. Bamboo are used extensively by all of the tribes for supporting posts (poles), flooring, frames, partitions, ceilings, walls, thatching, other roofing, doors, windows and tying.

MATERIALS AND METHODS

During field visits within Northeast India the different tribal groups were interviewed and their uses of bamboo in housing were identified and recorded. Local names were noted as well. The results are presented here in tabular form.

RESULTS

The results of the survey are presented in Table 1.

Table 1. Bamboo uses for housing by the different tribes of Northeast India.

Species	Local Name	Tribal Group	States	Form of Use
<i>Arundinaria elegans</i>	Jilli (Nag.)	Naga	Na.	Walling
<i>Arundinaria hirsuta</i>	Ustoh (Kh.)	Khasi	A.P., Me., Na.	Roofing, Partitions, Walls, Door
<i>Arundinaria manii</i>	Tajir (A.G.) Beneng (Kh.) Kabeng (Ja.)	Adi Gallong Khasi Jantia	A.P., Me.	Door, Window, Walling, Flooring, Partitions
<i>Arundinaria suberecta</i>	Ukadai (Kh.)	Khasi	A.P., Me.	Walling, Flooring, Partitions
<i>Bambusa arundinacea</i> (= <i>B. bambos</i>)	Kotoba (Ass.) Saneibi (Man.)	Assamese Manipuri	As., Ma.	Walling, Flooring, Partitions
<i>Bambusa balcooa</i>	Baluka (Ass.) Wamnel (Ga.) Barak (Tri.) Dzutere (Nag.)	Assamese Garó Tripuri Naga	A.P., As., Ma, Me., Na., Tr.	Walling, Flooring, Partitions, Thatching.
<i>Bambusa burmanica</i>	Thaikawa (Ass.)	Assamese	As.	Walling, Flooring, Roofing, Thatching.
<i>Bambusa nutans</i>	Dibang (A.M.) Deobans (Ass.) Serngial (Kh.) Wamatang (Ku.) Kali (Tri.)	Adi Minyong Assamese Khasi Kuki Tripuri	A.P., As., Me.	Poles
<i>Bambusa polymorpha</i>	Jamabetwa (Ass.) Bari (Tri.)	Assamese Tripuri	As., Tr.	Walling, Flooring, Roofing.
<i>Bambusa tulda</i>	Ejo (A.G.) Dibang (A.M.) Jati (Ass.) Wati (Ga.) Sejangjai (Kh.) Rwathing (Miz.) Bari (Tri.)	Adi Gallong Adi Minyong Assamese Garó Khasi Mizo Tripuri	A.P., As., Me., Mi., Na., Tr.	Roofing.
<i>Bambusa vulgaris</i>	Vairua (Miz.) Bakal (Man.)	Mizo Manipuri	Mi., Ma.	Poles, Walling, Flooring, Roofing, Framing.

<i>Cephalostachyum pergracile</i>	Madang (Ass.) Wootang (Man.) Latang (Nag.)	Assamese Manipuri Naga	As., Ma., Na.	Walling, Flooring, Roofing.
<i>Chimnobambusa callosus</i>	Tao (A.G.) Rejang (A.P.) Uskung (Kh.) Reji (Ni.)	Adi Gallong Apatani Jantia Khasi Nishi	A.P., Ma., Me., Mi., Na.	Tying of thatch on houses.
<i>Chimnobambusa griffithiana</i>	Tao (A.G.) Rejang (A.P.) Uskung (Kh.) Reji (Ni.)	Adi Gallong Apatani Jantia Khasi Nishi	A.P., Ma., Me., Mi., Na.	Tying of thatch on houses.
<i>Chimnobambusa khasiana</i>	Namlang (Kh.) Lik (Miz.)	Khasi Mizo	Ma., Me., Mi.	Walling
<i>Dendrocalamus brandisii</i>	Bulka (Ass.) Wanan (Man.)	Assamese Manipuri	As., Ma.	Walling, Flooring, Partitions.
<i>Dendrocalamus calostachys</i>	Seijong (Kh.) Aphbo (Nag.)	Khasi Naga	Me., Na.	Walling, Flooring, Partitions.
<i>Dendrocalamus giganteus</i>	Serung (A.M.) Worra(Ass.) Marobob (Man.) Aphbo (Nag.)	Adi Minyong Assamese Manipuri Naga	A.P., As., Ma., Na.	Walling, Flooring, Partitions.
<i>Dendrocalamus hamiltonii</i>	Eni (A.G.) Eom (A.M.) Ete (Apa.) Kako (Ass.) Phulrua (Miz.) Ratho (Nag.) Hebi (Ni.) Pecha (Tri.)	Adi Gallong Adi Minyong Apatani Assamese Mizo Naga Nishi Tripuri	A.P., As., Ma., Me., Mi., Na., Tr.	Walling, Poles, Thatching, Flooring, Partitions.
<i>Dendrocalamus hookeri</i>	Seiat. (ass.) Siejong (Jai.) Denga (Kh.) Ooci (Man.) Rawlak (Miz.)	Assamese Jantia Khasi Manipuri Mizo	A.P., As., Ma., Me., Mi., Na.	Walling, Flooring, Partitions.
<i>Dendrocalamus strictus</i>	Tursing (Miz.) Latibans (Tri.)	Mizo Tripuri	Mi., Tr.	Walling, Flooring, Partitions, Ceilings.

<i>Oxytenanthera nigrociliata</i>	Kailiyai (Tri.)	Tripuri	Tr.	Walling, Flooring, Partitions.
<i>Melocanna baccifera</i>	Terai (Ass.) Wati (Ca.) Watrai (Ga.) Moubi (Man.) Artem (Mik.) Mautak (Miz.) Turiyah (Nag.)	Assamese Cachari Garo Manipuri Mikkir Mizo Naga	As., Ma., Me., Mi., Tr.	Walling, Flooring, Partitions, Thatching.
<i>Pseudostachyum polymorphum</i>	Tadur (A.G.) Bajal (Ass.) Wachell (Ga.) Chal (Miz.) Sampit (Kh.) Uppit (Jai.) Karra (Nag.)	Adi Gallong Assamese Garo Mizo Khasi Jantia Naga	A.P., As., Ma., Me., Mi., Na.	Tying ceilings in the house.
<i>Thamnochlamus prainii</i>			Me., Na.	Walling, Flooring, Partitions.

Legend: Languages: A.G., Adi Gallong; A.M., Adi Minyong; Apa. Apatani; Ass., Assamese; Cac. Cachari; Gar, Garo; Jan., Jantia; Kh., Khasi; Man., Manipuri; Mik, Mikkir; Miz., Mizo; Nag, Nagamese; Ni., Nishi; Tri., Tripuri.

States: A.P., Arunachal Pradesh; As. Assam; Ma., Manipur; Me. Meghalaya; Mi., Mizoram; Na. Nagaland; Tr. Tripura.

Taxonomy follows Arora and Mauria (1988).

DISCUSSION

Bamboo is a valuable gift from nature to the tribes of Northeast India. It has wide acceptance for construction houses due to its desired structural properties of size, shape, flexibility, strength. It is a valuable timber that is abundant, easy to transport and quick seasoning (especially in split form). Bamboo houses are strong (Mathur 1981) and generally suffer very little damage due to earthquake. Temporary and quicker permanent construction are possible with bamboo making it ideal in this disaster prone region.

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Molecular evidence for polyphyly in the genus *Apoclada* (Poaceae: Bambusoideae)³

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ABSTRACT

The *ndhF* gene of chloroplast DNA from all three species of *Apoclada* was sequenced and compared with existing sequences for several of its relatives. The data show strong evidence for polyphyly in *Apoclada* as it has been traditionally described. The two cerrado species form a clade but *Apoclada simplex* is more closely allied with the genus *Guadua*.

RESUMO

A gene de *ndhF* de todas as três espécies de *Apoclada* foi arranjada em seqüência e comparada com as seqüências existentes para diversos de seus parentes. Encontramos de polyphyly a dentro da *Apoclada*, como foi descrito tradicionalmente. As duas espécies do cerrado dão forma a uma clade mas *A. simplex* é aliado mais próximo com o genus *Guadua*.

The genus *Apoclada* McClure & Smith consists of three species as monographed by Guala (1992, 1995). Two of the species, *A. arenicola* McClure and *A. cannaviera* (Alvaro da Silveira) McClure, are small tightly clumping bamboos of the cerrados of central Brazil. The third species, *A. simplex* McClure & Smith, is a tall loosely clumping bamboo of the forests (and forest edges) of southern Brazil. At the time of the research conducted to monograph the group (1989-1992) there was no cladogram for the bamboos that included *Apoclada*. This meant that outgroup choice was ambiguous and that the best hypothesis of relationships had to be determined based on much less evidence than is currently available. Guala (1992, 1995) pointed out that although the cladogram gen-

the genus was robust, the monophyly of the group was dependant upon a single striking characteristic, the presence of multiple equal primary branch buds in the midculm branch complement. The same concern was raised by E. Judziewicz (pers. comm. 1994) in a review of Guala (1995) but it was decided that until clear evidence for polyphyly became available, the genus would not be split.

Given the large amount of anatomical, morphological and molecular data that has been gathered for bamboos in recent years it is now a good time to re-examine the relationships within *Apoclada*. The first step in this re-examination is a molecular analysis of the *ndhF* gene of the chloroplast DNA. Now that *ndhF* sequences are available for a large number of

³This paper is number 29 in the Tropical Biology Program of Florida International University

possible relatives we were able to design a relatively small project to sequence the three species of *Apoclada* and compare them to existing sequences kindly provided by Dr. Lynn Clark.

This analysis provides an independent data set for comparison with other analyses currently underway, based on morphological characters.

MATERIALS AND METHODS

Leaf material was collected from plants grown in cultivation – *Otatea acuminata* (Munro) C.E. Calderón & Soderstr. (G.F.G #2444) – or from wild populations – *Apoclada arenicola*, G. F. G. #1358; *A. cannaviera*, G.F. G. # 1297, *A. simplex*, G. F. G. # 1438 – with voucher specimens deposited at FTG. *Otatea* was sequenced as a control.

Approximately 1 g of dried leaf material was ground with sand to a fine powder and extracted with 2x CTAB buffer with the addition of 0.2% β-mercaptoethanol and 1% PVP (Doyle and Doyle, 1987). The DNA extracts were further purified by the GeneClean (BIO 101, Inc.) method of binding the DNA to silica beads and washing away impurities with NEW Wash buffer. Amplifications were performed using a MJ Research PTC-200 thermal cycler. Primers for amplification and sequencing the 3' end of the *ndhF* gene were obtained from Terry et al. (1997) as follows: *ndhF* 1318F 5'-GGATTAACCGCATTTTATATGTTTC-3' and *ndhF* 2110R 5'-CCCCCTATATATTGATACCTTCTCC-3'.

Amplifications were carried out in 50 µl volumes consisting of 27.5 µl H₂O, 5 µl of 10' PCR buffer (Promega), 5 µl MgCl₂ (Promega, 25 mM), 4 µl dNTP mix (Promega, 2.5 µM each), 2 µl of each primer (IDT, 20 µM each), 0.5 µl taq DNA polymerase, and 4 µl DNA (approximately 200 ng DNA per reaction). Conditions for PCR amplification were 94 °C for 5 minutes, followed by 35 cycles of 94 °C for 30 seconds, 50 °C for 60 seconds, 72 °C for 90 seconds. Amplified *ndhF* sequences were purified by the GeneClean procedure, eluted in 20 µl 1xTE, and quantified by fluorimetry. Cycle sequencing was performed using Big Dye Terminators supplied in the Ready

Reaction mix (ABI Prism). Sequencing was performed on an ABI 377 automated DNA sequencer. Sequences were analyzed and edited with ABI Prism software and aligned with ClustalX. Additional *ndhF* sequences for comparison were obtained from Lynn Clark and combined with these sequences. All sequences used here are given in Appendix I.

Trees were generated using the Branch and Bound algorithm in PAUP* 4.0 (Swofford 2000). Bootstrapping was done using TBR branch swapping and 1000 replicates.

RESULTS

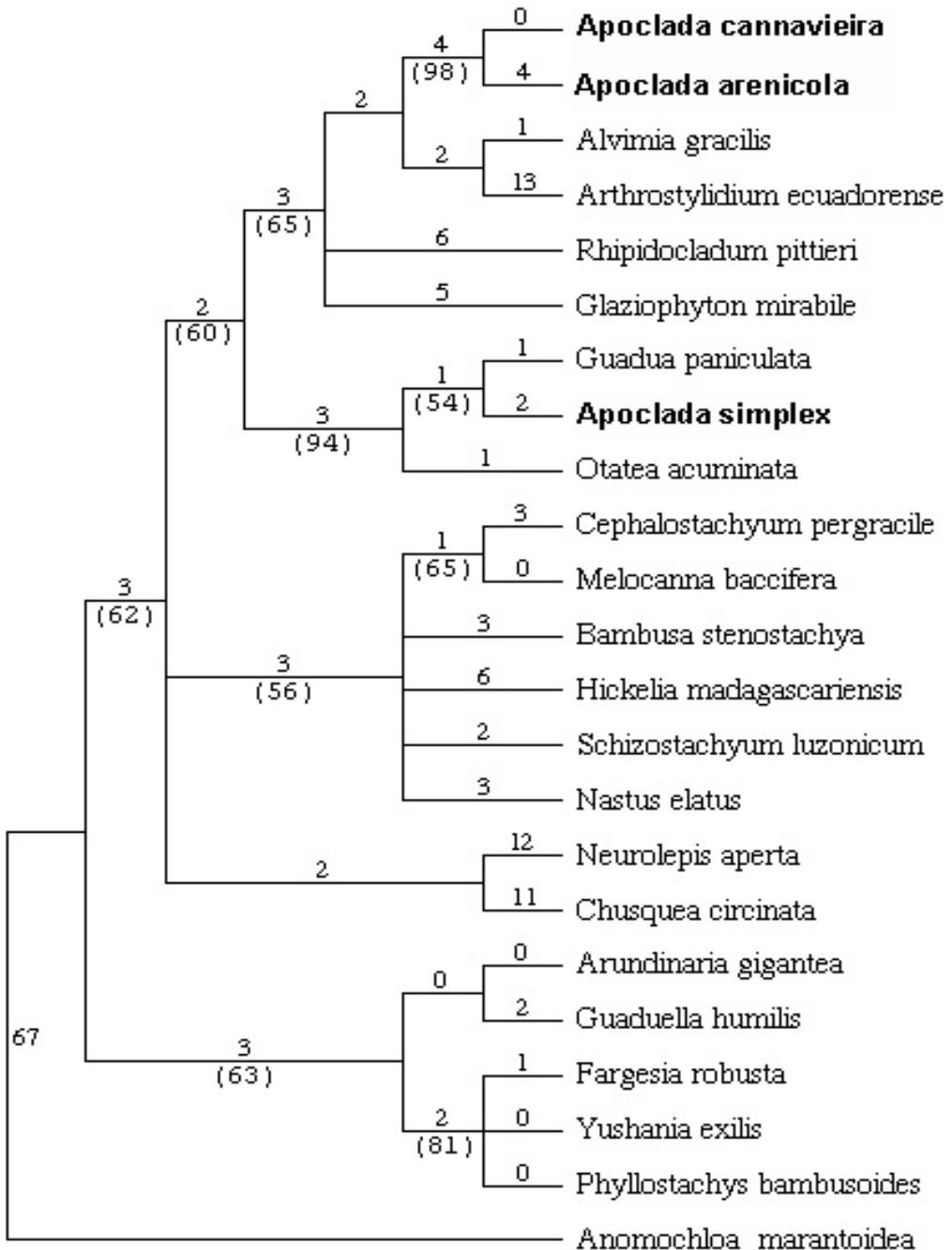
The cladogram is shown in Figure 1. Branch lengths are shown above and bootstrap support below where it exceeds 50%. The aligned matrix is shown in Appendix 1.

DISCUSSION

The cladogram clearly shows that *Apoclada simplex* is more closely related to *Guadua* and *Otatea* than it is to the other *Apocladas*. Both branches supporting this dichotomy are well supported. The tree is generally congruent with that of Zhang and Clark (2000) and is very reasonable given what we now know about bamboo phylogeny. The Arthrotyliidiinae and Guaduinae are clearly defined. The large insertion discovered in *A. arenicola* (Appendix I) is also interesting as a clear synapomorphy.

Judziwicz et al. (1999) placed *Apoclada* in the Guaduinae while Soderstrom and Ellis (1987) did not place the genus in a tribe. Guala (1992, 1995) showed that refractive papillae, intercostal sclerenchyma fibers, 3 stamens, 2 stigmas, a reduced leaf midrib, semelauctant multiflowered spikelets and an asymmetric leaf margin, which were reported by Soderstrom and Ellis (1987) as characteristic of the Arthrotyliidiinae occur in the genus although these characteristics have now been found to occur in other tribes. Morphological and molecular analyses of the Arthrotyliidiinae are underway by the senior author and appropriate nomenclatural changes will be made when these studies have progressed further.

Figure 1. Consensus cladogram of relationships of the species of *Apoclada* to several other species of bamboos. Branch lengths are shown above and bootstrap support is shown below each branch where it exceeds 50%. Tree length 174 steps, from 55 trees, CI=0.833, RI=0.766.



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ACKNOWLEDGEMENTS

We thank Dr. Lynn Clark for supplying sequence data for several species of bamboo used in this study. We also thank Dr. Ray Schnell for giving permission to collect *Otatea acuminata* at USDA Chapman Field.

Spatial habitat characterization and prediction for two endemic sister species of bamboo on the cerrados of central Brazil^{3,4}

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ABSTRACT

The habitats of *Apoclada cannavieira* and *A. arenicola* are characterized and compared using numerous layers of spatial environmental data in a Geographic Information System. (GIS). Predicted ranges were also generated using simple incidence of layers derived from known distribution points and projected across the continent.

RESUMO

Os habitats do *Apoclada cannavieira* e o *A. arenicola* são caracterizados e comparados usando camadas numerosas de dados ambientais espaciais em um sistema de informação geográfica. (GIS). As habitats previstas foram geradas também usando a incidência simples das camadas derivadas dos pontos sabidos da distribuição e projetadas através do continente.

Two of the three species of *Apoclada* McClure & Smith, *A. arenicola* McClure and *A. cannaviera* (Alvaro da Silveira) McClure, are small tightly clumping bamboos of the cerrados of central Brazil. The two are sister species (Guala 1992, 1995) and although the monophyly of the genus is now in question (See Guala *et al.* preceding article) their position as sister to each other is not in question.

Although both grow in cerrado, they are sequestered in different regions of the biome and environmental factors unquestionably play a role in this disjunction. Modern remotely sensed data and computer software that allows manipulation and spatial analysis of that data (Geographic Information Systems or GIS)

allows us to characterize habitats and predict distributions for species and predict spatial environmental factors that may have played a role in speciation (Guala 2000).

The genus *Apoclada* is poorly collected and rare but both of the cerrado species have great potential as both horticultural and forage plants. They are high in protein in comparison to other cerrado species (Guala 1992), form dense clumps, and stay green all year. The purpose of this paper is to augment previously published descriptions of the species (Guala 1992, 1995) with environmental data and to show predicted ranges for the species to aid in conservation and development of these two rare and beautiful bamboos.

³This paper is number 30 in the Tropical Biology Program of Florida International University

⁴This paper is dedicated to Ms. Isabel Soler who inspired its creation.

MATERIALS AND METHODS

Latitude and longitude were determined for all known populations of *Apoclada cannavieira* and *A. arenicola* as precisely as possible. Much of this work was actually completed as a part of Guala (1992) but recent records were added for this study. Data were then transferred to individual grid layers in ArcView 3.2 with Spatial Analyst (ESRI 1999).

Environmental data was compiled from the NOAA-EPA (1992) data set. The data were copied from the CD-ROM, converted from integer/binary format to real/binary format using the CONVERT module of IDRISI vers. 4.0 (Eastman 1992) and then converted to ArcView 3.2 grid layers. Conversion of files from IDRISI to Arcview was done manually on the layer of surface Albedo and the 13 surface temperature layers. All other layers were converted using an ArcView 3.0a Avenue script written and provided by Justin Moat of the Madagascar Biodiversity Project, Royal Botanic Gardens, Kew. Forty five data layers (or themes) were used in the GIS and each has inherent characteristics that may influence its accuracy and applicability. Surface temperature, precipitation and potential sunshine hours per month (each with 12 monthly means) are from the data set of Leemans and Cramer (1992) which was originally derived from Leemans and Cramer (1991). Although other precipitation and temperature data are available, these data were used for several reasons. First, they are complete and cover the entire study area. Second, they are all from the same source and were originally sampled on the same base map. Because of this, the numerous problems associated with re-sampling from different base maps and projections were avoided. Third, they appear to be more congruent, on a monthly basis, with my own field observations and comparisons with known data points than do other available data such as those of Legates and Willmott (1989, 1992). My own anecdotal comparisons were made using long term rainfall and temperature records (examined on site) from the Reserva Ecológica do IBGE in

Brasilia, Brazil (years 1975-1994). The Leemans and Cramer data were closer to the long term measured monthly means in almost all instances. The Leemans and Cramer data are interpolated using a spatial model described in Leemans and Cramer (1992) from long term means for each month compiled from available station records from 1931-1960. The annual summaries of precipitation and surface temperature in the data set of Legates and Willmott (1989, 1992) were also used in the GIS because none were included in the Leemans and Cramer set. Although the Legates and Willmott set matched my anecdotal sets less closely on a monthly basis, the annual totals were within the range of known annual totals for each of my anecdotal sets and are probably more realistic given that they are calculated from actual annual means rather than the sum of monthly means that I would have employed if I had used the Leemans and Cramer data.

Elevation data are from NOAA-EPA (1992), a re-gridding of Edwards (1989) commonly known as ETOPO5. These data were the most accurate available for the regions in question when the project was begun. The sand, silt and clay values in the top 1 m of soil are from Webb *et al.* (1991a, 1992). The values were calculated from an interpretation of the FAO Soil Map of the World (FAO-UNESCO 1981) and the World Soil File (Zobler 1986) using the algorithms described in Webb *et al.* (1991b). Albedo values are originally from (Matthews 1983). The amount of water in the root zone of the soil is from Webb *et al.* (1992).

Although all layers of data were taken from NOAA-EPA (1992) and gridded to 1 deg., the original data with resolutions are cited here to clarify which data from that set was used. Original resolutions are given the citations.

Ranges for spatial variables were computed simply by querying the GIS for each of the data layer values at each of the *Apoclada* distribution data points. Those ranges are given in Table 1.

Predicted ranges were computed by using rainfall data from the driest month (June), the wettest month (January for *A. arenicola* and December for *A. cannavieira*), and the inter

mediate month with the least variation among sites (April for *A. arenicola* and May for *A. cannavieira*). Although up to 44 layers could have been used to predict the ranges, my experience has shown that, with cerrado species, a point of diminishing returns is reached after these three layers and the predicted range does not contract significantly more as layers are added. This was tested with *A. arenicola* and 11 more layers. The resulting area with 14 coincident layers was less than 18% smaller.

Each of the layers was reclassified to values of 1 or 0 using the range of values determined from the species distributional points. For example, the distributional points (populations) for *A. arenicola* had a range of June rainfall values from 17-37 mm. Thus, all points on the layer with values of 17-37 were reclassified to one and all with values outside of that range were reclassified with values of zero.

The three layers were then superimposed on each other and the total value for each point was summed. Thus, values could range from zero to three for any point. Those points with a value of three were where all three rainfall layers were within the known range for the given species.

RESULTS

The results of the query for spatial environmental variables is given in Table 1. Distributions of the two species are given in Figure 1. Predicted natural ranges based on rainfall are given in figure 2.

DISCUSSION

It is clear that both species are cerrado endemics and that their distributions are correlated with different spatial environmental parameter ranges, especially rainfall. The interesting thing about this difference is that while annual values for rainfall overlap significantly, the June ranges do not. This is also the case with April temperature. Given that June is at the height of the dry season and that

Apocladas stay green all year, the lack of rain in June could be limiting for *Apoclada cannavieira*. April temperature is probably less likely to be limiting given that April is at neither extreme of the annual cycle. There are significant differences in soil as well but these data are not quite as reliable for Brazil as the climate data are (Guala 1998) and it is unlikely that the difference is real. Daytime hours of sunshine in November is the other very interesting disjunction in ranges that shows up in this data set. In Africa, this variable has been shown to be correlated with speciation in the andropogonoid grass *Homozeugos* (Guala 1998, 2000). Given that C₃ grasses do not tend to be light limited in tropical environments, it is likely that if this is really defining in some way for the distribution of the species, the variable is a covariant of another environmental variable that was not examined such as transpiration or humidity.

In conclusion, I hope that these data will provide the beginning of a characterization of the habitats for these two important cerrado bamboos and aid in their future conservation and development.

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Table 1. Ranges for spatial environmental variables in the two cerrado species of *Apoclada*.

Data Layer	<i>A. arenicola</i>	<i>A. cannavieira</i>
Percent Clay in Soil	6 - 76	5 - 73
Percent Silt in Soil	3 - 16	14 - 15
Percent Sand in Soil	13 - 91	8 - 13
Water in the root zone (mm)	428 - 1114	42 - 1114
Albedo	1100 - 1600	1500 - 1600
Elevation (m)	350 - 853	693 - 1082
Mean Rainfall in January (mm)	212 - 271	88 - 220
Mean Rainfall in February (mm)	164 - 249	175 - 243
Mean Rainfall in March (mm)	128 - 245	42 - 155
Mean Rainfall in April (mm)	89 - 107	68 - 118
Mean Rainfall in May (mm)	29 - 110	24 - 39
Mean Rainfall in June (mm)	17 - 37	0 - 17
Mean Rainfall in July (mm)	3 - 46	0 - 36
Mean Rainfall in August (mm)	11 - 39	3 - 19
Mean Rainfall in September (mm)	22 - 73	17 - 52
Mean Rainfall in October (mm)	101 - 177	127 - 179
Mean Rainfall in November (mm)	96 - 190	143 - 263
Mean Rainfall in December (mm)	211 - 267	180 - 295
Mean Annual Rainfall (mm)	1425 - 1774	1071 - 1654
Mean Temperature in January (deg. C)	21.5 - 27	21.2 - 22.9
Mean Temperature in February (deg. C)	21.5 - 26.5	20 - 22
Mean Temperature in March (deg. C)	22.1 - 26.4	21.2 - 22.4
Mean Temperature in April (deg. C)	21.5 - 25.1	17.9 - 21.5
Mean Temperature in May (deg. C)	18.9 - 22.9	17 - 20.3
Mean Temperature in June (deg. C)	17.9 - 22.2	15.1 - 19.8
Mean Temperature in July (deg. C)	17 - 22.3	15.8 - 19.4
Mean Temperature in August (deg. C)	19.1 - 22.9	16.3 - 21.2
Mean Temperature in September (deg. C)	21.2 - 24.6	18 - 22.6
Mean Temperature in October (deg. C)	22.1 - 26.3	18.8 - 22.3
Mean Rain in November (deg. C)	21.9 - 27.6	17.8 - 22.3
Mean Temperature in December (deg. C)	21.6 - 26	19 - 22.1
Mean Annual Temperature (deg. C)	22.8 - 24.6	18.5 - 23
Mean Percent of Daytime w/o Clouds in January	38 - 49	44 - 47
Mean Percent of Daytime w/o Clouds in February	39 - 51	47 - 50
Mean Percent of Daytime w/o Clouds in March	44 - 57	52 - 55
Mean Percent of Daytime w/o Clouds in April	56 - 63	60 - 64
Mean Percent of Daytime w/o Clouds in May	63 - 75	69 - 79
Mean Percent of Daytime w/o Clouds in June	63 - 79	73 - 86
Mean Percent of Daytime w/o Clouds in July	67 - 80	75 - 86
Mean Percent of Daytime w/o Clouds in August	63 - 79	71 - 87
Mean Percent of Daytime w/o Clouds in September	47 - 58	56 - 64
Mean Percent of Daytime w/o Clouds in October	47 - 55	47 - 56
Mean Percent of Daytime w/o Clouds in November	44 - 56	38 - 42
Mean Percent of Daytime w/o Clouds in December	34 - 47	32 - 36

Figure 1. Distributions of *Apoclada arenicola* and *Apoclada camavieira*.

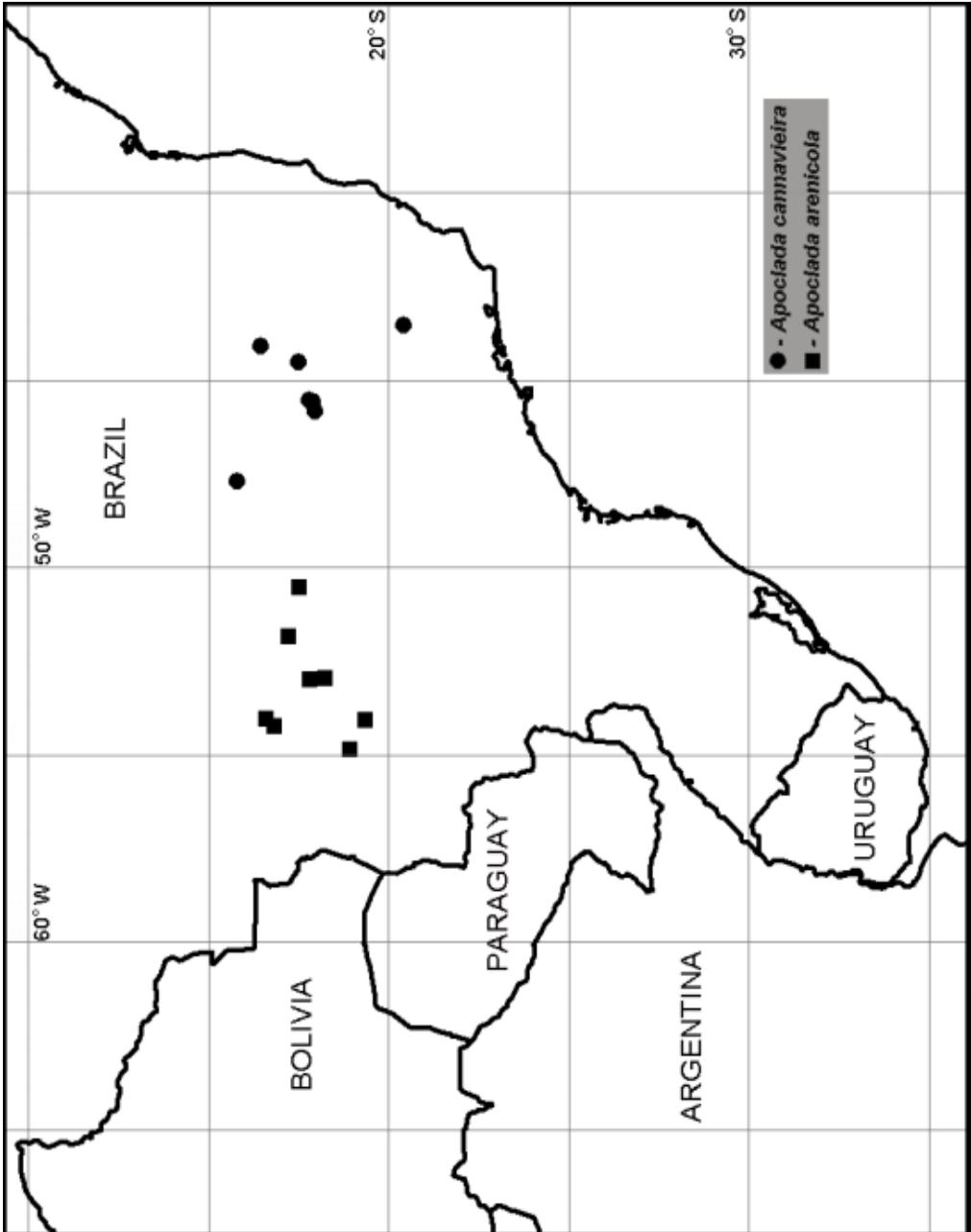
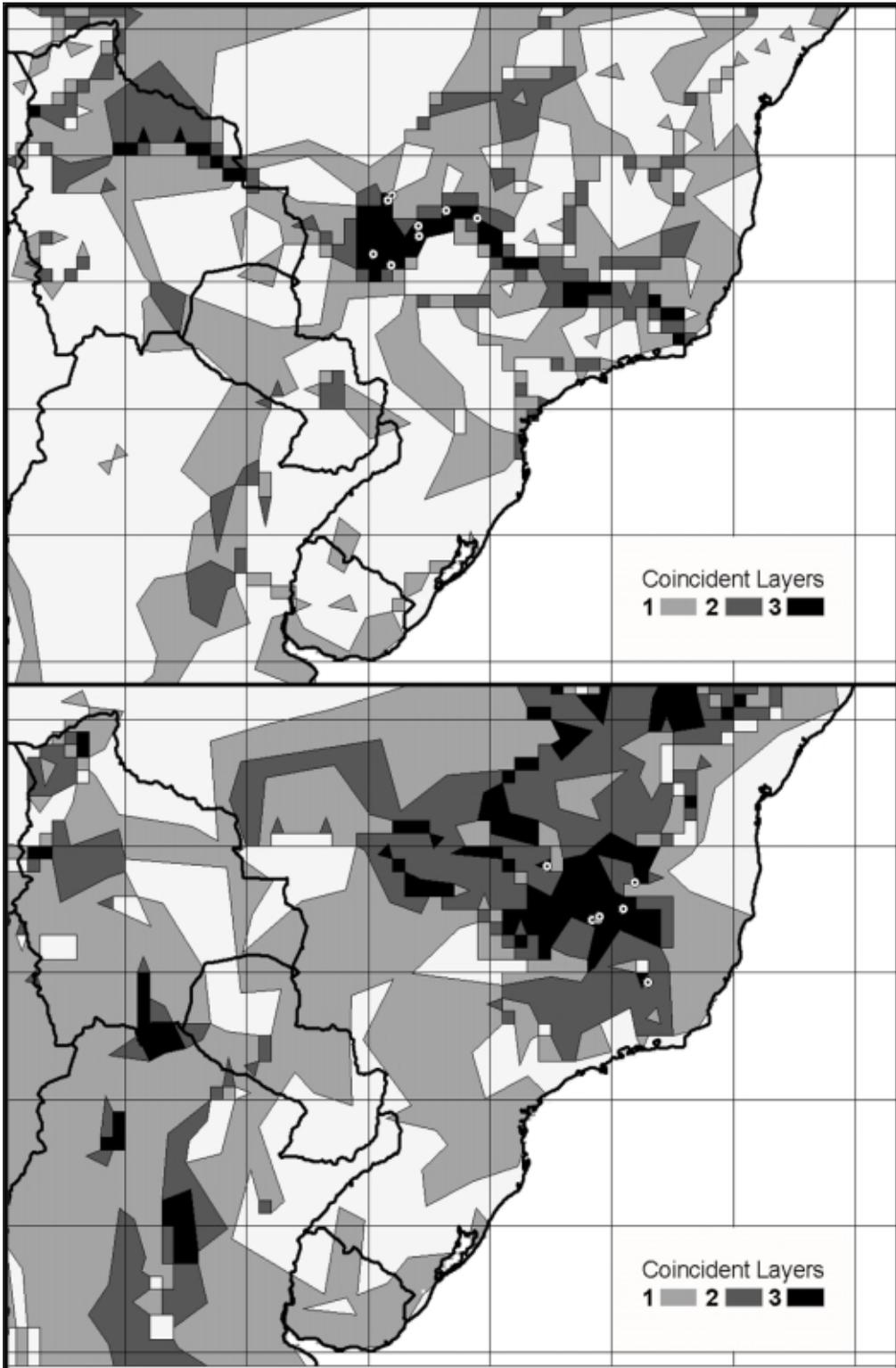


Figure 2. Predicted distributions based on rainfall. Top: *A. arenicola*. Bottom: *A. cannavieira*



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